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2011-12-22	4.0.3	AUTOSAR Administration	• Adapted to new version of meta model • Support for mixed compu methods with categories `SCALE_LINEAR_AND_TEXTTABLE` and `SCALE_RATIONAL_AND_TEXTTABLE` added • Support for compatibility of partial record types added • Consolidation of signal invalidation, data conversion, and out-of-range handling • General consolidation and bug fixes
2011-04-15	4.0.2	AUTOSAR Administration	• Adapted to new version of meta model • Backward compatibility to implicit communication behavior of AUTOSAR 2.1/3.0/3.1 added • Support of inter-runnable variables extended to composite data types • Clarification which API calls shall be implemented as macro accesses to the component data structure in compatibility mode • General consolidation and bug fixes

2009-12-18	4.0.1	AUTOSAR Administration	• Adapted to new version of meta model • RTE and Basic Software Scheduler merged • Support of multi core architectures added • Re-scaling at ports added • API enhancements added
2009-02-04	3.1.2	AUTOSAR Administration	• updated VFB-Tracing • unconnected R-Ports are supported • incompatible function declarations fixed • RTE server mapping updated
2008-02-01	3.0.2	AUTOSAR Administration	• Layout adaptations
2007-12-21	3.0.1	AUTOSAR Administration	• Adapted to new version of meta model • "RTE ECU Configuration" added • Calibration and measurement revised • Document meta information extended • Small layout adaptations made
2007-01-24	2.1.15	AUTOSAR Administration	• "Advice for users" revised • "Revision Information" added
2006-11-28	2.1	AUTOSAR Administration	• Adapted to new version of meta model • New feature 'debouncing of runnable activation' • New feature 'runnable activation offset' • 'Measurement and Calibration' added • Semantics of implicit communication enhanced • Legal disclaimer revised
2006-05-16	2.0	AUTOSAR Administration	Initial release

Table of Contents

References

[1] Virtual Functional Bus
AUTOSAR_EXP_VFB

[2] Software Component Template
AUTOSAR_TPS_SoftwareComponentTemplate

[3] Specification of Communication
AUTOSAR_SWS_COM

[4] Specification of Operating System
AUTOSAR_SWS_OS

[5] Specification of ECU Configuration
AUTOSAR_TPS_ECUConfiguration

[6] Methodology
AUTOSAR_TR_Methodology

[7] Specification of ECU State Manager
AUTOSAR_SWS_ECUStateManager

[8] System Template
AUTOSAR_TPS_SystemTemplate

[9] Basic Software Module Description Template
AUTOSAR_TPS_BSWModuleDescriptionTemplate

[10] Generic Structure Template
AUTOSAR_TPS_GenericStructureTemplate

[11] Glossary
AUTOSAR_TR_Glossary

[12] General Requirements on Basic Software Modules
AUTOSAR_SRS_BSWGeneral

[13] Requirements on Runtime Environment
AUTOSAR_SRS_RTE

[14] Specification of Timing Extensions
AUTOSAR_TPS_TimingExtensions

[15] Layered Software Architecture
AUTOSAR_EXP_LayeredSoftwareArchitecture

[16] Specification of ECU Resource Template
AUTOSAR_TPS_ECUResourceTemplate

[17] Specification of I/O Hardware Abstraction
AUTOSAR_SWS_IOHardwareAbstraction

[18] Requirements on Operating System
AUTOSAR_SRS_OS

[19] Requirements on Communication
AUTOSAR_SRS_COM

[20] ASAM MCD 2MC ASAP2 Interface Specification
http://www.asam.net
ASAP2-V1.51.pdf

[21] Specification of NVRAM Manager
AUTOSAR_SWS_NVRAMManager

[22] Collection of blueprints for AUTOSAR M1 models
AUTOSAR_MOD_GeneralBlueprints

[23] Specification of COM Based Transformer
AUTOSAR_SWS_COMBasedTransformer

[24] Guide to BSW Distribution
AUTOSAR_EXP_BSWDistributionGuide

[25] Specification of Default Error Tracer
AUTOSAR_SWS_DefaultErrorTracer

[26] General Specification on Transformers
AUTOSAR_ASWS_TransformerGeneral

[27] Guidelines for the use of the C language in critical systems, ISBN 978-1-906400-10-1
MISRA_C_2012.pdf

[28] Specification of Memory Mapping
AUTOSAR_SWS_MemoryMapping

[29] General Specification of Basic Software Modules
AUTOSAR_SWS_BSWGeneral

[30] Specification of Compiler Abstraction
AUTOSAR_SWS_CompilerAbstraction

[31] Specification of Standard Types
AUTOSAR_SWS_StandardTypes

[32] Specification of Bit Handling Routines
AUTOSAR_SWS_BFXLibrary

[33] Collection of constraints on AUTOSAR M1 models
AUTOSAR_TR_AutosarModelConstraints

Note on XML examples

This specification includes examples in XML based on the AUTOSAR metamodel available at the time of writing. These examples are included as illustrations of configurations and their expected outcome but should not be considered part of the specification.

1 Introduction

This document contains the software specification of the AUTOSAR Run-Time Environment (*RTE*) and the *Basic Software Scheduler*. Basically, the RTE together with the OS, AUTOSAR COM and other Basic Software Modules is the implementation of the Virtual Functional Bus concepts (*VFB*, [1]). The RTE implements the AUTOSAR Virtual Functional Bus interfaces and thereby realizes the communication between AUTOSAR software-components.

This document describes how these concepts are realized within the RTE. Furthermore, the Application Programming Interface (*API*) of the RTE and the interaction of the RTE with other basic software modules is specified.

The *Basic Software Scheduler* offers concepts and services to integrate Basic Software Modules Hence, the *Basic Software Scheduler*

- embed *Basic Software Module* implementations into the AUTOSAR OS context
- trigger main processing functions of the *Basic Software Module*s
- apply data consistency mechanisms for the *Basic Software Module*s
- to communicate modes between *Basic Software Module*s

1.1 Scope

This document is intended to be the main reference for developers of an RTE generator tool or of a concrete RTE implementation respectively. The document is also the reference for developers of AUTOSAR software-components and basic software modules that interact with the RTE, since it specifies the application programming interface of the RTE and therefore the mechanisms for accessing the RTE functionality. Furthermore, this specification should be read by the AUTOSAR working groups that are closely related to the RTE (see Section 1.2 below), since it describes the interfaces of the RTE to these modules as well as the behavior / functionality the RTE expects from them.

This document is structured as follows. After this general introduction, Chapter 2 gives a more detailed introduction of the concepts of the RTE. Chapter 3 describes how an RTE is generated in the context of the overall AUTOSAR methodology. Chapter 4 is the central part of this document. It specifies the RTE functionality in detail. The RTE API is described in Chapter 5.

The appendix of this document consists of five parts: Appendix A lists the restrictions to the AUTOSAR metamodel that this version of the RTE specification relies on. Appendix B explicitly lists all external requirements, i.e. all requirements that are not about the RTE itself but specify the assumptions on the environment and the input of an RTE generator. In Appendix C some MISRA-C rules are listed that are likely to be violated by RTE code, and the rationale why these violations may occur.

Note that Chapters 1 and 2, as well as Appendix C do not contain any requirements and are thus intended for information only.

Chapters 4 and 5 are probably of most interest for developers of an RTE Generator. Chapters 2, 3, 5 are important for developers of AUTOSAR software-components and basic software modules. The most important chapters for related AUTOSAR work packages would be Chapters 4, 5, as well as Appendix B.

The specifications in this document do not define details of the implementation of a concrete RTE or RTE generator respectively. Furthermore, aspects of the ECU- and system-generation process (like e.g. the mapping of SW-Cs to ECUs, or schedulability analysis) are also not in the scope of this specification. Nevertheless, it is specified what input the RTE generator expects from these configuration phases.

1.2 Dependency to other AUTOSAR specifications

The main documents that served as input for the specification of the RTE are the specification of the Virtual Functional Bus [1] and the specification of the Software Component Template [2]. Also of primary importance are the specifications of those Basic Software modules that closely interact with the RTE (or vice versa). These are especially the communication module [3] and the operating system [4]. The main input of an RTE generator is described (among others) in the ECU Configuration Description. Therefore, the corresponding specification [5] is also important for the RTE specification. Furthermore, as the process of RTE generation is an important part of the overall AUTOSAR Methodology, the corresponding document [6] is also considered.

The following list shows the specifications that are closely interdependent to the specification of the RTE:

- Specification of the Virtual Functional Bus [1]
- Specification of the Software Component Template [2]
- Specification of AUTOSAR COM [3]
- Specification of AUTOSAR OS [4]
- Specification of ECU State Manager and Communication Manager [7]
- Specification of ECU Configuration [5]

- Specification of System Description / Generation [8]
- AUTOSAR Methodology [6]
- Specification of BSW Module Description Template [9]
- AUTOSAR Generic Structure Template [10]

1.3 Acronyms and Abbreviations

All abbreviations used throughout this document – except the ones listed here – can be found in the official AUTOSAR glossary [11].

1.4 Technical Terms

All technical terms used throughout this document – except the ones listed here – can be found in the official AUTOSAR glossary [11] or the Software Component Template Specification [2].

Term	Description
application mode manager	An *application mode manager* is an *AUTOSAR software-component* that provides the service of switching modes. The modes of an application mode manager do not have to be standardized.
associated RTE Implementation Plug-In	The RTE Implementation Plug-In which is assigned to a communication graph, ExclusiveArea, mode machine instance or distributed shared mode group and therefore handles all accesses via RTE APIs, SchM APIs or RTE internal code.
AutosarDataPrototype implementation	Definitions and declarations for non automatic[1] memory objects which are allocated by the RTE and implementing AutosarDataPrototypes or their belonging status handling.
BswSchedulableEntity activation	The activation of a BswSchedulableEntity is defined as the activation of the task that contains the BswSchedulableEntity and eventually includes setting a flag that tells the glue code in the task which BswSchedulableEntity is to be executed.
BswSchedulableEntity start	A BswSchedulableEntity is started by the calling the C-function that implements the BswSchedulableEntity from within a started task.
'C' typed PerInstanceMemory	'C' typed PerInstanceMemory is defined with the class PerInstanceMemory. The type of the memory is defined with a 'C' typedef in the attribute typeDefinition.

[1] declaration with no static or external specifier defines an automatic variable

client	A client is defined as one ClientServerOperation in one RPortPrototype of one Software Component instance. For the definition of the client neither the number of ServerCallPoints nor RunnableEntity accesses to the ServerCallPoint are relevant. A Software Component instance can appear as several clients to the same server if it defines ServerCallPoints for several PortPrototypes of the same PortInterface's ClientServerOperation.
CodeGenerationTime variability	Variability defined with an VariationPoint or *AttributeValueVariationPoint* with latest bindingTime CodeGenerationTime.
coherency group	A set of implicit read accesses and implicit write accesses for which the RTE cares for data coherency. Please note that in the context of this specification the definition of coherency includes that • read data values of different VariableDataPrototypes have to be from the same age, except the values are changed by implicit write accesses belonging to the coherency group • written data values of different VariableDataPrototypes are communicated to readers NOT belonging to the coherency group after the last implicit write access belonging to the coherency group.
coherent implicit data access	An implicit read access or an implicit write access which belongs to coherency group. Therefore it is referenced by a RteVariableReadAccessRef or RteVariableWriteAccessRef belonging to a RteImplicitCommunication container which RteCoherentAccess parameter is set to true.
coherent implicit read access	An implicit read access which belongs to coherency group. Therefore it is referenced by a RteVariableReadAccessRef belonging to a RteImplicitCommunication container which RteCoherentAccess parameter is set to true.
coherent implicit write access	An implicit write access which belongs to coherency group. Therefore it is referenced by a RteVariableReadAccessRef or RteVariableWriteAccessRef belonging to a RteImplicitCommunication container which RteCoherentAccess parameter is set to true.
common mode machine instance	A 'common mode machine instance' is a special 'mode machine instance' shared by BSW Modules and SW-Cs: The RTE Generator creates only one mode machine instance if a *ModeDeclarationGroupPrototype* instantiated in a port of a software-component is synchronized (*synchronizedModeGroup* of a *SwcBswMapping*) with a *providedModeGroup ModeDeclarationGroupPrototype* of a Basic Software Module instance. The related mode machine instance is called common mode machine instance.

Communication Graph	The sum of all AbstractAccessPoints to elements of PortInterfaces instantiated in PortPrototypes which are connected to each other, or the sum of all accesses from BswModuleEntitys to interface elements in a BswModuleDescriptions connected to each other.
Data Communication Graph	The sum of all VariableAccesses to DataPrototypes instantiated in PortPrototypes which are connected to each other, or the sum of all VariableAccesses to DataPrototypes in the InternalBehavior, or the sum of all BswVariableAccesses to DataPrototypes in BswModuleDescriptions connected to each other.
Client Server Communication Graph	The sum of all ServerCallPoints to operations instantiated in PortPrototypes which are connected to each other inclusive the belonging server runnable.
Trigger Communication Graph	The sum of all ExternalTriggeringPoints for triggers instantiated in PortPrototypes which are connected to each other inclusive the belonging triggered runnable.
copy semantic	Copy semantic means, that the accessing entities are able to read or write the "copied" data from their execution context in a non concurrent and non preempting manner. If all accessing entities are in the same preemption area this might not require a real physical data copy.
core local mode user group	In the case that mode users belong to different partitions which in turn are scheduled on different micro controller cores the overall mode machine instance needs to be distributed cross core. Thereby some restrictions are only applicable between the mode users executed on the same micro controller core. All mode users of the same mode manager which belong to EcucPartition which in turn belong to OsApplications referring to the same EcucCoreDefinition are belonging to the same core local mode user group.
data semantic	When data is distributed, the last received value is of interest (last-is-best semantics). Therefore the software implementation policy, stated in the swImplPolicy attribute of the SwDataDefProps, shouldn't be 'queued'.
event semantic	When events are distributed the whole history of received events is of interest, hence they must be queued on receiver side. Therefore the software implementation policy, stated in the swImplPolicy attribute of the SwDataDefProps, will have the value 'queued'(corresponding to event distribution with a queue).
execution-instance	An execution-instance of an ExecutableEntity is one instance or call context of an ExecutableEntity with respect to concurrent execution, see section 4.2.3.
implicit read access	VariableAccess aggregated in the role dataReadAccess to a VariableDataPrototype
implicit write access	VariableAccess aggregated in the role dataWriteAccess to a VariableDataPrototype

incoherent implicit data access	An implicit read access or an implicit write access which does not belong to a coherency group. Therefore it is NOT referenced by any RteVariableReadAccessRef or RteVariableWriteAccessRef belonging to a RteImplicitCommunication container which RteCoherentAccess parameter is set to true.
incoherent implicit read access	An implicit read access which does not belong to a coherency group. Therefore it is NOT referenced by any RteVariableReadAccessRef belonging to a RteImplicitCommunication container which RteCoherentAccess parameter is set to true.
incoherent implicit write access	An implicit write access which does not belong to a coherency group. Therefore it is NOT referenced by any RteVariableWriteAccessRef belonging to a RteImplicitCommunication container which RteCoherentAccess parameter is set to true.
inter-ECU communication	The communication between ECUs, typically using COM is called inter-ECU communication in this document.
inter-partition communication	The communication within one ECU but between different partitions, represented by different OS applications, is called inter-partition communication in this document. It may involve the use of OS mechanisms like IOC or trusted function calls. The partitions can be located on different cores or use different memory sections of the ECU.
intra-ECU communication	The communication within one ECU is called intra-ECU communication in this document. It is a super set of inter-partition communication and intra-partition communication.
intra-partition communication	The communication within one partition of one ECU is called intra-partition communication. In this case, RTE can make use of internal buffers and queues for communication.
invalidateable	Invalidateable VariableDataPrototypes are VariableDataPrototypes that have an invalidValue.
LinkTime variability	Variability defined with an VariationPoint or *AttributeValueVariationPoint* with latest bindingTime LinkTime.
mode disabling	When a 'mode disabling' is active, RTE and *Basic Software Scheduler* disables the start of mode disabling dependent ExecutableEntitys. The 'mode disabling' is active during the mode that is referenced in the mode disabling dependency and during the transitions that enter and leave this mode. See also section 4.4.1.
mode disabling dependency	A RTEEvent (respectively a BswEvent) that starts a RunnableEntity (respectively a BswSchedulableEntity) can contain a *disabledMode* (respectively *disabledInMode*) association which *references* a *ModeDeclaration*. This association is called *mode disabling dependency* in this document.
mode disabling dependent ExecutableEntity	A mode disabling dependent RunnableEntity or a BswSchedulableEntity is triggered by an RTEEvent respectively a BswEvent with a mode disabling dependency. RTE and *Basic Software Scheduler* prevent the start of those RunnableEntity or BswSchedulableEntity by the RTEEvent / BswEvent, when the corresponding mode disabling is active. See also section 4.4.1.

mode machine instance	The instances of mode machines or *ModeDeclarationGroups* are defined by the *ModeDeclarationGroupPrototypes* of the mode managers. Since a mode switch is not executed instantaneously, The RTE or *Basic Software Scheduler* has to maintain it's own states. For each mode manager's ModeDeclarationGroupPrototype, RTE or *Basic Software Scheduler* has one state machine. This state machine is called *mode machine instance*. For all mode users of the same mode manager's *ModeDeclarationGroupPrototype*, RTE and *Basic Software Scheduler* uses the same *mode machine instance*. See also section 4.4.2.
mode manager	Entering and leaving modes is initiated by a *mode manager*. A *mode manager* is either a software component that provides a p-port typed by a ModeSwitchInterface or a BSW module which defines in its BswModuleDescription a *ModeDeclarationGroupPrototype* in the role *providedModeGroup*. See also section 4.4.2.
ModeSwitchAck ExecutableEntity	A RunnableEntity or a BswSchedulableEntity that is triggered by a ModeSwitchedAckEvent respectively a BswModeSwitchedAckEvent connected to the mode manager's ModeDeclarationGroupPrototype. It is called *ModeSwitchAck ExecutableEntity*. See also section 4.4.1.
mode switch notification	The communication of a mode switch from the mode manager to the mode user using either the ModeSwitchInterface or *providedModeGroup* and *requiredModeGroup ModeDeclarationGroupPrototypes* is called *mode switch notification*.
mode switch port	The port for receiving (or sending) a mode switch notification. For this purpose, a *mode switch port* is typed by a ModeSwitchInterface.
mode user	An *AUTOSAR SW-C* or *AUTOSAR Basic Software Module* that depends on modes is called a mode user. The dependency can occur through a SwcModeSwitchEvent/BswModeSwitchEvent, a ModeAccessPoint for a provided/required mode switch port, or a accessedModeGroup for a providedModeGroup/requiredModeGroup ModeDeclarationGroupPrototype. See also section 4.4.1.
NvBlockSwComponent	NvBlockSwComponent is a SwComponentPrototype typed an NvBlockSwComponentType.
on-entry ExecutableEntity	A RunnableEntity or a BswSchedulableEntity that is triggered by a SwcModeSwitchEvent respectively a BswModeSwitchEvent with *ModeActivationKind* 'entry' is triggered on entering the mode. It is called *on-entry ExecutableEntity*. See also section 4.4.1.
on-exit ExecutableEntity	A RunnableEntity or a BswSchedulableEntity that is triggered by a SwcModeSwitchEvent respectively a BswModeSwitchEvent with *ModeActivationKind* 'exit' is triggered on exiting the mode. It is called *on-exit ExecutableEntity*. See also section 4.4.1.
on-transition ExecutableEntity	A RunnableEntity or a BswSchedulableEntity that is triggered by a SwcModeSwitchEvent respectively a BswModeSwitchEvent with *ModeActivationKind* 'transition' is triggered on a transition between the two specified modes. It is called *on-transition ExecutableEntity*. See also section 4.4.1.

post-build variability	Variability defined with an VariationPoint having an postBuildVariantCriterion
pre-build variability	Variability defined with an VariationPoint or *AttributeValueVariationPoint* with latest bindingTime SystemDesignTime, CodeGenerationTime, PreCompileTime or LinkTime.
PreCompileTime variability	Variability defined with an VariationPoint or *AttributeValueVariationPoint* with latest bindingTime PreCompileTime.
preemption area	A preemption area defines a set of tasks which are scheduled cooperatively. Therefore tasks of one preemption area are preempting each other only at dedicated schedule points. A schedule point is not allowed to occur during the execution of a RunnableEntity.
primitive data type	Primitive data types are the types implemented by a boolean, integer (up to 32 bits), floating point, or opaque type (up to 32 bits).
RIPS FlatInstanceDescriptor	FlatInstanceDescriptor with rtePluginProps referencing a Communication Graph.
hline RP enabler flag	A Boolean flag to permit run-time enabling/disabling bypass.
RP event id	Identifier for bypassed event; passed as parameter to RP service function.
RP global buffer	A buffer read/written by RP. The RP global buffer is conceptually separated from the RTE managed buffer holding the variable data prototype value.
RP global measurement buffer	A buffer used by RP to store the original variable data prototype value for subsequent measurement purposes before replacement by the RP generated value.
RP runnable disabler flag	A Boolean flag to permit conditional RunnableEntity execution. When conditional execution is configured the runnable is executed if the flag is FALSE.
RP service component	An AUTOSAR or vendor specific BSW module providing an RP service, e.g. “XCP on CAN” or “XCP on Ethernet”.
RP service profile	A definition of a service combining the symbol of the function providing the service and the permitted range of RP service point ids.
RP service function	An invocation of a function provided by a RP service component where data is sampled and/or stimulated.
RP service point	A location where one or more RP service functions provided by a RP service component are invoked.
RP service point id	Integer identifier for RP service point.
RP service invocation wrapper	A “wrapper” function created by the RTE that is responsible for invoking the RP RP service function(s). The indirection thus introduced enables a post-build tool to replace the invocation of the RTE generated function with arbitrary functionality.
RP stimulation enabler flag	A Boolean flag to permit conditional RP stimulation.
RTE event identifier	Integer identifier used by RP to identify RTE event associated with an RP service point.
RTE Implementation Plug-In	A RTE Implementation Plug-In is a part of the overall RTE implementation which is not provided by the RTE Generator but from an additional source (e.g. a Plug-In Generator or a manually implemented source code).
RTE Implementation Plug-In Service	A RTE Implementation Plug-In Service is a single entry point into the RTE Implementation Plug-In implementing a low level service for the RTE. For instance access to a specific buffer.

RIPS	The acronym RIPS stands for RTE Implementation Plug-In Service and the related API infix Rips is derived from this.
RIPS FlatInstanceDescriptor	A FlatInstanceDescriptor which assigns the communication graph with an RTE Implementation Plug-In
runnable activation	The activation of a runnable is linked to the RTEEvent that leads to the execution of the runnable. It is defined as the incident that is referred to by the RTEEvent. E. g., for a timing event, the corresponding runnable is activated, when the timer expires, and for a data received event, the runnable is activated when the data is received by the RTE.
runnable start	A runnable is started by the calling the C-function that implements the runnable from within a started task.
server	A server is defined as one RunnableEntity which is the target of an OperationInvokedEvent. Call serialization is on activation of RunnableEntity.
server ExecutableEntity	A server that is triggered either by an OperationInvokedEvent or by an BswOperationInvokedEvent. In certain situations, RTE can implement the client server communication as a simple function call.
server runnable	A server that is triggered by an OperationInvokedEvent. It has a mixed behavior between a runnable and a function call. In certain situations, RTE can implement the client server communication as a simple function call.
SystemDesignTime variability	Variability defined with an VariationPoint or *AttributeValueVariationPoint* with latest bindingTime SystemDesignTime.
trigger emitter	A *trigger emitter* has the ability to release triggers which in turn are activating triggered ExecutableEntitys. *trigger emitter* are described by the meta model with provide trigger ports, Trigger in role releasedTrigger, InternalTriggeringPoints and BswInternalTriggeringPoints.
trigger port	A PortPrototype which is typed by an TriggerInterface
trigger sink	A *trigger sink* relies on the activation of *Runnable Entities* or *Basic Software Schedulable Entities* if a particular *Trigger* is raised. A *trigger sink* has a dedicated require trigger port(s) or / and *requiredTrigger Trigger*(s) to communicate to the trigger source(s).
trigger source	A *trigger source* administrate the particular *Trigger* and informs the RTE or *Basic Software Scheduler* if the *Trigger* is raised. A *trigger source* has dedicated provide trigger port(s) or / and *releasedTrigger Trigger*(s) to communicate to the trigger sink(s).
triggered BswSchedulableEntity	A BswSchedulableEntity that is triggered at least by one BswExternalTriggerOccurredEvent or BswInternalTriggerOccurredEvent. In particular cases, the *Trigger Event Communication* or the *Inter Basic Software Schedulable Entity Triggering* is implemented by *Basic Software Scheduler* as a direct function call of the *triggered ExecutableEntity* by the triggering *ExecutableEntity*.

triggered ExecutableEntity	A *Runnable Entity* or a *Basic Software Schedulable Entity* that is triggered at least by one ExternalTriggerOccurredEvent / BswExternalTriggerOccurredEvent or InternalTriggerOccurredEvent / BswInternalTriggerOccurredEvent. In particular cases, the Trigger Event Communication or the *Inter Runnable Triggering* is implemented by RTE or *Basic Software Scheduler* as a direct function call of the *triggered ExecutableEntity* by the triggering ExecutableEntity.
triggered runnable	A *Runnable Entity* that is triggered at least by one ExternalTriggerOccurredEvent or InternalTriggerOccurredEvent. In particular cases, the Trigger Event Communication or the *Inter Runnable Triggering* is implemented by RTE as a direct function call of the *triggered runnable* by the triggering runnable.
unconnected port	An *unconnected port* is a RPortPrototype or PPortPrototype referenced by no AssemblySwConnectors and/or DelegationSwConnectors, or with at least no DataMapping of any of the elements in the port interface. Hint: PRPortPrototypes are always treated as connected ports. (See [SWS_Rte_06030])

Table 1.1: Technical Terms

1.5 Document Conventions

Requirements in the SRS are referenced using **[SRS_Rte_<n>]** where <**n**> is the requirement id. For example, [SRS_Rte_00098].

Requirements in the SWS are marked with **[SWS_Rte_<nnnnn>]** as the first text in a paragraph. The scope of the requirement is marked with the half brackets.

Constraints on the input of the RTE are marked with **[SWS_Rte_CONSTR_<XXXXX>]**.

Technical terms are typeset in monospace font, e.g. `Warp Core`.

AUTOSAR Meta Class Names and Attributes are typeset in monospace font, e.g. `ApplicationSwComponentType`. As a general rule, plural forms of AUTOSAR Meta Class Names and Attributes are created by adding "s" to the singular form, e.g. `PortPrototype`s. By this means the document resembles terminology used in the AUTOSAR XML Schema.

AUTOSAR ECU Configuration Parameters are typeset in monospace font, e.g. `RteCodeVendorId`. As a general rule, plural forms of ECU Configuration Parameters are created by adding "s" to the singular form, e.g. `RteEventToTaskMapping`s. By this means the document resembles terminology used in the ARXML file of AUTOSAR ECU Configuration Parameter Definition.

API function calls are also marked with monospace font, like `Rte_EjectWarpCore`.

1.6 Requirements Tracing

The following table references the requirements specified in [12] as well as [13] and links to the fulfillment of these. Please note that if column “Satisfied by” is empty for a specific requirement this means that this requirement is not fulfilled by this document.

Requirement	Description	Satisfied by
[SRS_BSW_00004]	All Basic SW Modules shall perform a pre-processor check of the versions of all imported include files	[SWS_Rte_07692]
[SRS_BSW_00007]	All Basic SW Modules written in C language shall conform to the MISRA C 2012 Standard.	[SWS_Rte_01168] [SWS_Rte_03715] [SWS_Rte_06804] [SWS_Rte_06805] [SWS_Rte_06806] [SWS_Rte_06807] [SWS_Rte_06808] [SWS_Rte_06809] [SWS_Rte_06810] [SWS_Rte_07086] [SWS_Rte_07300]
[SRS_BSW_00101]	The Basic Software Module shall be able to initialize variables and hardware in a separate initialization function	[SWS_Rte_04546] [SWS_Rte_04547] [SWS_Rte_04548] [SWS_Rte_04549] [SWS_Rte_04550] [SWS_Rte_04551] [SWS_Rte_07270] [SWS_Rte_07271] [SWS_Rte_07273] [SWS_Rte_70047] [SWS_Rte_80051] [SWS_Rte_80052] [SWS_Rte_80055]
[SRS_BSW_00161]	The AUTOSAR Basic Software shall provide a microcontroller abstraction layer which provides a standardized interface to higher software layers	[SWS_Rte_02734]
[SRS_BSW_00300]	All AUTOSAR Basic Software Modules shall be identified by an unambiguous name	[SWS_Rte_01003] [SWS_Rte_01157] [SWS_Rte_01158] [SWS_Rte_01161] [SWS_Rte_01169] [SWS_Rte_01171] [SWS_Rte_07122] [SWS_Rte_07139] [SWS_Rte_07284] [SWS_Rte_07288] [SWS_Rte_07295] [SWS_Rte_07504] [SWS_Rte_07922]
[SRS_BSW_00305]	Data types naming convention	[SWS_Rte_01055] [SWS_Rte_01150] [SWS_Rte_02301] [SWS_Rte_02310] [SWS_Rte_02311] [SWS_Rte_03731] [SWS_Rte_03733]
[SRS_BSW_00307]	Global variables naming convention	[SWS_Rte_01171] [SWS_Rte_03712] [SWS_Rte_07284]
[SRS_BSW_00308]	AUTOSAR Basic Software Modules shall not define global data in their header files, but in the C file	[SWS_Rte_03786] [SWS_Rte_07121] [SWS_Rte_07502] [SWS_Rte_07921]

[SRS_BSW_00310]	API naming convention	[SWS_Rte_01071] [SWS_Rte_01072] [SWS_Rte_01083] [SWS_Rte_01091] [SWS_Rte_01092] [SWS_Rte_01102] [SWS_Rte_01111] [SWS_Rte_01118] [SWS_Rte_01120] [SWS_Rte_01123] [SWS_Rte_01206] [SWS_Rte_01252] [SWS_Rte_02569] [SWS_Rte_02631] [SWS_Rte_02725] [SWS_Rte_03550] [SWS_Rte_03553] [SWS_Rte_03560] [SWS_Rte_03565] [SWS_Rte_03741] [SWS_Rte_03744] [SWS_Rte_03800] [SWS_Rte_03928] [SWS_Rte_03929] [SWS_Rte_05509] [SWS_Rte_06207] [SWS_Rte_07367] [SWS_Rte_07390] [SWS_Rte_07394] [SWS_Rte_07556]
[SRS_BSW_00312]	Shared code shall be reentrant	[SWS_Rte_01012]
[SRS_BSW_00327]	Error values naming convention	[SWS_Rte_01058] [SWS_Rte_01060] [SWS_Rte_01061] [SWS_Rte_01064] [SWS_Rte_01065] [SWS_Rte_01317] [SWS_Rte_02312] [SWS_Rte_02571] [SWS_Rte_02594] [SWS_Rte_02702] [SWS_Rte_02739] [SWS_Rte_02747] [SWS_Rte_02757] [SWS_Rte_07054] [SWS_Rte_07289] [SWS_Rte_07290] [SWS_Rte_07384] [SWS_Rte_07562] [SWS_Rte_07563] [SWS_Rte_07655] [SWS_Rte_08065] [SWS_Rte_08551] [SWS_Rte_08725] [SWS_Rte_08726]
[SRS_BSW_00330]	It shall be allowed to use macros instead of functions where source code is used and runtime is critical	[SWS_Rte_01274]
[SRS_BSW_00336]	Basic SW module shall be able to shutdown	[SWS_Rte_07274] [SWS_Rte_07275] [SWS_Rte_07277] [SWS_Rte_70047] [SWS_Rte_80053] [SWS_Rte_80054] [SWS_Rte_80055]
[SRS_BSW_00337]	Classification of development errors	[SWS_Rte_06631] [SWS_Rte_06632] [SWS_Rte_06633] [SWS_Rte_06634] [SWS_Rte_06635] [SWS_Rte_06637] [SWS_Rte_07675] [SWS_Rte_07682] [SWS_Rte_07683] [SWS_Rte_07684] [SWS_Rte_07685]
[SRS_BSW_00342]	It shall be possible to create an AUTOSAR ECU out of modules provided as source code and modules provided as object code, even mixed	[SWS_Rte_07511]
[SRS_BSW_00346]	All AUTOSAR Basic Software Modules shall provide at least a basic set of module files	[SWS_Rte_06638]

[SRS_BSW_00347]	A Naming seperation of different instances of BSW drivers shall be in place	[SWS_Rte_06203] [SWS_Rte_06532] [SWS_Rte_06535] [SWS_Rte_06536] [SWS_Rte_07093] [SWS_Rte_07250] [SWS_Rte_07253] [SWS_Rte_07255] [SWS_Rte_07260] [SWS_Rte_07263] [SWS_Rte_07266] [SWS_Rte_07282] [SWS_Rte_07295] [SWS_Rte_07504] [SWS_Rte_07528] [SWS_Rte_07694] [SWS_Rte_08765] [SWS_Rte_08789] [SWS_Rte_08790]
[SRS_BSW_00351]	Encapsulation of compiler specific methods to map objects	[SWS_Rte_04557]
[SRS_BSW_00353]	All integer type definitions of target and compiler specific scope shall be placed and organized in a single type header	[SWS_Rte_01163] [SWS_Rte_01164] [SWS_Rte_07104] [SWS_Rte_07641]
[SRS_BSW_00384]	The Basic Software Module specifications shall specify at least in the description which other modules they require	[SWS_Rte_01412]
[SRS_BSW_00407]	Each BSW module shall provide a function to read out the version information of a dedicated module implementation	[SWS_Rte_07278] [SWS_Rte_07279] [SWS_Rte_07280] [SWS_Rte_07281]
[SRS_BSW_00415]	Interfaces which are provided exclusively for one module shall be separated into a dedicated header file	[SWS_Rte_07295] [SWS_Rte_07500] [SWS_Rte_07501] [SWS_Rte_07503] [SWS_Rte_07504] [SWS_Rte_07505] [SWS_Rte_07506] [SWS_Rte_07510]
[SRS_BSW_00447]	Standardizing Include file structure of BSW Modules Implementing Autosar Service	[SWS_Rte_07120]
[SRS_Com_02044]	AUTOSAR COM and LargeData COM shall provide a transmit confirmation function	[SWS_Rte_01407] [SWS_Rte_01411]
[SRS_Rte_00003]	Tracing of sender-receiver communication	[SWS_Rte_01238] [SWS_Rte_01240] [SWS_Rte_01241] [SWS_Rte_01242] [SWS_Rte_01357] [SWS_Rte_03814] [SWS_Rte_04531] [SWS_Rte_04532] [SWS_Rte_07639]
[SRS_Rte_00004]	Tracing of client-server communication	[SWS_Rte_01238] [SWS_Rte_01240] [SWS_Rte_01241] [SWS_Rte_01242] [SWS_Rte_01357] [SWS_Rte_03814] [SWS_Rte_04531] [SWS_Rte_04532] [SWS_Rte_07639]
[SRS_Rte_00005]	The RTE generator shall support "trace" builds	[SWS_Rte_01320] [SWS_Rte_01322] [SWS_Rte_01323] [SWS_Rte_01327] [SWS_Rte_01328] [SWS_Rte_03607] [SWS_Rte_05091] [SWS_Rte_05092] [SWS_Rte_05093] [SWS_Rte_05106] [SWS_Rte_06031] [SWS_Rte_08000]

[SRS_Rte_00008]	VFB tracing configuration	[SWS_Rte_01236] [SWS_Rte_01320] [SWS_Rte_01321] [SWS_Rte_01322] [SWS_Rte_01323] [SWS_Rte_01324] [SWS_Rte_01325] [SWS_Rte_03607] [SWS_Rte_05091] [SWS_Rte_05092] [SWS_Rte_05093] [SWS_Rte_08000]
[SRS_Rte_00011]	Support for multiple Application Software Component instances.	[SWS_Rte_01012] [SWS_Rte_01013] [SWS_Rte_01016] [SWS_Rte_01126] [SWS_Rte_01148] [SWS_Rte_01349] [SWS_Rte_02001] [SWS_Rte_02002] [SWS_Rte_02008] [SWS_Rte_02009] [SWS_Rte_02015] [SWS_Rte_02310] [SWS_Rte_02311] [SWS_Rte_03015] [SWS_Rte_03711] [SWS_Rte_03716] [SWS_Rte_03717] [SWS_Rte_03718] [SWS_Rte_03719] [SWS_Rte_03720] [SWS_Rte_03721] [SWS_Rte_03722] [SWS_Rte_03793] [SWS_Rte_03806] [SWS_Rte_06031] [SWS_Rte_07194] [SWS_Rte_07225] [SWS_Rte_07837] [SWS_Rte_07838] [SWS_Rte_07839] [SWS_Rte_08091]
[SRS_Rte_00012]	Multiple instantiated AUTOSAR software components delivered as binary code shall share code	[SWS_Rte_01007] [SWS_Rte_02015] [SWS_Rte_03015]
[SRS_Rte_00013]	Per-instance memory	[SWS_Rte_02301] [SWS_Rte_02302] [SWS_Rte_02303] [SWS_Rte_02304] [SWS_Rte_02305] [SWS_Rte_03782] [SWS_Rte_05062] [SWS_Rte_07045] [SWS_Rte_07133] [SWS_Rte_07134] [SWS_Rte_07135] [SWS_Rte_07161] [SWS_Rte_07182] [SWS_Rte_07183] [SWS_Rte_07184] [SWS_Rte_08303] [SWS_Rte_08304]
[SRS_Rte_00017]	Rejection of inconsistent component implementations	[SWS_Rte_01004] [SWS_Rte_02751] [SWS_Rte_07123] [SWS_Rte_07510]
[SRS_Rte_00018]	Rejection of invalid configurations	[SWS_Rte_01287] [SWS_Rte_01313] [SWS_Rte_01358] [SWS_Rte_01373] [SWS_Rte_02009] [SWS_Rte_02051] [SWS_Rte_02204] [SWS_Rte_02254] [SWS_Rte_02500] [SWS_Rte_02526] [SWS_Rte_02529] [SWS_Rte_02662] [SWS_Rte_02663] [SWS_Rte_02664] [SWS_Rte_02670] [SWS_Rte_02706] [SWS_Rte_02723] [SWS_Rte_02730] [SWS_Rte_02733] [SWS_Rte_02738] [SWS_Rte_02750] [SWS_Rte_03010] [SWS_Rte_03014] [SWS_Rte_03018]

		[SWS_Rte_03019] [SWS_Rte_03526] [SWS_Rte_03527] [SWS_Rte_03594] [SWS_Rte_03605] [SWS_Rte_03755] [SWS_Rte_03764] [SWS_Rte_03813] [SWS_Rte_03817] [SWS_Rte_03820] [SWS_Rte_03823] [SWS_Rte_03826] [SWS_Rte_03831] [SWS_Rte_03851] [SWS_Rte_03862] [SWS_Rte_03866] [SWS_Rte_03869] [SWS_Rte_03950] [SWS_Rte_03951] [SWS_Rte_03970] [SWS_Rte_03986] [SWS_Rte_03987] [SWS_Rte_03988] [SWS_Rte_03989] [SWS_Rte_05149] [SWS_Rte_06502] [SWS_Rte_06503] [SWS_Rte_06504] [SWS_Rte_06505] [SWS_Rte_06508] [SWS_Rte_06509] [SWS_Rte_06511] [SWS_Rte_06547] [SWS_Rte_06548] [SWS_Rte_06610] [SWS_Rte_06613] [SWS_Rte_06719] [SWS_Rte_06724] [SWS_Rte_06732] [SWS_Rte_06768] [SWS_Rte_06769] [SWS_Rte_06770] [SWS_Rte_06801] [SWS_Rte_06802] [SWS_Rte_06803] [SWS_Rte_06814] [SWS_Rte_06839] [SWS_Rte_07005] [SWS_Rte_07006] [SWS_Rte_07007] [SWS_Rte_07026] [SWS_Rte_07028] [SWS_Rte_07039] [SWS_Rte_07044] [SWS_Rte_07057] [SWS_Rte_07075] [SWS_Rte_07101] [SWS_Rte_07135] [SWS_Rte_07157] [SWS_Rte_07170] [SWS_Rte_07175] [SWS_Rte_07181] [SWS_Rte_07190] [SWS_Rte_07191] [SWS_Rte_07192] [SWS_Rte_07343] [SWS_Rte_07347] [SWS_Rte_07353] [SWS_Rte_07356] [SWS_Rte_07402] [SWS_Rte_07403] [SWS_Rte_07516] [SWS_Rte_07524] [SWS_Rte_07545] [SWS_Rte_07548] [SWS_Rte_07549] [SWS_Rte_07564] [SWS_Rte_07588] [SWS_Rte_07610] [SWS_Rte_07621] [SWS_Rte_07638] [SWS_Rte_07640] [SWS_Rte_07642] [SWS_Rte_07654] [SWS_Rte_07662] [SWS_Rte_07667] [SWS_Rte_07670] [SWS_Rte_07681] [SWS_Rte_07686] [SWS_Rte_07803] [SWS_Rte_07808] [SWS_Rte_07809] [SWS_Rte_07810] [SWS_Rte_07811] [SWS_Rte_07812] [SWS_Rte_07842]

		[SWS_Rte_07845] [SWS_Rte_07927] [SWS_Rte_08072] [SWS_Rte_08076] [SWS_Rte_08311] [SWS_Rte_08417] [SWS_Rte_08423] [SWS_Rte_08603] [SWS_Rte_08604] [SWS_Rte_08605] [SWS_Rte_08700] [SWS_Rte_08767] [SWS_Rte_08768] [SWS_Rte_08788] [SWS_Rte_08800]
[SRS_Rte_00019]	RTE is the communication infrastructure	[SWS_Rte_01264] [SWS_Rte_02527] [SWS_Rte_02528] [SWS_Rte_02610] [SWS_Rte_02611] [SWS_Rte_02612] [SWS_Rte_03000] [SWS_Rte_03001] [SWS_Rte_03002] [SWS_Rte_03004] [SWS_Rte_03005] [SWS_Rte_03007] [SWS_Rte_03008] [SWS_Rte_03760] [SWS_Rte_03761] [SWS_Rte_03762] [SWS_Rte_03769] [SWS_Rte_03775] [SWS_Rte_03776] [SWS_Rte_03795] [SWS_Rte_03796] [SWS_Rte_04515] [SWS_Rte_04516] [SWS_Rte_04520] [SWS_Rte_04522] [SWS_Rte_04526] [SWS_Rte_04527] [SWS_Rte_05065] [SWS_Rte_05084] [SWS_Rte_05085] [SWS_Rte_05500] [SWS_Rte_06000] [SWS_Rte_06011] [SWS_Rte_06023] [SWS_Rte_06024] [SWS_Rte_07662] [SWS_Rte_08001] [SWS_Rte_08002] [SWS_Rte_08586] [SWS_Rte_08587] [SWS_Rte_CONSTR_03873] [SWS_Rte_CONSTR_03874]
[SRS_Rte_00020]	Access to OS	[SWS_Rte_02250]
[SRS_Rte_00021]	Per-ECU RTE customization	[SWS_Rte_01316] [SWS_Rte_05000]
[SRS_Rte_00022]	Interaction with call-backs	[SWS_Rte_01165]
[SRS_Rte_00023]	RTE Overheads	[SWS_Rte_05053]
[SRS_Rte_00024]	Source-code AUTOSAR software components	[SWS_Rte_01000] [SWS_Rte_01195] [SWS_Rte_01315] [SWS_Rte_07120]
[SRS_Rte_00025]	Static communication	[SWS_Rte_06026]
[SRS_Rte_00027]	VFB to RTE mapping shall be semantic preserving	[SWS_Rte_01274] [SWS_Rte_02200] [SWS_Rte_02201] [SWS_Rte_02649] [SWS_Rte_02651] [SWS_Rte_02653] [SWS_Rte_02654] [SWS_Rte_02657] [SWS_Rte_04544] [SWS_Rte_07346] [SWS_Rte_08700] [SWS_Rte_08703] [SWS_Rte_08705] [SWS_Rte_08707] [SWS_Rte_08709]

[SRS_Rte_00028]	"1:n" Sender-receiver communication	[SWS_Rte_01071] [SWS_Rte_01072] [SWS_Rte_01082] [SWS_Rte_01091] [SWS_Rte_01092] [SWS_Rte_01135] [SWS_Rte_02631] [SWS_Rte_02633] [SWS_Rte_02635] [SWS_Rte_04526] [SWS_Rte_06023] [SWS_Rte_06024] [SWS_Rte_07394] [SWS_Rte_07824] [SWS_Rte_07825] [SWS_Rte_07826] [SWS_Rte_07827] [SWS_Rte_08413] [SWS_Rte_08414] [SWS_Rte_08415] [SWS_Rte_08586] [SWS_Rte_08587] [SWS_Rte_08592] [SWS_Rte_08593] [SWS_Rte_08594] [SWS_Rte_08595]
[SRS_Rte_00029]	"n:1" Client-server communication	[SWS_Rte_01102] [SWS_Rte_01109] [SWS_Rte_01133] [SWS_Rte_01166] [SWS_Rte_01359] [SWS_Rte_03763] [SWS_Rte_03767] [SWS_Rte_03768] [SWS_Rte_03769] [SWS_Rte_03770] [SWS_Rte_04517] [SWS_Rte_04519] [SWS_Rte_06019] [SWS_Rte_07023] [SWS_Rte_07024] [SWS_Rte_07026] [SWS_Rte_07027] [SWS_Rte_07845] [SWS_Rte_08310]
[SRS_Rte_00031]	Multiple Runnable Entities	[SWS_Rte_01016] [SWS_Rte_01126] [SWS_Rte_01130] [SWS_Rte_01132] [SWS_Rte_02202] [SWS_Rte_06713]
[SRS_Rte_00032]	Data consistency mechanisms	[SWS_Rte_01122] [SWS_Rte_02740] [SWS_Rte_02741] [SWS_Rte_02743] [SWS_Rte_02744] [SWS_Rte_02745] [SWS_Rte_02746] [SWS_Rte_03500] [SWS_Rte_03504] [SWS_Rte_03514] [SWS_Rte_03516] [SWS_Rte_03517] [SWS_Rte_03519] [SWS_Rte_03595] [SWS_Rte_03739] [SWS_Rte_03740] [SWS_Rte_03812] [SWS_Rte_03999] [SWS_Rte_04545] [SWS_Rte_05164] [SWS_Rte_07005] [SWS_Rte_08318] [SWS_Rte_08319] [SWS_Rte_08320] [SWS_Rte_08321] [SWS_Rte_08322] [SWS_Rte_08419]
[SRS_Rte_00033]	Serialized execution of Server Runnable Entities	[SWS_Rte_02527] [SWS_Rte_02528] [SWS_Rte_02529] [SWS_Rte_02530] [SWS_Rte_04515] [SWS_Rte_04518] [SWS_Rte_04522] [SWS_Rte_07008] [SWS_Rte_08001] [SWS_Rte_08002] [SWS_Rte_CONSTR_03873] [SWS_Rte_CONSTR_03874]
[SRS_Rte_00036]	Assignment to OS Applications	[SWS_Rte_07347]

[SRS_Rte_00045]	Standardized VFB tracing interface	[SWS_Rte_01238] [SWS_Rte_01239] [SWS_Rte_01240] [SWS_Rte_01241] [SWS_Rte_01242] [SWS_Rte_01243] [SWS_Rte_01244] [SWS_Rte_01245] [SWS_Rte_01246] [SWS_Rte_01247] [SWS_Rte_01248] [SWS_Rte_01249] [SWS_Rte_01250] [SWS_Rte_01251] [SWS_Rte_01319] [SWS_Rte_01321] [SWS_Rte_01326] [SWS_Rte_03814] [SWS_Rte_04531] [SWS_Rte_04532] [SWS_Rte_04533] [SWS_Rte_04534] [SWS_Rte_06032] [SWS_Rte_06113] [SWS_Rte_06114] [SWS_Rte_07639]
[SRS_Rte_00046]	Support for "Executable Entity runs inside" Exclusive Areas	[SWS_Rte_01120] [SWS_Rte_01122] [SWS_Rte_01123] [SWS_Rte_02740] [SWS_Rte_02741] [SWS_Rte_02743] [SWS_Rte_02744] [SWS_Rte_02745] [SWS_Rte_02746] [SWS_Rte_03500] [SWS_Rte_03515] [SWS_Rte_07250] [SWS_Rte_07251] [SWS_Rte_07252] [SWS_Rte_07253] [SWS_Rte_07254] [SWS_Rte_07522] [SWS_Rte_07523] [SWS_Rte_07524] [SWS_Rte_07578] [SWS_Rte_07579] [SWS_Rte_08318] [SWS_Rte_08319] [SWS_Rte_08320] [SWS_Rte_08321] [SWS_Rte_08322]
[SRS_Rte_00048]	RTE Generator input	[SWS_Rte_08769] [SWS_Rte_08770] [SWS_Rte_08771] [SWS_Rte_08772] [SWS_Rte_08773] [SWS_Rte_08774] [SWS_Rte_08775] [SWS_Rte_08776]
[SRS_Rte_00049]	Construction of task bodies	[SWS_Rte_02204] [SWS_Rte_02254] [SWS_Rte_04557] [SWS_Rte_04558] [SWS_Rte_04559] [SWS_Rte_06200] [SWS_Rte_06201] [SWS_Rte_07516] [SWS_Rte_08417] [SWS_Rte_CONSTR_04558] [SWS_Rte_CONSTR_04559]
[SRS_Rte_00051]	RTE API mapping	[SWS_Rte_01053] [SWS_Rte_01055] [SWS_Rte_01119] [SWS_Rte_01123] [SWS_Rte_01132] [SWS_Rte_01146] [SWS_Rte_01148] [SWS_Rte_01153] [SWS_Rte_01156] [SWS_Rte_01159] [SWS_Rte_01197] [SWS_Rte_01266] [SWS_Rte_01268] [SWS_Rte_01269] [SWS_Rte_01274] [SWS_Rte_01280] [SWS_Rte_01281] [SWS_Rte_01282] [SWS_Rte_01283] [SWS_Rte_01284] [SWS_Rte_01285] [SWS_Rte_01286] [SWS_Rte_01287] [SWS_Rte_01288]

		[SWS_Rte_01289] [SWS_Rte_01290] [SWS_Rte_01293] [SWS_Rte_01294] [SWS_Rte_01296] [SWS_Rte_01297] [SWS_Rte_01298] [SWS_Rte_01299] [SWS_Rte_01300] [SWS_Rte_01301] [SWS_Rte_01302] [SWS_Rte_01303] [SWS_Rte_01304] [SWS_Rte_01305] [SWS_Rte_01306] [SWS_Rte_01307] [SWS_Rte_01308] [SWS_Rte_01309] [SWS_Rte_01310] [SWS_Rte_01312] [SWS_Rte_01313] [SWS_Rte_01342] [SWS_Rte_01343] [SWS_Rte_01349] [SWS_Rte_01354] [SWS_Rte_01355] [SWS_Rte_01363] [SWS_Rte_01364] [SWS_Rte_01365] [SWS_Rte_01366] [SWS_Rte_02301] [SWS_Rte_02302] [SWS_Rte_02588] [SWS_Rte_02589] [SWS_Rte_02607] [SWS_Rte_02608] [SWS_Rte_02613] [SWS_Rte_02614] [SWS_Rte_02615] [SWS_Rte_02616] [SWS_Rte_02617] [SWS_Rte_02618] [SWS_Rte_02619] [SWS_Rte_02620] [SWS_Rte_02621] [SWS_Rte_02623] [SWS_Rte_02632] [SWS_Rte_02666] [SWS_Rte_02676] [SWS_Rte_02677] [SWS_Rte_02678] [SWS_Rte_02679] [SWS_Rte_02730] [SWS_Rte_03014] [SWS_Rte_03562] [SWS_Rte_03567] [SWS_Rte_03602] [SWS_Rte_03603] [SWS_Rte_03605] [SWS_Rte_03706] [SWS_Rte_03707] [SWS_Rte_03716] [SWS_Rte_03717] [SWS_Rte_03718] [SWS_Rte_03719] [SWS_Rte_03720] [SWS_Rte_03721] [SWS_Rte_03723] [SWS_Rte_03725] [SWS_Rte_03726] [SWS_Rte_03730] [SWS_Rte_03731] [SWS_Rte_03733] [SWS_Rte_03734] [SWS_Rte_03739] [SWS_Rte_03740] [SWS_Rte_03746] [SWS_Rte_03752] [SWS_Rte_03791] [SWS_Rte_03799] [SWS_Rte_03801] [SWS_Rte_03812] [SWS_Rte_03835] [SWS_Rte_03837] [SWS_Rte_03872] [SWS_Rte_03927] [SWS_Rte_03930] [SWS_Rte_03949] [SWS_Rte_03952] [SWS_Rte_04545] [SWS_Rte_05510] [SWS_Rte_05511] [SWS_Rte_06205] [SWS_Rte_06208] [SWS_Rte_06209] [SWS_Rte_06639]

		[SWS_Rte_06713] [SWS_Rte_06817] [SWS_Rte_06818] [SWS_Rte_06819] [SWS_Rte_06820] [SWS_Rte_06821] [SWS_Rte_06823] [SWS_Rte_06827] [SWS_Rte_06831] [SWS_Rte_07137] [SWS_Rte_07138] [SWS_Rte_07170] [SWS_Rte_07225] [SWS_Rte_07226] [SWS_Rte_07227] [SWS_Rte_07228] [SWS_Rte_07291] [SWS_Rte_07395] [SWS_Rte_07396] [SWS_Rte_07416] [SWS_Rte_07677] [SWS_Rte_07837] [SWS_Rte_07838] [SWS_Rte_07839] [SWS_Rte_07850] [SWS_Rte_07851] [SWS_Rte_08073] [SWS_Rte_08091] [SWS_Rte_08092] [SWS_Rte_08093] [SWS_Rte_08094] [SWS_Rte_08309] [SWS_Rte_08312] [SWS_Rte_08777] [SWS_Rte_08778] [SWS_Rte_08779] [SWS_Rte_08780] [SWS_Rte_08782] [SWS_Rte_08783] [SWS_Rte_08784] [SWS_Rte_08785] [SWS_Rte_08786]
[SRS_Rte_00052]	Initialization and finalization of components	[SWS_Rte_02503] [SWS_Rte_02562] [SWS_Rte_02564] [SWS_Rte_02707] [SWS_Rte_03852] [SWS_Rte_07046]
[SRS_Rte_00055]	RTE use of global namespace	[SWS_Rte_01171] [SWS_Rte_03609] [SWS_Rte_03610] [SWS_Rte_06706] [SWS_Rte_06707] [SWS_Rte_06708] [SWS_Rte_06812] [SWS_Rte_06813] [SWS_Rte_07036] [SWS_Rte_07037] [SWS_Rte_07104] [SWS_Rte_07109] [SWS_Rte_07110] [SWS_Rte_07111] [SWS_Rte_07114] [SWS_Rte_07115] [SWS_Rte_07116] [SWS_Rte_07117] [SWS_Rte_07118] [SWS_Rte_07119] [SWS_Rte_07144] [SWS_Rte_07145] [SWS_Rte_07146] [SWS_Rte_07148] [SWS_Rte_07149] [SWS_Rte_07162] [SWS_Rte_07163] [SWS_Rte_07166] [SWS_Rte_07284]
[SRS_Rte_00059]	RTE API shall pass "in" primitive data types by value	[SWS_Rte_01017] [SWS_Rte_01020] [SWS_Rte_06805] [SWS_Rte_06807] [SWS_Rte_07069] [SWS_Rte_07070] [SWS_Rte_07071] [SWS_Rte_07072] [SWS_Rte_07073] [SWS_Rte_07074] [SWS_Rte_07076] [SWS_Rte_07077] [SWS_Rte_07078] [SWS_Rte_07079] [SWS_Rte_07080] [SWS_Rte_07081] [SWS_Rte_07083] [SWS_Rte_07084] [SWS_Rte_07661] [SWS_Rte_08300]
[SRS_Rte_00060]	RTE API shall pass "in" composite data types by reference	[SWS_Rte_01018] [SWS_Rte_05107] [SWS_Rte_05108] [SWS_Rte_06804] [SWS_Rte_06807] [SWS_Rte_07082] [SWS_Rte_07084] [SWS_Rte_07086]

[SRS_Rte_00061]	"in/out" and "out" parameters	[SWS_Rte_01017] [SWS_Rte_01018] [SWS_Rte_01019] [SWS_Rte_01020] [SWS_Rte_05107] [SWS_Rte_05108] [SWS_Rte_05109] [SWS_Rte_06806] [SWS_Rte_07082] [SWS_Rte_07083] [SWS_Rte_07084] [SWS_Rte_07661]
[SRS_Rte_00062]	Local access to basic software components	[SWS_Rte_02051]
[SRS_Rte_00065]	Deterministic generation	[SWS_Rte_02514] [SWS_Rte_05150]
[SRS_Rte_00068]	Signal initial values	[SWS_Rte_02517] [SWS_Rte_03852] [SWS_Rte_05078] [SWS_Rte_07046] [SWS_Rte_07642] [SWS_Rte_07668] [SWS_Rte_08311]
[SRS_Rte_00069]	Communication timeouts	[SWS_Rte_01064] [SWS_Rte_01095] [SWS_Rte_01107] [SWS_Rte_01114] [SWS_Rte_03754] [SWS_Rte_03758] [SWS_Rte_03759] [SWS_Rte_03763] [SWS_Rte_03767] [SWS_Rte_03768] [SWS_Rte_03770] [SWS_Rte_03771] [SWS_Rte_03772] [SWS_Rte_06002] [SWS_Rte_06013] [SWS_Rte_07056] [SWS_Rte_07059] [SWS_Rte_07060] [SWS_Rte_08310]
[SRS_Rte_00070]	Invocation order of Runnable Entities	[SWS_Rte_02207]
[SRS_Rte_00072]	Activation of Runnable Entities	[SWS_Rte_01131] [SWS_Rte_01133] [SWS_Rte_01135] [SWS_Rte_01137] [SWS_Rte_01166] [SWS_Rte_01292] [SWS_Rte_01359] [SWS_Rte_02203] [SWS_Rte_02512] [SWS_Rte_02697] [SWS_Rte_02758] [SWS_Rte_03520] [SWS_Rte_03523] [SWS_Rte_03524] [SWS_Rte_03526] [SWS_Rte_03527] [SWS_Rte_03530] [SWS_Rte_03531] [SWS_Rte_03532] [SWS_Rte_06748] [SWS_Rte_06759] [SWS_Rte_06760] [SWS_Rte_06771] [SWS_Rte_07023] [SWS_Rte_07024] [SWS_Rte_07026] [SWS_Rte_07027] [SWS_Rte_07061] [SWS_Rte_07177] [SWS_Rte_07178] [SWS_Rte_07207] [SWS_Rte_07208] [SWS_Rte_07379] [SWS_Rte_07403] [SWS_Rte_07515] [SWS_Rte_07575] [SWS_Rte_08791]
[SRS_Rte_00073]	Atomic transport of Data Elements	[SWS_Rte_04527]
[SRS_Rte_00075]	API for accessing per-instance memory	[SWS_Rte_01118] [SWS_Rte_01119] [SWS_Rte_06203] [SWS_Rte_06204] [SWS_Rte_06205]

[SRS_Rte_00077]	Instantiation of per-instance memory	[SWS_Rte_02303] [SWS_Rte_02304] [SWS_Rte_02305] [SWS_Rte_03782] [SWS_Rte_05062] [SWS_Rte_07045] [SWS_Rte_07133] [SWS_Rte_07161] [SWS_Rte_07182] [SWS_Rte_07183] [SWS_Rte_07184] [SWS_Rte_08303] [SWS_Rte_08304]
[SRS_Rte_00078]	Support for Data Element Invalidation	[SWS_Rte_01206] [SWS_Rte_01282] [SWS_Rte_02309] [SWS_Rte_02589] [SWS_Rte_02590] [SWS_Rte_02594] [SWS_Rte_02599] [SWS_Rte_02600] [SWS_Rte_02603] [SWS_Rte_02607] [SWS_Rte_02609] [SWS_Rte_02626] [SWS_Rte_02629] [SWS_Rte_02666] [SWS_Rte_02702] [SWS_Rte_03778] [SWS_Rte_03800] [SWS_Rte_03801] [SWS_Rte_03802] [SWS_Rte_05024] [SWS_Rte_05025] [SWS_Rte_05026] [SWS_Rte_05030] [SWS_Rte_05032] [SWS_Rte_05048] [SWS_Rte_05049] [SWS_Rte_05064] [SWS_Rte_06727] [SWS_Rte_06820] [SWS_Rte_06821] [SWS_Rte_06822] [SWS_Rte_06823] [SWS_Rte_06824] [SWS_Rte_06825] [SWS_Rte_06829] [SWS_Rte_07031] [SWS_Rte_07032] [SWS_Rte_08004] [SWS_Rte_08005] [SWS_Rte_08007] [SWS_Rte_08008] [SWS_Rte_08009] [SWS_Rte_08046] [SWS_Rte_08047] [SWS_Rte_08048] [SWS_Rte_08049] [SWS_Rte_08050] [SWS_Rte_08096] [SWS_Rte_08097] [SWS_Rte_08098] [SWS_Rte_08099] [SWS_Rte_08100] [SWS_Rte_08101] [SWS_Rte_08102] [SWS_Rte_08405] [SWS_Rte_08406] [SWS_Rte_08407] [SWS_Rte_08501]
[SRS_Rte_00079]	Single asynchronous client-server interaction	[SWS_Rte_01105] [SWS_Rte_01109] [SWS_Rte_01133] [SWS_Rte_01166] [SWS_Rte_01359] [SWS_Rte_02658] [SWS_Rte_03765] [SWS_Rte_03766] [SWS_Rte_03771] [SWS_Rte_03772] [SWS_Rte_07023] [SWS_Rte_07024] [SWS_Rte_07026] [SWS_Rte_07027] [SWS_Rte_08800]
[SRS_Rte_00080]	Multiple requests of servers	[SWS_Rte_03769] [SWS_Rte_04516] [SWS_Rte_04520]
[SRS_Rte_00082]	Standardized communication protocol	[SWS_Rte_02649] [SWS_Rte_02651] [SWS_Rte_02653] [SWS_Rte_02654] [SWS_Rte_02655] [SWS_Rte_02656] [SWS_Rte_02657] [SWS_Rte_04544] [SWS_Rte_07346] [SWS_Rte_07413] [SWS_Rte_08700] [SWS_Rte_08703] [SWS_Rte_08705] [SWS_Rte_08707] [SWS_Rte_08709] [SWS_Rte_08711] [SWS_Rte_08712]

[SRS_Rte_00083]	Optimization for source-code components	[SWS_Rte_01152] [SWS_Rte_01274]
[SRS_Rte_00084]	Support infrastructural errors	[SWS_Rte_01318] [SWS_Rte_02593]
[SRS_Rte_00087]	Software Module Header File generation	[SWS_Rte_01000] [SWS_Rte_01004] [SWS_Rte_01006] [SWS_Rte_01132] [SWS_Rte_01274] [SWS_Rte_03786] [SWS_Rte_05078] [SWS_Rte_06703] [SWS_Rte_06704] [SWS_Rte_06705] [SWS_Rte_06713] [SWS_Rte_07127] [SWS_Rte_07131] [SWS_Rte_07924]
[SRS_Rte_00089]	Independent access to interface elements	[SWS_Rte_06008]
[SRS_Rte_00091]	Inter-ECU Marshalling	[SWS_Rte_02557] [SWS_Rte_03863] [SWS_Rte_03864] [SWS_Rte_03865] [SWS_Rte_04504] [SWS_Rte_04505] [SWS_Rte_04508] [SWS_Rte_04527] [SWS_Rte_05081] [SWS_Rte_05173] [SWS_Rte_07413] [SWS_Rte_08546] [SWS_Rte_08547] [SWS_Rte_08548] [SWS_Rte_08549] [SWS_Rte_08551] [SWS_Rte_08552] [SWS_Rte_08553] [SWS_Rte_08554] [SWS_Rte_08555] [SWS_Rte_08556] [SWS_Rte_08557] [SWS_Rte_08572] [SWS_Rte_08573] [SWS_Rte_08576] [SWS_Rte_08577] [SWS_Rte_08578] [SWS_Rte_08579] [SWS_Rte_08580] [SWS_Rte_08581] [SWS_Rte_08591] [SWS_Rte_08700] [SWS_Rte_08703] [SWS_Rte_08705] [SWS_Rte_08707] [SWS_Rte_08709] [SWS_Rte_08711] [SWS_Rte_08712] [SWS_Rte_08725] [SWS_Rte_08726] [SWS_Rte_08727] [SWS_Rte_08728] [SWS_Rte_08729] [SWS_Rte_08731] [SWS_Rte_08793] [SWS_Rte_70054] [SWS_Rte_70055] [SWS_Rte_70060] [SWS_Rte_70061] [SWS_Rte_70066] [SWS_Rte_70067] [SWS_Rte_70068] [SWS_Rte_70069] [SWS_Rte_70073] [SWS_Rte_70074] [SWS_Rte_70075] [SWS_Rte_70076]
[SRS_Rte_00092]	Implementation of VFB model "waitpoints"	[SWS_Rte_01358] [SWS_Rte_02740] [SWS_Rte_02741] [SWS_Rte_02743] [SWS_Rte_02744] [SWS_Rte_02745] [SWS_Rte_02746] [SWS_Rte_03010] [SWS_Rte_03018] [SWS_Rte_07402] [SWS_Rte_07846] [SWS_Rte_07847] [SWS_Rte_08318] [SWS_Rte_08319] [SWS_Rte_08320] [SWS_Rte_08321] [SWS_Rte_08322]

[SRS_Rte_00094]	Communication and Resource Errors	[SWS_Rte_01034] [SWS_Rte_01084] [SWS_Rte_01086] [SWS_Rte_01093] [SWS_Rte_01094] [SWS_Rte_01095] [SWS_Rte_01103] [SWS_Rte_01104] [SWS_Rte_01105] [SWS_Rte_01106] [SWS_Rte_01107] [SWS_Rte_01112] [SWS_Rte_01113] [SWS_Rte_01114] [SWS_Rte_01207] [SWS_Rte_01259] [SWS_Rte_01260] [SWS_Rte_01261] [SWS_Rte_01262] [SWS_Rte_01318] [SWS_Rte_01330] [SWS_Rte_01331] [SWS_Rte_01333] [SWS_Rte_01334] [SWS_Rte_01339] [SWS_Rte_01344] [SWS_Rte_02312] [SWS_Rte_02313] [SWS_Rte_02524] [SWS_Rte_02525] [SWS_Rte_02571] [SWS_Rte_02572] [SWS_Rte_02578] [SWS_Rte_02598] [SWS_Rte_02602] [SWS_Rte_02674] [SWS_Rte_02721] [SWS_Rte_02727] [SWS_Rte_02728] [SWS_Rte_02729] [SWS_Rte_03606] [SWS_Rte_03774] [SWS_Rte_03785] [SWS_Rte_03853] [SWS_Rte_04530] [SWS_Rte_06210] [SWS_Rte_06828] [SWS_Rte_06830] [SWS_Rte_07258] [SWS_Rte_07374] [SWS_Rte_07375] [SWS_Rte_07376] [SWS_Rte_07392] [SWS_Rte_07393] [SWS_Rte_07636] [SWS_Rte_07637] [SWS_Rte_07650] [SWS_Rte_07651] [SWS_Rte_07652] [SWS_Rte_07659] [SWS_Rte_07660] [SWS_Rte_07673] [SWS_Rte_07820] [SWS_Rte_07821] [SWS_Rte_07822] [SWS_Rte_07823] [SWS_Rte_07848] [SWS_Rte_07849] [SWS_Rte_08301] [SWS_Rte_08302] [SWS_Rte_08546] [SWS_Rte_08547] [SWS_Rte_08548] [SWS_Rte_08549] [SWS_Rte_08552] [SWS_Rte_08553] [SWS_Rte_08554] [SWS_Rte_08555] [SWS_Rte_08556] [SWS_Rte_08557] [SWS_Rte_08572] [SWS_Rte_08573] [SWS_Rte_08576] [SWS_Rte_08577] [SWS_Rte_08578] [SWS_Rte_08579] [SWS_Rte_08580] [SWS_Rte_08581] [SWS_Rte_08591] [SWS_Rte_08727] [SWS_Rte_08728] [SWS_Rte_08729] [SWS_Rte_70053] [SWS_Rte_70054] [SWS_Rte_70055] [SWS_Rte_70059] [SWS_Rte_70060] [SWS_Rte_70061] [SWS_Rte_70065] [SWS_Rte_70066] [SWS_Rte_70067] [SWS_Rte_70068] [SWS_Rte_70069] [SWS_Rte_70072] [SWS_Rte_70073] [SWS_Rte_70074] [SWS_Rte_70075] [SWS_Rte_70076] [SWS_Rte_70100] [SWS_Rte_70101]

[SRS_Rte_00098]	Explicit Sending	[SWS_Rte_01071] [SWS_Rte_06011] [SWS_Rte_06016]
[SRS_Rte_00099]	Decoupling of interrupts	[SWS_Rte_03530] [SWS_Rte_03531] [SWS_Rte_03532] [SWS_Rte_03594] [SWS_Rte_03600]
[SRS_Rte_00100]	Compiler independent API	[SWS_Rte_01314]
[SRS_Rte_00107]	Support for INFORMATION_TYPE attribute	[SWS_Rte_01135] [SWS_Rte_01137] [SWS_Rte_01331] [SWS_Rte_02312] [SWS_Rte_02313] [SWS_Rte_02516] [SWS_Rte_02518] [SWS_Rte_02520] [SWS_Rte_02521] [SWS_Rte_02522] [SWS_Rte_02523] [SWS_Rte_02524] [SWS_Rte_02525] [SWS_Rte_02571] [SWS_Rte_02572] [SWS_Rte_02718] [SWS_Rte_02719] [SWS_Rte_02720] [SWS_Rte_02721] [SWS_Rte_02758] [SWS_Rte_04500] [SWS_Rte_06010] [SWS_Rte_06771] [SWS_Rte_70101]
[SRS_Rte_00108]	Support for INIT_VALUE attribute	[SWS_Rte_01268] [SWS_Rte_02517] [SWS_Rte_04501] [SWS_Rte_04502] [SWS_Rte_05078] [SWS_Rte_06009] [SWS_Rte_07642] [SWS_Rte_07668] [SWS_Rte_07680] [SWS_Rte_07681] [SWS_Rte_08311]
[SRS_Rte_00109]	Support for RECEIVE_MODE attribute	[SWS_Rte_02519] [SWS_Rte_03018] [SWS_Rte_06002] [SWS_Rte_06012]
[SRS_Rte_00110]	Support for BUFFERING attribute	[SWS_Rte_01331] [SWS_Rte_02312] [SWS_Rte_02313] [SWS_Rte_02515] [SWS_Rte_02522] [SWS_Rte_02523] [SWS_Rte_02524] [SWS_Rte_02525] [SWS_Rte_02526] [SWS_Rte_02527] [SWS_Rte_02529] [SWS_Rte_02530] [SWS_Rte_02571] [SWS_Rte_02572] [SWS_Rte_02719] [SWS_Rte_02720] [SWS_Rte_02721] [SWS_Rte_02723] [SWS_Rte_07008] [SWS_Rte_70101]
[SRS_Rte_00111]	Support for CLIENT_MODE attribute	[SWS_Rte_01293] [SWS_Rte_01294] [SWS_Rte_06639]
[SRS_Rte_00115]	API for data consistency mechanism	[SWS_Rte_01120] [SWS_Rte_01122] [SWS_Rte_01307] [SWS_Rte_01308]
[SRS_Rte_00116]	RTE Initialization and finalization	[SWS_Rte_02535] [SWS_Rte_02536] [SWS_Rte_02538] [SWS_Rte_02544] [SWS_Rte_02569] [SWS_Rte_02570] [SWS_Rte_02584] [SWS_Rte_02585] [SWS_Rte_03852] [SWS_Rte_04552] [SWS_Rte_06766] [SWS_Rte_06767] [SWS_Rte_07046] [SWS_Rte_07270] [SWS_Rte_07586]
[SRS_Rte_00121]	Support for FILTER attribute	[SWS_Rte_05500] [SWS_Rte_05501] [SWS_Rte_05503] [SWS_Rte_08077] [SWS_Rte_08078] [SWS_Rte_08079]

[SRS_Rte_00122]	Support for Transmission Acknowledgement	[SWS_Rte_01080] [SWS_Rte_01083] [SWS_Rte_01084] [SWS_Rte_01086] [SWS_Rte_01137] [SWS_Rte_01283] [SWS_Rte_01284] [SWS_Rte_01285] [SWS_Rte_01286] [SWS_Rte_01287] [SWS_Rte_01344] [SWS_Rte_02612] [SWS_Rte_02676] [SWS_Rte_02677] [SWS_Rte_02678] [SWS_Rte_02725] [SWS_Rte_02727] [SWS_Rte_02729] [SWS_Rte_02758] [SWS_Rte_03002] [SWS_Rte_03005] [SWS_Rte_03604] [SWS_Rte_03754] [SWS_Rte_03756] [SWS_Rte_03757] [SWS_Rte_03758] [SWS_Rte_03774] [SWS_Rte_03775] [SWS_Rte_03776] [SWS_Rte_05065] [SWS_Rte_05084] [SWS_Rte_05085] [SWS_Rte_05504] [SWS_Rte_06771] [SWS_Rte_07055] [SWS_Rte_07286] [SWS_Rte_07367] [SWS_Rte_07374] [SWS_Rte_07375] [SWS_Rte_07376] [SWS_Rte_07379] [SWS_Rte_07557] [SWS_Rte_07558] [SWS_Rte_07560] [SWS_Rte_07561] [SWS_Rte_07634] [SWS_Rte_07635] [SWS_Rte_07636] [SWS_Rte_07637] [SWS_Rte_07646] [SWS_Rte_07647] [SWS_Rte_07648] [SWS_Rte_07650] [SWS_Rte_07651] [SWS_Rte_07652] [SWS_Rte_07659] [SWS_Rte_07660] [SWS_Rte_07846] [SWS_Rte_07847] [SWS_Rte_07848] [SWS_Rte_07849] [SWS_Rte_07850] [SWS_Rte_07851] [SWS_Rte_07927] [SWS_Rte_08017] [SWS_Rte_08018] [SWS_Rte_08020] [SWS_Rte_08021] [SWS_Rte_08022] [SWS_Rte_08023] [SWS_Rte_08043] [SWS_Rte_08044] [SWS_Rte_08045] [SWS_Rte_08074] [SWS_Rte_08075] [SWS_Rte_08076] [SWS_Rte_08583]
[SRS_Rte_00123]	The RTE shall forward application level errors from server to client	[SWS_Rte_01103] [SWS_Rte_02576] [SWS_Rte_02577] [SWS_Rte_02578] [SWS_Rte_02593] [SWS_Rte_07925] [SWS_Rte_07926] [SWS_Rte_08705] [SWS_Rte_08709]
[SRS_Rte_00124]	API for application level errors during Client Server communication	[SWS_Rte_01103] [SWS_Rte_01130] [SWS_Rte_02573] [SWS_Rte_02575]

[SRS_Rte_00126]	C language support	[SWS_Rte_01005] [SWS_Rte_01162] [SWS_Rte_01167] [SWS_Rte_01169] [SWS_Rte_03709] [SWS_Rte_03710] [SWS_Rte_03724] [SWS_Rte_07124] [SWS_Rte_07125] [SWS_Rte_07126] [SWS_Rte_07297] [SWS_Rte_07298] [SWS_Rte_07299] [SWS_Rte_07507] [SWS_Rte_07508] [SWS_Rte_07509] [SWS_Rte_07678] [SWS_Rte_07923]
[SRS_Rte_00128]	Implicit Reception	[SWS_Rte_01268] [SWS_Rte_03598] [SWS_Rte_03599] [SWS_Rte_03741] [SWS_Rte_03954] [SWS_Rte_03955] [SWS_Rte_03956] [SWS_Rte_06000] [SWS_Rte_06001] [SWS_Rte_06004] [SWS_Rte_06011] [SWS_Rte_07007] [SWS_Rte_07020] [SWS_Rte_07062] [SWS_Rte_07063] [SWS_Rte_07064] [SWS_Rte_07652] [SWS_Rte_08408]
[SRS_Rte_00129]	Implicit Sending	[SWS_Rte_03570] [SWS_Rte_03571] [SWS_Rte_03572] [SWS_Rte_03573] [SWS_Rte_03574] [SWS_Rte_03598] [SWS_Rte_03744] [SWS_Rte_03746] [SWS_Rte_03953] [SWS_Rte_03954] [SWS_Rte_03955] [SWS_Rte_03957] [SWS_Rte_05509] [SWS_Rte_06011] [SWS_Rte_07007] [SWS_Rte_07021] [SWS_Rte_07041] [SWS_Rte_07062] [SWS_Rte_07065] [SWS_Rte_07066] [SWS_Rte_07067] [SWS_Rte_07068] [SWS_Rte_07367] [SWS_Rte_07374] [SWS_Rte_07375] [SWS_Rte_07376] [SWS_Rte_07646] [SWS_Rte_07647] [SWS_Rte_07648] [SWS_Rte_07650] [SWS_Rte_07651] [SWS_Rte_07660] [SWS_Rte_08408] [SWS_Rte_08418]
[SRS_Rte_00131]	"n:1" Sender-receiver communication	[SWS_Rte_01071] [SWS_Rte_01072] [SWS_Rte_01091] [SWS_Rte_01092] [SWS_Rte_01135] [SWS_Rte_02631] [SWS_Rte_02633] [SWS_Rte_02635] [SWS_Rte_02670] [SWS_Rte_03760] [SWS_Rte_03761] [SWS_Rte_03762] [SWS_Rte_07394] [SWS_Rte_07824] [SWS_Rte_07825] [SWS_Rte_07826] [SWS_Rte_07827] [SWS_Rte_08788]
[SRS_Rte_00133]	Concurrent invocation of Runnable Entities	[SWS_Rte_02697] [SWS_Rte_03523] [SWS_Rte_07007]
[SRS_Rte_00134]	Runnable Entity categories supported by the RTE	[SWS_Rte_03574] [SWS_Rte_03954] [SWS_Rte_06003] [SWS_Rte_06007] [SWS_Rte_07062]
[SRS_Rte_00137]	API for mismatched ports	[SWS_Rte_01368] [SWS_Rte_01369] [SWS_Rte_01370]

[SRS_Rte_00138]	C++ language support	[SWS_Rte_01005] [SWS_Rte_01011] [SWS_Rte_03709] [SWS_Rte_03710] [SWS_Rte_07124] [SWS_Rte_07125] [SWS_Rte_07126] [SWS_Rte_07297] [SWS_Rte_07298] [SWS_Rte_07299] [SWS_Rte_07507] [SWS_Rte_07508] [SWS_Rte_07509]
[SRS_Rte_00139]	Support for unconnected ports	[SWS_Rte_01329] [SWS_Rte_01330] [SWS_Rte_01331] [SWS_Rte_01332] [SWS_Rte_01333] [SWS_Rte_01334] [SWS_Rte_01344] [SWS_Rte_01346] [SWS_Rte_01347] [SWS_Rte_01375] [SWS_Rte_02638] [SWS_Rte_02639] [SWS_Rte_02640] [SWS_Rte_02641] [SWS_Rte_02642] [SWS_Rte_02749] [SWS_Rte_02750] [SWS_Rte_03019] [SWS_Rte_03783] [SWS_Rte_03784] [SWS_Rte_03785] [SWS_Rte_03978] [SWS_Rte_03980] [SWS_Rte_04530] [SWS_Rte_05099] [SWS_Rte_05101] [SWS_Rte_05102] [SWS_Rte_05170] [SWS_Rte_06030] [SWS_Rte_06210] [SWS_Rte_07378] [SWS_Rte_07655] [SWS_Rte_07659] [SWS_Rte_07660] [SWS_Rte_07663] [SWS_Rte_07667] [SWS_Rte_07668] [SWS_Rte_07669] [SWS_Rte_07847]
[SRS_Rte_00140]	Binary-code AUTOSAR software components	[SWS_Rte_01000] [SWS_Rte_01195] [SWS_Rte_01315] [SWS_Rte_07120]
[SRS_Rte_00141]	Explicit Reception	[SWS_Rte_01072] [SWS_Rte_01091] [SWS_Rte_01092] [SWS_Rte_06011] [SWS_Rte_07394] [SWS_Rte_07673]
[SRS_Rte_00142]	Support for InterRunnable Variables	[SWS_Rte_01303] [SWS_Rte_01304] [SWS_Rte_01305] [SWS_Rte_01306] [SWS_Rte_01350] [SWS_Rte_01351] [SWS_Rte_02636] [SWS_Rte_03516] [SWS_Rte_03517] [SWS_Rte_03519] [SWS_Rte_03550] [SWS_Rte_03553] [SWS_Rte_03560] [SWS_Rte_03562] [SWS_Rte_03565] [SWS_Rte_03567] [SWS_Rte_03580] [SWS_Rte_03582] [SWS_Rte_03583] [SWS_Rte_03584] [SWS_Rte_03589] [SWS_Rte_06207] [SWS_Rte_06208] [SWS_Rte_07007] [SWS_Rte_07022] [SWS_Rte_07187]

[SRS_Rte_00143]	Mode Switches	[SWS_Rte_02500] [SWS_Rte_02503] [SWS_Rte_02504] [SWS_Rte_02512] [SWS_Rte_02544] [SWS_Rte_02546] [SWS_Rte_02562] [SWS_Rte_02563] [SWS_Rte_02564] [SWS_Rte_02587] [SWS_Rte_02630] [SWS_Rte_02631] [SWS_Rte_02634] [SWS_Rte_02661] [SWS_Rte_02662] [SWS_Rte_02663] [SWS_Rte_02664] [SWS_Rte_02665] [SWS_Rte_02667] [SWS_Rte_02668] [SWS_Rte_02669] [SWS_Rte_02675] [SWS_Rte_02679] [SWS_Rte_02706] [SWS_Rte_02707] [SWS_Rte_02708] [SWS_Rte_02730] [SWS_Rte_03869] [SWS_Rte_06766] [SWS_Rte_06767] [SWS_Rte_06768] [SWS_Rte_06769] [SWS_Rte_06770] [SWS_Rte_06772] [SWS_Rte_06773] [SWS_Rte_06774] [SWS_Rte_06775] [SWS_Rte_06776] [SWS_Rte_06777] [SWS_Rte_06778] [SWS_Rte_06779] [SWS_Rte_06780] [SWS_Rte_06785] [SWS_Rte_06786] [SWS_Rte_06787] [SWS_Rte_06788] [SWS_Rte_06789] [SWS_Rte_06790] [SWS_Rte_06791] [SWS_Rte_06792] [SWS_Rte_06793] [SWS_Rte_06794] [SWS_Rte_06795] [SWS_Rte_06796] [SWS_Rte_06797] [SWS_Rte_06832] [SWS_Rte_06833] [SWS_Rte_06834] [SWS_Rte_06835] [SWS_Rte_06836] [SWS_Rte_06837] [SWS_Rte_06838] [SWS_Rte_06839] [SWS_Rte_06840] [SWS_Rte_07056] [SWS_Rte_07057] [SWS_Rte_07058] [SWS_Rte_07059] [SWS_Rte_07060] [SWS_Rte_07150] [SWS_Rte_07151] [SWS_Rte_07152] [SWS_Rte_07153] [SWS_Rte_07154] [SWS_Rte_07155] [SWS_Rte_07157] [SWS_Rte_07173] [SWS_Rte_07259] [SWS_Rte_07533] [SWS_Rte_07535] [SWS_Rte_07559] [SWS_Rte_07564] [SWS_Rte_70102]
[SRS_Rte_00144]	RTE shall support the notification of mode switches via AUTOSAR interfaces	[SWS_Rte_02508] [SWS_Rte_02544] [SWS_Rte_02546] [SWS_Rte_02549] [SWS_Rte_02566] [SWS_Rte_02567] [SWS_Rte_02568] [SWS_Rte_02624] [SWS_Rte_02628] [SWS_Rte_02659] [SWS_Rte_02660] [SWS_Rte_02732] [SWS_Rte_02738] [SWS_Rte_03858] [SWS_Rte_03859] [SWS_Rte_06742] [SWS_Rte_06743] [SWS_Rte_06744] [SWS_Rte_06745] [SWS_Rte_06746] [SWS_Rte_06747] [SWS_Rte_06766] [SWS_Rte_06767] [SWS_Rte_06772]

		[SWS_Rte_06773] [SWS_Rte_06774] [SWS_Rte_06775] [SWS_Rte_06776] [SWS_Rte_06777] [SWS_Rte_06778] [SWS_Rte_06779] [SWS_Rte_06780] [SWS_Rte_06781] [SWS_Rte_06782] [SWS_Rte_06783] [SWS_Rte_06784] [SWS_Rte_06785] [SWS_Rte_06786] [SWS_Rte_06787] [SWS_Rte_06788] [SWS_Rte_06789] [SWS_Rte_06790] [SWS_Rte_06791] [SWS_Rte_06792] [SWS_Rte_06793] [SWS_Rte_06794] [SWS_Rte_06795] [SWS_Rte_06796] [SWS_Rte_06797] [SWS_Rte_07155] [SWS_Rte_07262] [SWS_Rte_07540] [SWS_Rte_07640] [SWS_Rte_07666] [SWS_Rte_08500] [SWS_Rte_08504] [SWS_Rte_08505] [SWS_Rte_08506] [SWS_Rte_08509] [SWS_Rte_08510]
[SRS_Rte_00145]	Compatibility mode	[SWS_Rte_01151] [SWS_Rte_01216] [SWS_Rte_01234] [SWS_Rte_01257] [SWS_Rte_01277] [SWS_Rte_01279] [SWS_Rte_01326] [SWS_Rte_03794] [SWS_Rte_03871]
[SRS_Rte_00146]	Vendor mode	[SWS_Rte_01234]
[SRS_Rte_00147]	Support for communication infrastructure time-out notification	[SWS_Rte_02589] [SWS_Rte_02590] [SWS_Rte_02599] [SWS_Rte_02600] [SWS_Rte_02604] [SWS_Rte_02607] [SWS_Rte_02609] [SWS_Rte_02610] [SWS_Rte_02611] [SWS_Rte_02629] [SWS_Rte_02666] [SWS_Rte_02703] [SWS_Rte_02710] [SWS_Rte_03759] [SWS_Rte_05021] [SWS_Rte_06820] [SWS_Rte_06821] [SWS_Rte_06822] [SWS_Rte_06823] [SWS_Rte_06824] [SWS_Rte_06825] [SWS_Rte_06829] [SWS_Rte_08004] [SWS_Rte_08061] [SWS_Rte_08062] [SWS_Rte_08103] [SWS_Rte_08104] [SWS_Rte_08501]
[SRS_Rte_00148]	Support "Specification of Memory Mapping"	[SWS_Rte_03788] [SWS_Rte_03868] [SWS_Rte_05088] [SWS_Rte_05089] [SWS_Rte_06741] [SWS_Rte_07047] [SWS_Rte_07048] [SWS_Rte_07049] [SWS_Rte_07050] [SWS_Rte_07051] [SWS_Rte_07052] [SWS_Rte_07053] [SWS_Rte_07194] [SWS_Rte_07195] [SWS_Rte_07421] [SWS_Rte_07422] [SWS_Rte_07423] [SWS_Rte_07424] [SWS_Rte_07425] [SWS_Rte_07426] [SWS_Rte_07427] [SWS_Rte_07589] [SWS_Rte_07590] [SWS_Rte_07591] [SWS_Rte_07592] [SWS_Rte_07593] [SWS_Rte_07594] [SWS_Rte_07595] [SWS_Rte_07596] [SWS_Rte_07830] [SWS_Rte_07831] [SWS_Rte_07832] [SWS_Rte_08787]

[SRS_Rte_00149]	Support "Specification of Compiler Abstraction"	[SWS_Rte_01164] [SWS_Rte_03787] [SWS_Rte_07194] [SWS_Rte_07195] [SWS_Rte_07593] [SWS_Rte_07594] [SWS_Rte_07595] [SWS_Rte_07596] [SWS_Rte_07641]
[SRS_Rte_00150]	Support "Specification of Platform Types"	[SWS_Rte_01164] [SWS_Rte_07641]
[SRS_Rte_00152]	Support for port-defined argument values	[SWS_Rte_01166] [SWS_Rte_01360]
[SRS_Rte_00153]	Support for Measurement	[SWS_Rte_03900] [SWS_Rte_03901] [SWS_Rte_03902] [SWS_Rte_03903] [SWS_Rte_03904] [SWS_Rte_03950] [SWS_Rte_03951] [SWS_Rte_03972] [SWS_Rte_03973] [SWS_Rte_03974] [SWS_Rte_03975] [SWS_Rte_03976] [SWS_Rte_03977] [SWS_Rte_03978] [SWS_Rte_03979] [SWS_Rte_03980] [SWS_Rte_03981] [SWS_Rte_03982] [SWS_Rte_05087] [SWS_Rte_05101] [SWS_Rte_05102] [SWS_Rte_05120] [SWS_Rte_05121] [SWS_Rte_05122] [SWS_Rte_05123] [SWS_Rte_05124] [SWS_Rte_05125] [SWS_Rte_05136] [SWS_Rte_05168] [SWS_Rte_05169] [SWS_Rte_05170] [SWS_Rte_05172] [SWS_Rte_05174] [SWS_Rte_05175] [SWS_Rte_05176] [SWS_Rte_06206] [SWS_Rte_06700] [SWS_Rte_06701] [SWS_Rte_06702] [SWS_Rte_06726] [SWS_Rte_07160] [SWS_Rte_07174] [SWS_Rte_07197] [SWS_Rte_07198] [SWS_Rte_07344] [SWS_Rte_07349] [SWS_Rte_70086] [SWS_Rte_80073]
[SRS_Rte_00154]	Support for Calibration	[SWS_Rte_03835] [SWS_Rte_03905] [SWS_Rte_03906] [SWS_Rte_03907] [SWS_Rte_03908] [SWS_Rte_03909] [SWS_Rte_03910] [SWS_Rte_03911] [SWS_Rte_03912] [SWS_Rte_03913] [SWS_Rte_03914] [SWS_Rte_03915] [SWS_Rte_03916] [SWS_Rte_03922] [SWS_Rte_03932] [SWS_Rte_03933] [SWS_Rte_03934] [SWS_Rte_03935] [SWS_Rte_03936] [SWS_Rte_03942] [SWS_Rte_03943] [SWS_Rte_03947] [SWS_Rte_03948] [SWS_Rte_03949]

		[SWS_Rte_03958] [SWS_Rte_03959] [SWS_Rte_03960] [SWS_Rte_03961] [SWS_Rte_03962] [SWS_Rte_03963] [SWS_Rte_03964] [SWS_Rte_03965] [SWS_Rte_03968] [SWS_Rte_03970] [SWS_Rte_03971] [SWS_Rte_05112] [SWS_Rte_05145] [SWS_Rte_05194] [SWS_Rte_06815] [SWS_Rte_06816] [SWS_Rte_07029] [SWS_Rte_07030] [SWS_Rte_07033] [SWS_Rte_07034] [SWS_Rte_07035] [SWS_Rte_07096] [SWS_Rte_07185] [SWS_Rte_07186] [SWS_Rte_07693]
[SRS_Rte_00155]	API to access calibration parameters	[SWS_Rte_01252] [SWS_Rte_01300] [SWS_Rte_03835] [SWS_Rte_03927] [SWS_Rte_03928] [SWS_Rte_03929] [SWS_Rte_03930] [SWS_Rte_03949] [SWS_Rte_03952] [SWS_Rte_07093] [SWS_Rte_07094] [SWS_Rte_07095]
[SRS_Rte_00156]	Support for different calibration data emulation methods	[SWS_Rte_03905] [SWS_Rte_03906] [SWS_Rte_03908] [SWS_Rte_03909] [SWS_Rte_03910] [SWS_Rte_03911] [SWS_Rte_03913] [SWS_Rte_03914] [SWS_Rte_03915] [SWS_Rte_03916] [SWS_Rte_03922] [SWS_Rte_03932] [SWS_Rte_03933] [SWS_Rte_03934] [SWS_Rte_03935] [SWS_Rte_03936] [SWS_Rte_03942] [SWS_Rte_03943] [SWS_Rte_03947] [SWS_Rte_03948] [SWS_Rte_03960] [SWS_Rte_03961] [SWS_Rte_03962] [SWS_Rte_03963] [SWS_Rte_03964] [SWS_Rte_03965] [SWS_Rte_03968] [SWS_Rte_03970] [SWS_Rte_03971] [SWS_Rte_05145] [SWS_Rte_06816]
[SRS_Rte_00157]	Support for calibration parameters in NVRAM	[SWS_Rte_03936]
[SRS_Rte_00158]	Support separation of calibration parameters	[SWS_Rte_03907] [SWS_Rte_03908] [SWS_Rte_03911] [SWS_Rte_03912] [SWS_Rte_03959] [SWS_Rte_05145] [SWS_Rte_05194] [SWS_Rte_07096]
[SRS_Rte_00159]	Sharing of calibration parameters	[SWS_Rte_02749] [SWS_Rte_02750] [SWS_Rte_03958] [SWS_Rte_05112] [SWS_Rte_07186]
[SRS_Rte_00160]	Debounced start of Runnable Entities	[SWS_Rte_02697]
[SRS_Rte_00161]	Activation offset of Runnable Entities	[SWS_Rte_07000]
[SRS_Rte_00162]	"1:n" External Trigger communication	[SWS_Rte_06210] [SWS_Rte_07200] [SWS_Rte_07201] [SWS_Rte_07207] [SWS_Rte_07212] [SWS_Rte_07213] [SWS_Rte_07214] [SWS_Rte_07215] [SWS_Rte_07216] [SWS_Rte_07218] [SWS_Rte_07229] [SWS_Rte_07543]

[SRS_Rte_00163]	Support for InterRunnable Triggering	[SWS_Rte_07203] [SWS_Rte_07204] [SWS_Rte_07208] [SWS_Rte_07220] [SWS_Rte_07221] [SWS_Rte_07223] [SWS_Rte_07224] [SWS_Rte_07226] [SWS_Rte_07227] [SWS_Rte_07228] [SWS_Rte_07229] [SWS_Rte_07555]
[SRS_Rte_00164]	Ensure a unique naming of generated types visible in the global namespace	[SWS_Rte_03609] [SWS_Rte_03610] [SWS_Rte_06706] [SWS_Rte_06707] [SWS_Rte_06708] [SWS_Rte_06812] [SWS_Rte_06813] [SWS_Rte_07110] [SWS_Rte_07111] [SWS_Rte_07114] [SWS_Rte_07115] [SWS_Rte_07116] [SWS_Rte_07117] [SWS_Rte_07118] [SWS_Rte_07119] [SWS_Rte_07144] [SWS_Rte_07145] [SWS_Rte_07146]
[SRS_Rte_00165]	Suppress identical "C" type re-definitions	[SWS_Rte_07105] [SWS_Rte_07107] [SWS_Rte_07112] [SWS_Rte_07113] [SWS_Rte_07134] [SWS_Rte_07143] [SWS_Rte_07167] [SWS_Rte_07169]
[SRS_Rte_00166]	Use the AUTOSAR Standard Types in the global namespace if the AUTOSAR data type is mapped to an AUTOSAR Standard Type	[SWS_Rte_07036] [SWS_Rte_07037] [SWS_Rte_07104] [SWS_Rte_07109] [SWS_Rte_07148] [SWS_Rte_07149] [SWS_Rte_07162] [SWS_Rte_07163] [SWS_Rte_07166]
[SRS_Rte_00167]	Encapsulate a Software Component local name space	[SWS_Rte_01004] [SWS_Rte_02310] [SWS_Rte_02311] [SWS_Rte_02575] [SWS_Rte_03809] [SWS_Rte_03810] [SWS_Rte_03854] [SWS_Rte_05051] [SWS_Rte_05052] [SWS_Rte_06513] [SWS_Rte_06515] [SWS_Rte_06518] [SWS_Rte_06519] [SWS_Rte_06520] [SWS_Rte_06530] [SWS_Rte_06541] [SWS_Rte_06542] [SWS_Rte_06551] [SWS_Rte_06552] [SWS_Rte_06716] [SWS_Rte_06717] [SWS_Rte_06718] [SWS_Rte_07122] [SWS_Rte_07123] [SWS_Rte_07140] [SWS_Rte_07410] [SWS_Rte_07411] [SWS_Rte_07412] [SWS_Rte_07414] [SWS_Rte_08401] [SWS_Rte_08402] [SWS_Rte_08416]
[SRS_Rte_00168]	Typing of RTE API.	[SWS_Rte_07104]
[SRS_Rte_00169]	Map code and memory allocated by the RTE to memory sections	[SWS_Rte_03868] [SWS_Rte_05088] [SWS_Rte_05089] [SWS_Rte_06741] [SWS_Rte_07047] [SWS_Rte_07048] [SWS_Rte_07049] [SWS_Rte_07050] [SWS_Rte_07051] [SWS_Rte_07052] [SWS_Rte_07053] [SWS_Rte_07421] [SWS_Rte_07422] [SWS_Rte_07423] [SWS_Rte_07424] [SWS_Rte_07425] [SWS_Rte_07426] [SWS_Rte_07427] [SWS_Rte_07589] [SWS_Rte_07590] [SWS_Rte_07591] [SWS_Rte_07592] [SWS_Rte_08787]

[SRS_Rte_00170]	Provide used memory sections description	[SWS_Rte_05086] [SWS_Rte_05089] [SWS_Rte_06725]
[SRS_Rte_00171]	Support for fixed and constant data	[SWS_Rte_03930]
[SRS_Rte_00176]	Sharing of NVRAM data	[SWS_Rte_07301]
[SRS_Rte_00177]	Support of NvBlockComponent Type	[SWS_Rte_04535] [SWS_Rte_06211] [SWS_Rte_06212] [SWS_Rte_07303] [SWS_Rte_07312] [SWS_Rte_07317] [SWS_Rte_07343] [SWS_Rte_07353] [SWS_Rte_07355] [SWS_Rte_07398] [SWS_Rte_07399] [SWS_Rte_07632] [SWS_Rte_07633] [SWS_Rte_08063] [SWS_Rte_08064] [SWS_Rte_08080] [SWS_Rte_08081] [SWS_Rte_08082] [SWS_Rte_08083] [SWS_Rte_08084] [SWS_Rte_08085] [SWS_Rte_08086] [SWS_Rte_08087] [SWS_Rte_08088] [SWS_Rte_08089] [SWS_Rte_08090] [SWS_Rte_08111]
[SRS_Rte_00178]	Data consistency of NvBlock ComponentType	[SWS_Rte_07310] [SWS_Rte_07311] [SWS_Rte_07315] [SWS_Rte_07316] [SWS_Rte_07319] [SWS_Rte_07350] [SWS_Rte_07601] [SWS_Rte_07602] [SWS_Rte_07613] [SWS_Rte_07614]
[SRS_Rte_00179]	Support of Update Flag for Data Reception	[SWS_Rte_01413] [SWS_Rte_04528] [SWS_Rte_07385] [SWS_Rte_07386] [SWS_Rte_07387] [SWS_Rte_07390] [SWS_Rte_07391] [SWS_Rte_07392] [SWS_Rte_07393] [SWS_Rte_07654] [SWS_Rte_07689]
[SRS_Rte_00180]	DataSemantics range check during runtime	[SWS_Rte_01371] [SWS_Rte_01372] [SWS_Rte_01374] [SWS_Rte_03839] [SWS_Rte_03840] [SWS_Rte_03841] [SWS_Rte_03842] [SWS_Rte_03843] [SWS_Rte_03845] [SWS_Rte_03846] [SWS_Rte_03847] [SWS_Rte_03848] [SWS_Rte_03849] [SWS_Rte_03861] [SWS_Rte_06829] [SWS_Rte_07038] [SWS_Rte_08016] [SWS_Rte_08024] [SWS_Rte_08025] [SWS_Rte_08026] [SWS_Rte_08027] [SWS_Rte_08028] [SWS_Rte_08029] [SWS_Rte_08030] [SWS_Rte_08031] [SWS_Rte_08032] [SWS_Rte_08033] [SWS_Rte_08034] [SWS_Rte_08035] [SWS_Rte_08036] [SWS_Rte_08037] [SWS_Rte_08038] [SWS_Rte_08039] [SWS_Rte_08040] [SWS_Rte_08041] [SWS_Rte_08042] [SWS_Rte_08065]

[SRS_Rte_00181]	Conversion between internal and network data types	[SWS_Rte_03827] [SWS_Rte_03828] [SWS_Rte_04536] [SWS_Rte_04537] [SWS_Rte_04538] [SWS_Rte_04539] [SWS_Rte_06737] [SWS_Rte_06738] [SWS_Rte_07828] [SWS_Rte_07829] [SWS_Rte_07844]
[SRS_Rte_00182]	Self Scaling Signals at Port Interfaces	[SWS_Rte_01374] [SWS_Rte_03815] [SWS_Rte_03816] [SWS_Rte_03817] [SWS_Rte_03818] [SWS_Rte_03819] [SWS_Rte_03820] [SWS_Rte_03821] [SWS_Rte_03822] [SWS_Rte_03823] [SWS_Rte_03829] [SWS_Rte_03830] [SWS_Rte_03831] [SWS_Rte_03832] [SWS_Rte_03833] [SWS_Rte_03855] [SWS_Rte_03856] [SWS_Rte_03857] [SWS_Rte_03860] [SWS_Rte_07038] [SWS_Rte_07091] [SWS_Rte_07092] [SWS_Rte_07099] [SWS_Rte_07925] [SWS_Rte_07926] [SWS_Rte_07928] [SWS_Rte_08801]
[SRS_Rte_00183]	RTE Read API returning the dataElement value	[SWS_Rte_07394] [SWS_Rte_07395] [SWS_Rte_07396]
[SRS_Rte_00184]	RTE Status "Never Received"	[SWS_Rte_04529] [SWS_Rte_06829] [SWS_Rte_07381] [SWS_Rte_07382] [SWS_Rte_07383] [SWS_Rte_07384] [SWS_Rte_07643] [SWS_Rte_07644] [SWS_Rte_07645] [SWS_Rte_08005] [SWS_Rte_08008] [SWS_Rte_08009] [SWS_Rte_08046] [SWS_Rte_08047] [SWS_Rte_08048] [SWS_Rte_08096] [SWS_Rte_08097] [SWS_Rte_08098]
[SRS_Rte_00185]	RTE API with Rte_IFeedback	[SWS_Rte_02589] [SWS_Rte_02590] [SWS_Rte_02608] [SWS_Rte_02666] [SWS_Rte_03836] [SWS_Rte_06820] [SWS_Rte_06821] [SWS_Rte_06822] [SWS_Rte_06823] [SWS_Rte_06824] [SWS_Rte_06826] [SWS_Rte_06827] [SWS_Rte_07367] [SWS_Rte_07374] [SWS_Rte_07375] [SWS_Rte_07376] [SWS_Rte_07378] [SWS_Rte_07379] [SWS_Rte_07646] [SWS_Rte_07647] [SWS_Rte_07648] [SWS_Rte_07650] [SWS_Rte_07651] [SWS_Rte_07652] [SWS_Rte_07660]

[SRS_Rte_00189]	A2L Generation Support	[SWS_Rte_03998] [SWS_Rte_05087] [SWS_Rte_05118] [SWS_Rte_05119] [SWS_Rte_05120] [SWS_Rte_05121] [SWS_Rte_05122] [SWS_Rte_05123] [SWS_Rte_05124] [SWS_Rte_05125] [SWS_Rte_05126] [SWS_Rte_05127] [SWS_Rte_05128] [SWS_Rte_05129] [SWS_Rte_05130] [SWS_Rte_05131] [SWS_Rte_05132] [SWS_Rte_05133] [SWS_Rte_05135] [SWS_Rte_05136] [SWS_Rte_05137] [SWS_Rte_05138] [SWS_Rte_05139] [SWS_Rte_05140] [SWS_Rte_05141] [SWS_Rte_05142] [SWS_Rte_05143] [SWS_Rte_05144] [SWS_Rte_05152] [SWS_Rte_05153] [SWS_Rte_05154] [SWS_Rte_05155] [SWS_Rte_05156] [SWS_Rte_05157] [SWS_Rte_05158] [SWS_Rte_05159] [SWS_Rte_05160] [SWS_Rte_05161] [SWS_Rte_05162] [SWS_Rte_06702] [SWS_Rte_06726] [SWS_Rte_07097] [SWS_Rte_08313] [SWS_Rte_08314] [SWS_Rte_08315] [SWS_Rte_08316] [SWS_Rte_08317]
[SRS_Rte_00191]	Support for Variant Handling	[SWS_Rte_05168] [SWS_Rte_05169] [SWS_Rte_05174] [SWS_Rte_05175] [SWS_Rte_05176] [SWS_Rte_06500] [SWS_Rte_06501] [SWS_Rte_06507] [SWS_Rte_06509] [SWS_Rte_06510] [SWS_Rte_06512] [SWS_Rte_06543] [SWS_Rte_06546] [SWS_Rte_06547] [SWS_Rte_06549] [SWS_Rte_06550] [SWS_Rte_06553] [SWS_Rte_06611] [SWS_Rte_06612] [SWS_Rte_06613] [SWS_Rte_06814] [SWS_Rte_06815] [SWS_Rte_06816] [SWS_Rte_08066] [SWS_Rte_08067] [SWS_Rte_08068] [SWS_Rte_08069] [SWS_Rte_08070]
[SRS_Rte_00192]	Support multiple trace clients	[SWS_Rte_05086] [SWS_Rte_05091] [SWS_Rte_05092] [SWS_Rte_05093] [SWS_Rte_05106] [SWS_Rte_06725]
[SRS_Rte_00193]	Support for Runnable Entity execution chaining	[SWS_Rte_07800] [SWS_Rte_07802]
[SRS_Rte_00195]	No activation of Runnable Entities in terminated or restarting partitions	[SWS_Rte_07604] [SWS_Rte_07606]
[SRS_Rte_00196]	Inter-partition communication consistency	[SWS_Rte_02761] [SWS_Rte_05147] [SWS_Rte_07610]
[SRS_Rte_00200]	Support of unconnected R-Ports	[SWS_Rte_01330] [SWS_Rte_01331] [SWS_Rte_01333] [SWS_Rte_01334] [SWS_Rte_03785] [SWS_Rte_04530] [SWS_Rte_06210] [SWS_Rte_07655] [SWS_Rte_07663]

[SRS_Rte_00201]	Contract Phase with Variant Handling support	[SWS_Rte_06500] [SWS_Rte_06502] [SWS_Rte_06505] [SWS_Rte_06514] [SWS_Rte_06515] [SWS_Rte_06516] [SWS_Rte_06518] [SWS_Rte_06519] [SWS_Rte_06520] [SWS_Rte_06521] [SWS_Rte_06522] [SWS_Rte_06523] [SWS_Rte_06524] [SWS_Rte_06525] [SWS_Rte_06526] [SWS_Rte_06527] [SWS_Rte_06528] [SWS_Rte_06529] [SWS_Rte_06530] [SWS_Rte_06531] [SWS_Rte_06539] [SWS_Rte_06540] [SWS_Rte_06541] [SWS_Rte_06542] [SWS_Rte_06543] [SWS_Rte_06546] [SWS_Rte_06551] [SWS_Rte_06552] [SWS_Rte_06620] [SWS_Rte_06638] [SWS_Rte_08095]
[SRS_Rte_00202]	Support for array size variants	[SWS_Rte_06500] [SWS_Rte_06505] [SWS_Rte_06543] [SWS_Rte_06546]
[SRS_Rte_00203]	API to read system constant	[SWS_Rte_03854] [SWS_Rte_06513] [SWS_Rte_06514] [SWS_Rte_06517]
[SRS_Rte_00204]	Support the selection / de-selection of SWC prototypes	[SWS_Rte_06601]
[SRS_Rte_00206]	Support the selection of a signal provider	[SWS_Rte_06601] [SWS_Rte_06602] [SWS_Rte_06603] [SWS_Rte_06604] [SWS_Rte_06605] [SWS_Rte_06606]
[SRS_Rte_00207]	Support N to M communication patterns while unresolved variations are affecting these communications	[SWS_Rte_06601] [SWS_Rte_06602] [SWS_Rte_06603] [SWS_Rte_06604] [SWS_Rte_06605] [SWS_Rte_06606]
[SRS_Rte_00210]	Support for inter OS application communication	[SWS_Rte_02728] [SWS_Rte_02732] [SWS_Rte_02752] [SWS_Rte_02753] [SWS_Rte_02754] [SWS_Rte_02755] [SWS_Rte_02756] [SWS_Rte_03853] [SWS_Rte_07606] [SWS_Rte_08400] [SWS_Rte_08504] [SWS_Rte_08506]
[SRS_Rte_00211]	Cyclic time based scheduling of BSW Schedulable Entities	[SWS_Rte_02697] [SWS_Rte_04542] [SWS_Rte_04543] [SWS_Rte_07282] [SWS_Rte_07514] [SWS_Rte_07574] [SWS_Rte_07584]
[SRS_Rte_00212]	Activation Offset of BSW Schedulable Entities	[SWS_Rte_07520]
[SRS_Rte_00213]	Mode Switches for BSW Modules	[SWS_Rte_02500] [SWS_Rte_02562] [SWS_Rte_02563] [SWS_Rte_02564] [SWS_Rte_02587] [SWS_Rte_02630] [SWS_Rte_02661] [SWS_Rte_02662] [SWS_Rte_02663] [SWS_Rte_02664] [SWS_Rte_02665] [SWS_Rte_02667] [SWS_Rte_02668] [SWS_Rte_02669] [SWS_Rte_02707] [SWS_Rte_02708] [SWS_Rte_04542] [SWS_Rte_04543] [SWS_Rte_06839] [SWS_Rte_07055] [SWS_Rte_07150] [SWS_Rte_07151] [SWS_Rte_07152] [SWS_Rte_07153]

		[SWS_Rte_07154] [SWS_Rte_07157] [SWS_Rte_07173] [SWS_Rte_07258] [SWS_Rte_07259] [SWS_Rte_07260] [SWS_Rte_07282] [SWS_Rte_07286] [SWS_Rte_07293] [SWS_Rte_07294] [SWS_Rte_07514] [SWS_Rte_07530] [SWS_Rte_07531] [SWS_Rte_07532] [SWS_Rte_07534] [SWS_Rte_07535] [SWS_Rte_07538] [SWS_Rte_07539] [SWS_Rte_07540] [SWS_Rte_07541] [SWS_Rte_07556] [SWS_Rte_07557] [SWS_Rte_07558] [SWS_Rte_07559] [SWS_Rte_07560] [SWS_Rte_07561] [SWS_Rte_07564] [SWS_Rte_07694] [SWS_Rte_08600] [SWS_Rte_08601]
[SRS_Rte_00214]	Common Mode handling for Basic SW and Application SW	[SWS_Rte_02697] [SWS_Rte_07258] [SWS_Rte_07259] [SWS_Rte_07286] [SWS_Rte_07535] [SWS_Rte_07564] [SWS_Rte_07582] [SWS_Rte_07583]
[SRS_Rte_00215]	API for Mode switch notification to the SchM	[SWS_Rte_07255] [SWS_Rte_07256] [SWS_Rte_07261] [SWS_Rte_08507]
[SRS_Rte_00216]	Triggering of BSW Schedulable Entities by occurrence of External Trigger	[SWS_Rte_04542] [SWS_Rte_04543] [SWS_Rte_07213] [SWS_Rte_07214] [SWS_Rte_07216] [SWS_Rte_07218] [SWS_Rte_07282] [SWS_Rte_07514] [SWS_Rte_07542] [SWS_Rte_07544] [SWS_Rte_07545] [SWS_Rte_07546] [SWS_Rte_07548] [SWS_Rte_07549]
[SRS_Rte_00217]	Synchronized activation of Runnable Entities and BSW Schedulable Entities	[SWS_Rte_02697] [SWS_Rte_07218] [SWS_Rte_07549]
[SRS_Rte_00218]	API for Triggering BSW modules by Triggered Events	[SWS_Rte_07263] [SWS_Rte_07264] [SWS_Rte_07266] [SWS_Rte_07267]
[SRS_Rte_00219]	Support for interlaced execution sequences of Runnable Entities and BSW Schedulable Entities	[SWS_Rte_02697] [SWS_Rte_07517] [SWS_Rte_07518]
[SRS_Rte_00220]	ECU life cycle dependent scheduling	[SWS_Rte_02538] [SWS_Rte_07580]
[SRS_Rte_00221]	Support for "BSW integration" builds	[SWS_Rte_07569] [SWS_Rte_07585]
[SRS_Rte_00222]	Support shared exclusive areas in BSW Service Modules and the corresponding Service Component	[SWS_Rte_07250] [SWS_Rte_07251] [SWS_Rte_07252] [SWS_Rte_07253] [SWS_Rte_07254] [SWS_Rte_07522] [SWS_Rte_07523] [SWS_Rte_07524] [SWS_Rte_07578] [SWS_Rte_07579]
[SRS_Rte_00223]	Callout for partition termination notification	[SWS_Rte_07330] [SWS_Rte_07331] [SWS_Rte_07334] [SWS_Rte_07335] [SWS_Rte_07617] [SWS_Rte_07619] [SWS_Rte_07620] [SWS_Rte_07622]
[SRS_Rte_00224]	Callout for partition restart request	[SWS_Rte_07188] [SWS_Rte_07336] [SWS_Rte_07338] [SWS_Rte_07339] [SWS_Rte_07340] [SWS_Rte_07341] [SWS_Rte_07342] [SWS_Rte_07643] [SWS_Rte_07644] [SWS_Rte_07645]

[SRS_Rte_00228]	Fan-out NvBlock callback function	[SWS_Rte_07623] [SWS_Rte_07624] [SWS_Rte_07625] [SWS_Rte_07626] [SWS_Rte_07627] [SWS_Rte_07628] [SWS_Rte_07629] [SWS_Rte_07630] [SWS_Rte_07631] [SWS_Rte_07671] [SWS_Rte_07672]
[SRS_Rte_00229]	Support for Variant Handling of BSW Modules	[SWS_Rte_06500] [SWS_Rte_06503] [SWS_Rte_06504] [SWS_Rte_06507] [SWS_Rte_06508] [SWS_Rte_06532] [SWS_Rte_06533] [SWS_Rte_06534] [SWS_Rte_06535] [SWS_Rte_06536] [SWS_Rte_06537] [SWS_Rte_06543] [SWS_Rte_06546] [SWS_Rte_06548] [SWS_Rte_08789] [SWS_Rte_08790]
[SRS_Rte_00230]	Triggering of BSW Schedulable Entities by occurrence of Internal Trigger	[SWS_Rte_07229] [SWS_Rte_07551] [SWS_Rte_07552] [SWS_Rte_07553] [SWS_Rte_07554]
[SRS_Rte_00231]	Support native interface between Rte and Com for Strings and uint8 arrays	[SWS_Rte_01377] [SWS_Rte_01378] [SWS_Rte_07408] [SWS_Rte_07817]
[SRS_Rte_00232]	Synchronization of runnable entities	[SWS_Rte_07804] [SWS_Rte_07805] [SWS_Rte_07806] [SWS_Rte_07807]
[SRS_Rte_00233]	Generation of the Basic Software Module Description	[SWS_Rte_05086] [SWS_Rte_05165] [SWS_Rte_05166] [SWS_Rte_05167] [SWS_Rte_05177] [SWS_Rte_05179] [SWS_Rte_05180] [SWS_Rte_05181] [SWS_Rte_05182] [SWS_Rte_05183] [SWS_Rte_05184] [SWS_Rte_05185] [SWS_Rte_05186] [SWS_Rte_05187] [SWS_Rte_05188] [SWS_Rte_05189] [SWS_Rte_05190] [SWS_Rte_05191] [SWS_Rte_05192] [SWS_Rte_06725] [SWS_Rte_07085] [SWS_Rte_08305] [SWS_Rte_08404]
[SRS_Rte_00234]	Support for Record Type sub-setting	[SWS_Rte_07091] [SWS_Rte_07092] [SWS_Rte_07099]
[SRS_Rte_00235]	Support queued triggers	[SWS_Rte_06720] [SWS_Rte_06721] [SWS_Rte_06722] [SWS_Rte_06723] [SWS_Rte_07087] [SWS_Rte_07088] [SWS_Rte_07089] [SWS_Rte_07090]
[SRS_Rte_00236]	Support for ModeInterface Mapping	[SWS_Rte_08511] [SWS_Rte_08512] [SWS_Rte_08513] [SWS_Rte_08514]
[SRS_Rte_00237]	Time recurrent activation of Runnable Entities	[SWS_Rte_06728] [SWS_Rte_06729] [SWS_Rte_06730]
[SRS_Rte_00238]	Allow enabling of RTE-Feature to get the activating Event of Executable Entity	[SWS_Rte_01126] [SWS_Rte_07194] [SWS_Rte_07195] [SWS_Rte_07282] [SWS_Rte_08051] [SWS_Rte_08052] [SWS_Rte_08053] [SWS_Rte_08054] [SWS_Rte_08055] [SWS_Rte_08056] [SWS_Rte_08057] [SWS_Rte_08058] [SWS_Rte_08059] [SWS_Rte_08060] [SWS_Rte_08071]

[SRS_Rte_00239]	Support rule-based initialization of composite DataPrototypes and compound primitive Data Prototypes	[SWS_Rte_06733] [SWS_Rte_06734] [SWS_Rte_06735] [SWS_Rte_06736] [SWS_Rte_06764] [SWS_Rte_06765] [SWS_Rte_08542] [SWS_Rte_08792]
[SRS_Rte_00240]	Support of init runnables for initialization purposes	[SWS_Rte_06748] [SWS_Rte_06749] [SWS_Rte_06750] [SWS_Rte_06751] [SWS_Rte_06752] [SWS_Rte_06753] [SWS_Rte_06754] [SWS_Rte_06755] [SWS_Rte_06756] [SWS_Rte_06757] [SWS_Rte_06758] [SWS_Rte_06759] [SWS_Rte_06760] [SWS_Rte_06761] [SWS_Rte_06762] [SWS_Rte_06767] [SWS_Rte_06768] [SWS_Rte_06769] [SWS_Rte_06770]
[SRS_Rte_00241]	Support for Local or Remote Handling of BSW Service Calls on Partitioned Systems	[SWS_Rte_08765]
[SRS_Rte_00243]	Support for inter-partition communication of BSW modules	[SWS_Rte_08420] [SWS_Rte_08421] [SWS_Rte_08422] [SWS_Rte_08733] [SWS_Rte_08734] [SWS_Rte_08735] [SWS_Rte_08736] [SWS_Rte_08737] [SWS_Rte_08738] [SWS_Rte_08739] [SWS_Rte_08743] [SWS_Rte_08744] [SWS_Rte_08747] [SWS_Rte_08748] [SWS_Rte_08751] [SWS_Rte_08752] [SWS_Rte_08753] [SWS_Rte_08754] [SWS_Rte_08755] [SWS_Rte_08756] [SWS_Rte_08763] [SWS_Rte_08764] [SWS_Rte_08765] [SWS_Rte_08766]
[SRS_Rte_00244]	Support for bypass	[SWS_Rte_06033] [SWS_Rte_06034] [SWS_Rte_06035] [SWS_Rte_06036] [SWS_Rte_06037] [SWS_Rte_06038] [SWS_Rte_06039] [SWS_Rte_06040] [SWS_Rte_06041] [SWS_Rte_06042] [SWS_Rte_06043] [SWS_Rte_06044] [SWS_Rte_06045] [SWS_Rte_06046] [SWS_Rte_06047] [SWS_Rte_06048] [SWS_Rte_06049] [SWS_Rte_06050] [SWS_Rte_06051] [SWS_Rte_06052] [SWS_Rte_06053] [SWS_Rte_06054] [SWS_Rte_06055] [SWS_Rte_06056] [SWS_Rte_06057] [SWS_Rte_06058] [SWS_Rte_06059] [SWS_Rte_06060] [SWS_Rte_06061] [SWS_Rte_06064] [SWS_Rte_06065] [SWS_Rte_06066] [SWS_Rte_06067] [SWS_Rte_06068] [SWS_Rte_06069] [SWS_Rte_06073] [SWS_Rte_06074] [SWS_Rte_06075] [SWS_Rte_06076] [SWS_Rte_06077] [SWS_Rte_06079] [SWS_Rte_06080] [SWS_Rte_06081] [SWS_Rte_06082] [SWS_Rte_06083] [SWS_Rte_06084] [SWS_Rte_06085] [SWS_Rte_06086]

		[SWS_Rte_06087] [SWS_Rte_06088] [SWS_Rte_06089] [SWS_Rte_06090] [SWS_Rte_06091] [SWS_Rte_06092] [SWS_Rte_06093] [SWS_Rte_06094] [SWS_Rte_06095] [SWS_Rte_06096] [SWS_Rte_06097] [SWS_Rte_06098] [SWS_Rte_06099] [SWS_Rte_06100] [SWS_Rte_06101] [SWS_Rte_06102] [SWS_Rte_06103] [SWS_Rte_06104] [SWS_Rte_06105] [SWS_Rte_06106] [SWS_Rte_06107] [SWS_Rte_06108] [SWS_Rte_06109] [SWS_Rte_06110] [SWS_Rte_06111] [SWS_Rte_06112] [SWS_Rte_06113] [SWS_Rte_06114] [SWS_Rte_06115] [SWS_Rte_06120] [SWS_Rte_07833] [SWS_Rte_07834] [SWS_Rte_07835] [SWS_Rte_07836] [SWS_Rte_07837] [SWS_Rte_07838] [SWS_Rte_07839] [SWS_Rte_07840] [SWS_Rte_07841] [SWS_Rte_70094] [SWS_Rte_70095] [SWS_Rte_CONSTR_80011]
[SRS_Rte_00245]	Support of Writing Strategies for NV data	[SWS_Rte_07416] [SWS_Rte_08080] [SWS_Rte_08081] [SWS_Rte_08082] [SWS_Rte_08083] [SWS_Rte_08084] [SWS_Rte_08085] [SWS_Rte_08086] [SWS_Rte_08087] [SWS_Rte_08088] [SWS_Rte_08089] [SWS_Rte_08090] [SWS_Rte_08091] [SWS_Rte_08092] [SWS_Rte_08093] [SWS_Rte_08094] [SWS_Rte_08111]
[SRS_Rte_00246]	Support of Efficient COM for large data	[SWS_Rte_01376] [SWS_Rte_01379] [SWS_Rte_01380] [SWS_Rte_01381] [SWS_Rte_01382] [SWS_Rte_01383] [SWS_Rte_01384] [SWS_Rte_01385] [SWS_Rte_01386] [SWS_Rte_01387] [SWS_Rte_01388] [SWS_Rte_01389] [SWS_Rte_01390] [SWS_Rte_01391] [SWS_Rte_01392] [SWS_Rte_01393] [SWS_Rte_01394] [SWS_Rte_01395] [SWS_Rte_01396] [SWS_Rte_01397] [SWS_Rte_01398] [SWS_Rte_01399] [SWS_Rte_01400] [SWS_Rte_01401] [SWS_Rte_01402] [SWS_Rte_01403] [SWS_Rte_01404] [SWS_Rte_01405] [SWS_Rte_01406] [SWS_Rte_01407] [SWS_Rte_01408] [SWS_Rte_01409] [SWS_Rte_01410] [SWS_Rte_01411]

[SRS_Rte_00247]	The Rte shall execute transformer chains for SWC communication	[SWS_Rte_04540] [SWS_Rte_04541] [SWS_Rte_06023] [SWS_Rte_08110] [SWS_Rte_08515] [SWS_Rte_08516] [SWS_Rte_08517] [SWS_Rte_08518] [SWS_Rte_08519] [SWS_Rte_08520] [SWS_Rte_08521] [SWS_Rte_08522] [SWS_Rte_08523] [SWS_Rte_08524] [SWS_Rte_08525] [SWS_Rte_08526] [SWS_Rte_08527] [SWS_Rte_08528] [SWS_Rte_08529] [SWS_Rte_08530] [SWS_Rte_08538] [SWS_Rte_08570] [SWS_Rte_08571] [SWS_Rte_08587] [SWS_Rte_08588] [SWS_Rte_08589] [SWS_Rte_08590] [SWS_Rte_08596] [SWS_Rte_08597] [SWS_Rte_08598] [SWS_Rte_08599] [SWS_Rte_08793] [SWS_Rte_08794] [SWS_Rte_08795] [SWS_Rte_08796] [SWS_Rte_08797] [SWS_Rte_08798] [SWS_Rte_08799]
[SRS_Rte_00248]	The Rte shall provide the buffer for the data transformation	[SWS_Rte_03867] [SWS_Rte_08531] [SWS_Rte_08532] [SWS_Rte_08534] [SWS_Rte_08535] [SWS_Rte_08536] [SWS_Rte_08537] [SWS_Rte_08550]
[SRS_Rte_00249]	The Rte shall provide transformation errors to the SWCs	[SWS_Rte_03608] [SWS_Rte_05300] [SWS_Rte_05301] [SWS_Rte_07417] [SWS_Rte_07418] [SWS_Rte_07419] [SWS_Rte_07420] [SWS_Rte_08424] [SWS_Rte_08539] [SWS_Rte_08540] [SWS_Rte_08541] [SWS_Rte_08543] [SWS_Rte_08544] [SWS_Rte_08545] [SWS_Rte_08558] [SWS_Rte_08559] [SWS_Rte_08560] [SWS_Rte_08561] [SWS_Rte_08562] [SWS_Rte_08563] [SWS_Rte_08564] [SWS_Rte_08565] [SWS_Rte_08566] [SWS_Rte_08567] [SWS_Rte_08568] [SWS_Rte_08569] [SWS_Rte_08574] [SWS_Rte_08575] [SWS_Rte_08582] [SWS_Rte_08584] [SWS_Rte_08585] [SWS_Rte_08791]
[SRS_Rte_00251]	Array based signal group handling with Com	[SWS_Rte_08586]
[SRS_Rte_00252]	Encapsulate a BSW Module local name space	[SWS_Rte_03983] [SWS_Rte_03984] [SWS_Rte_03985] [SWS_Rte_03990] [SWS_Rte_03991] [SWS_Rte_03992] [SWS_Rte_03994] [SWS_Rte_03995] [SWS_Rte_03996] [SWS_Rte_03997] [SWS_Rte_07415]
[SRS_Rte_00253]	The RTE shall execute data transformation for SWC/BSW communication within one ECU	[SWS_Rte_08105] [SWS_Rte_08107] [SWS_Rte_08108] [SWS_Rte_08109]
[SRS_Rte_00261]	The RTE shall support optional struct members.	[SWS_Rte_03611] [SWS_Rte_03612] [SWS_Rte_03613] [SWS_Rte_03614] [SWS_Rte_03615] [SWS_Rte_03616] [SWS_Rte_03617] [SWS_Rte_03618]

[SRS_Rte_00300]	RTE Implementation Plug-Ins for explicit communication	[SWS_Rte_70019] [SWS_Rte_70020] [SWS_Rte_70021] [SWS_Rte_70022] [SWS_Rte_70023] [SWS_Rte_70024] [SWS_Rte_70025] [SWS_Rte_70026] [SWS_Rte_70032] [SWS_Rte_70039] [SWS_Rte_70042] [SWS_Rte_70043] [SWS_Rte_70044] [SWS_Rte_70045] [SWS_Rte_70048] [SWS_Rte_70049] [SWS_Rte_70050] [SWS_Rte_70051] [SWS_Rte_70052] [SWS_Rte_70053] [SWS_Rte_70054] [SWS_Rte_70055] [SWS_Rte_70056] [SWS_Rte_70057] [SWS_Rte_70058] [SWS_Rte_70059] [SWS_Rte_70060] [SWS_Rte_70061] [SWS_Rte_70082] [SWS_Rte_70083] [SWS_Rte_70084] [SWS_Rte_70085] [SWS_Rte_70087] [SWS_Rte_70088] [SWS_Rte_70090] [SWS_Rte_70091] [SWS_Rte_70100] [SWS_Rte_70101] [SWS_Rte_70102] [SWS_Rte_70107] [SWS_Rte_70110] [SWS_Rte_70111] [SWS_Rte_70112] [SWS_Rte_70113] [SWS_Rte_70114] [SWS_Rte_80016] [SWS_Rte_80017] [SWS_Rte_80018] [SWS_Rte_80019] [SWS_Rte_80031] [SWS_Rte_80032] [SWS_Rte_80033] [SWS_Rte_80034] [SWS_Rte_80035] [SWS_Rte_80036] [SWS_Rte_80037] [SWS_Rte_80038] [SWS_Rte_80039] [SWS_Rte_80040] [SWS_Rte_80041] [SWS_Rte_80043] [SWS_Rte_80057] [SWS_Rte_80058] [SWS_Rte_80059] [SWS_Rte_80060] [SWS_Rte_80061] [SWS_Rte_80063] [SWS_Rte_80064] [SWS_Rte_80065] [SWS_Rte_80066] [SWS_Rte_80075] [SWS_Rte_80100] [SWS_Rte_80101] [SWS_Rte_80103] [SWS_Rte_80104] [SWS_Rte_80105] [SWS_Rte_CONSTR_80002] [SWS_Rte_CONSTR_80003]
[SRS_Rte_00301]	RTE Implementation Plug-Ins for implicit communication	[SWS_Rte_70003] [SWS_Rte_70004] [SWS_Rte_70013] [SWS_Rte_70015] [SWS_Rte_70016] [SWS_Rte_70017] [SWS_Rte_70018] [SWS_Rte_70032] [SWS_Rte_70039] [SWS_Rte_70042] [SWS_Rte_70043] [SWS_Rte_70046] [SWS_Rte_70048] [SWS_Rte_70049] [SWS_Rte_70078] [SWS_Rte_70082] [SWS_Rte_70083] [SWS_Rte_70084] [SWS_Rte_70085] [SWS_Rte_70087] [SWS_Rte_70088] [SWS_Rte_70108] [SWS_Rte_80010] [SWS_Rte_80011]

		[SWS_Rte_80012] [SWS_Rte_80013] [SWS_Rte_80014] [SWS_Rte_80015] [SWS_Rte_80031] [SWS_Rte_80032] [SWS_Rte_80033] [SWS_Rte_80034] [SWS_Rte_80035] [SWS_Rte_80036] [SWS_Rte_80037] [SWS_Rte_80038] [SWS_Rte_80039] [SWS_Rte_80040] [SWS_Rte_80041] [SWS_Rte_80044] [SWS_Rte_80046] [SWS_Rte_80047] [SWS_Rte_80048] [SWS_Rte_80049] [SWS_Rte_80050] [SWS_Rte_80056] [SWS_Rte_80057] [SWS_Rte_80058] [SWS_Rte_80059] [SWS_Rte_80060] [SWS_Rte_80061] [SWS_Rte_80063] [SWS_Rte_80064] [SWS_Rte_80076] [SWS_Rte_80079] [SWS_Rte_80084] [SWS_Rte_80103] [SWS_Rte_80104] [SWS_Rte_80105] [SWS_Rte_CONSTR_80002] [SWS_Rte_CONSTR_80003]
[SRS_Rte_00302]	RTE Implementation Plug-Ins for exclusive areas	[SWS_Rte_70007] [SWS_Rte_70027] [SWS_Rte_70028] [SWS_Rte_70032] [SWS_Rte_70039] [SWS_Rte_80020] [SWS_Rte_80021] [SWS_Rte_80022] [SWS_Rte_80023] [SWS_Rte_80024] [SWS_Rte_80079] [SWS_Rte_CONSTR_80000] [SWS_Rte_CONSTR_80001]
[SRS_Rte_00303]	RTE Implementation Plug-Ins for global copy instantiation	[SWS_Rte_70043] [SWS_Rte_70050] [SWS_Rte_70051] [SWS_Rte_70056] [SWS_Rte_70057] [SWS_Rte_70085] [SWS_Rte_70086] [SWS_Rte_80065] [SWS_Rte_80066] [SWS_Rte_80073]
[SRS_Rte_00304]	Multiple RTE Plug-Ins	[SWS_Rte_70027] [SWS_Rte_70028] [SWS_Rte_70047] [SWS_Rte_70062] [SWS_Rte_70063] [SWS_Rte_70070] [SWS_Rte_70071] [SWS_Rte_70077] [SWS_Rte_80020] [SWS_Rte_80021] [SWS_Rte_80051] [SWS_Rte_80052] [SWS_Rte_80053] [SWS_Rte_80054] [SWS_Rte_80055] [SWS_Rte_80071] [SWS_Rte_80072]
[SRS_Rte_00305]	Graduated validation strategy	[SWS_Rte_70040] [SWS_Rte_80029] [SWS_Rte_80030] [SWS_Rte_CONSTR_80013]

[SRS_Rte_00306]	Standardized interfaces for RTE Implementation Plug-Ins	[SWS_Rte_70000] [SWS_Rte_70001] [SWS_Rte_70002] [SWS_Rte_70003] [SWS_Rte_70004] [SWS_Rte_70005] [SWS_Rte_70006] [SWS_Rte_70007] [SWS_Rte_70008] [SWS_Rte_70009] [SWS_Rte_70010] [SWS_Rte_70011] [SWS_Rte_70012] [SWS_Rte_70013] [SWS_Rte_70015] [SWS_Rte_70016] [SWS_Rte_70017] [SWS_Rte_70018] [SWS_Rte_70019] [SWS_Rte_70020] [SWS_Rte_70021] [SWS_Rte_70022] [SWS_Rte_70023] [SWS_Rte_70024] [SWS_Rte_70025] [SWS_Rte_70026] [SWS_Rte_70027] [SWS_Rte_70028] [SWS_Rte_70029] [SWS_Rte_70030] [SWS_Rte_70031] [SWS_Rte_70032] [SWS_Rte_70033] [SWS_Rte_70034] [SWS_Rte_70035] [SWS_Rte_70036] [SWS_Rte_70037] [SWS_Rte_70038] [SWS_Rte_70039] [SWS_Rte_70046] [SWS_Rte_70047] [SWS_Rte_70050] [SWS_Rte_70051] [SWS_Rte_70052] [SWS_Rte_70053] [SWS_Rte_70054] [SWS_Rte_70055] [SWS_Rte_70056] [SWS_Rte_70057] [SWS_Rte_70058] [SWS_Rte_70059] [SWS_Rte_70060] [SWS_Rte_70061] [SWS_Rte_70062] [SWS_Rte_70063] [SWS_Rte_70064] [SWS_Rte_70070] [SWS_Rte_70071] [SWS_Rte_70077] [SWS_Rte_70078] [SWS_Rte_70087] [SWS_Rte_70088] [SWS_Rte_70090] [SWS_Rte_70091] [SWS_Rte_70098] [SWS_Rte_70099] [SWS_Rte_70100] [SWS_Rte_70101] [SWS_Rte_70102] [SWS_Rte_70107] [SWS_Rte_70108] [SWS_Rte_80000] [SWS_Rte_80001] [SWS_Rte_80002] [SWS_Rte_80003] [SWS_Rte_80005] [SWS_Rte_80006] [SWS_Rte_80007] [SWS_Rte_80008] [SWS_Rte_80009] [SWS_Rte_80010] [SWS_Rte_80011] [SWS_Rte_80012] [SWS_Rte_80013] [SWS_Rte_80014] [SWS_Rte_80015] [SWS_Rte_80016] [SWS_Rte_80017] [SWS_Rte_80018] [SWS_Rte_80019] [SWS_Rte_80020] [SWS_Rte_80021] [SWS_Rte_80025] [SWS_Rte_80026] [SWS_Rte_80027] [SWS_Rte_80028] [SWS_Rte_80051] [SWS_Rte_80052] [SWS_Rte_80053] [SWS_Rte_80054] [SWS_Rte_80055] [SWS_Rte_80065] [SWS_Rte_80066] [SWS_Rte_80071] [SWS_Rte_80072] [SWS_Rte_80075] [SWS_Rte_80078] [SWS_Rte_80079] [SWS_Rte_80100] [SWS_Rte_80101]

[SRS_Rte_00307]	RTE Implementation Plug-Ins for cross core communication	[SWS_Rte_70093] [SWS_Rte_80077] [SWS_Rte_CONSTR_80010]
[SRS_Rte_00309]	RTE Implementation Plug-Ins for cross safety partition communication	[SWS_Rte_70093] [SWS_Rte_80077] [SWS_Rte_CONSTR_80010]
[SRS_Rte_00310]	Shared mode queue	[SWS_Rte_06832] [SWS_Rte_06833] [SWS_Rte_06834] [SWS_Rte_06835] [SWS_Rte_06836] [SWS_Rte_06837] [SWS_Rte_06838] [SWS_Rte_06839] [SWS_Rte_06840] [SWS_Rte_70032] [SWS_Rte_70039] [SWS_Rte_70098] [SWS_Rte_80083] [SWS_Rte_CONSTR_80012]
[SRS_Rte_00311]	Core synchronous transitions for mode switches	[SWS_Rte_80111] [SWS_Rte_80112] [SWS_Rte_80113] [SWS_Rte_80114] [SWS_Rte_80115] [SWS_Rte_80116] [SWS_Rte_80117] [SWS_Rte_80118] [SWS_Rte_80119] [SWS_Rte_80120] [SWS_Rte_80121] [SWS_Rte_80122] [SWS_Rte_80123] [SWS_Rte_80124] [SWS_Rte_80125]
[SRS_Rte_00312]	RTE Implementation Plug-Ins for transformers in client server communication	[SWS_Rte_70032] [SWS_Rte_70039] [SWS_Rte_70062] [SWS_Rte_70063] [SWS_Rte_70064] [SWS_Rte_70070] [SWS_Rte_70071] [SWS_Rte_70077] [SWS_Rte_70079] [SWS_Rte_70080] [SWS_Rte_70081] [SWS_Rte_70089] [SWS_Rte_70110] [SWS_Rte_70111] [SWS_Rte_70112] [SWS_Rte_70113] [SWS_Rte_70114] [SWS_Rte_80067] [SWS_Rte_80068] [SWS_Rte_80069] [SWS_Rte_80070] [SWS_Rte_80071] [SWS_Rte_80072] [SWS_Rte_80074] [SWS_Rte_80106] [SWS_Rte_80107] [SWS_Rte_80108] [SWS_Rte_80109] [SWS_Rte_80110] [SWS_Rte_CONSTR_80004] [SWS_Rte_CONSTR_80005] [SWS_Rte_CONSTR_80006] [SWS_Rte_CONSTR_80007] [SWS_Rte_CONSTR_80009]
[SRS_Rte_00313]	Description of RTE Implementation Plug-in properties	[SWS_Rte_70092]
[SRS_Rte_00314]	Avoid nesting of critical sections	[SWS_Rte_80025]
[SRS_Rte_00315]	Protection of mode machine instance access	[SWS_Rte_70032] [SWS_Rte_70039] [SWS_Rte_70096] [SWS_Rte_70097] [SWS_Rte_70098] [SWS_Rte_70103] [SWS_Rte_70104] [SWS_Rte_70105] [SWS_Rte_70106] [SWS_Rte_70109] [SWS_Rte_70115] [SWS_Rte_80080] [SWS_Rte_80081] [SWS_Rte_80082] [SWS_Rte_80085]

[SRS_Rte_00316]	RTE Implementation Plug-Ins for compatibility mode	[SWS_Rte_80044] [SWS_Rte_80045]
[SRS_Rte_00317]	RTE Implementation Plug-Ins for transformers in trigger communication	[SWS_Rte_70079] [SWS_Rte_70080] [SWS_Rte_70081] [SWS_Rte_70110] [SWS_Rte_70111] [SWS_Rte_70112] [SWS_Rte_70113] [SWS_Rte_70114] [SWS_Rte_80068] [SWS_Rte_80069] [SWS_Rte_80070] [SWS_Rte_80102] [SWS_Rte_CONSTR_80009] [SWS_Rte_CONSTR_80014] [SWS_Rte_CONSTR_80015] [SWS_Rte_CONSTR_80016] [SWS_Rte_CONSTR_80017]

Table 1.2: Requirements tracing

2 RTE Overview

2.1 The RTE in the Context of AUTOSAR

The Run-Time Environment (RTE) is at the heart of the AUTOSAR ECU architecture. The RTE is the realization (for a particular ECU) of the interfaces of the AUTOSAR Virtual Function Bus (VFB). The RTE provides the infrastructure services that enable communication to occur between AUTOSAR software-components as well as acting as the means by which AUTOSAR software-components access basic software modules including the OS and communication service.

The RTE encompasses both the variable elements of the system infrastructure that arise from the different mappings of components to ECUs as well as standardized RTE services.

In principle the RTE can be logically divided into two sub-parts realizing:

- the communication between software components
- the scheduling of the software components

To fully describe the concept of the RTE, the Basic Software Scheduler has to be considered as well. The Basic Software Scheduler schedules the schedulable entities of the basic software modules. In some documents the schedulable entities are also called main processing functions.

Due to the situation that the same OS Task might be used for the scheduling of software components and basic software modules the scheduling part of the RTE is strongly linked with the Basic Software Scheduler and can not be clearly separated.

The RTE and the Basic Software Scheduler is generated[1] for each ECU to ensure that the RTE and Basic Software Scheduler is optimal for the ECU [SRS_Rte_00023].

2.2 AUTOSAR Concepts

This section introduces some important AUTOSAR concepts and how they are implemented within the context of the RTE.

2.2.1 AUTOSAR Software-components

In AUTOSAR, "application" software is conceptually located above the AUTOSAR RTE and consists of "AUTOSAR application software-components" that are ECU and loca-

[1] An implementation is free to *configure* rather than *generate* the RTE and Basic Software Scheduler. The remainder of this specification refers to generation for reasons of simplicity only and these references should not be interpreted as ruling out either a wholly configured, or partially generated and partially configured, RTE and Basic Software Scheduler implementation.

tion independent and "AUTOSAR sensor-actuator components" that are dependent on ECU hardware and thus not readily relocatable for reasons of performance/efficiency. This means that, subject to constraints imposed by the system designer, an AUTOSAR software-component can be deployed to any available ECU during system configuration. The RTE is then responsible for ensuring that components can communicate and that the system continues to function as expected wherever the components are deployed. Considering sensor/actuator software components, they may only directly address the local ECU abstraction. Therefore, access to remote ECU abstraction shall be done through an intermediate sensor/actuator software component which broadcasts the information on the remote ECU. Hence, moving the sensor/actuator software components on different ECUs, may then imply to also move connected devices (sensor/actuator) to the same ECU (provided that efficient access is needed).

An AUTOSAR software-component is defined by a *type* definition that defines the component's interfaces. A component type is instantiated when the component is deployed to an ECU. A component type can be instantiated more than once on the same ECU in which case the component type is said to be "multiple instantiated". The RTE supports per-instance memory sections that enable each component instance to have private states.

The RTE supports both AUTOSAR software-components where the source is available ("source-code software-components") [SRS_Rte_00024] and AUTOSAR software-components where only the object code ("object-code software components") is available [SRS_Rte_00140].

Details of AUTOSAR software-components in relation to the RTE are presented in Section 4.1.3.

2.2.2 Basic Software Modules

As well as "AUTOSAR software-components" an AUTOSAR ECU includes basic software modules. Basic software modules can access the ECU abstraction layer as well as other basic software modules directly and are thus neither ECU nor location independent [2].

An "AUTOSAR software-component" *cannot* directly access basic software modules – all communication is via AUTOSAR interfaces and therefore under the control of the RTE. The requirement to not have direct access applies to all *Basic Software Modules* including the operating system [SRS_Rte_00020] and the communication service.

[2] The functionality provided by a basic software module cannot be relocated in another ECU. However, the source of some basic software modules can be reused on other ECUs.

2.2.3 Communication

The communication interface of an AUTOSAR software-component consists of several ports (which are characterized by port-interfaces). An AUTOSAR software-component can communicate through its interfaces with other AUTOSAR software-components (whether that component is located on the same ECU or on a different ECU) or with basic software modules that have ports and runnables (i.e `ServiceSwComponent`s, `EcuAbstractionSwComponent`s and `ComplexDeviceDriverSwComponent`s) and are located on the same ECU. This communication can *only* occur via the component's ports. A port can be categorized by either a sender-receiver or client-server port-interface. A sender-receiver interface provides a message passing facility whereas a client-server interface provides function invocation.

2.2.3.1 Communication Paradigms

The RTE provides different paradigms for the communication between software-component instances: sender-receiver (signal passing), client-server (function invocation), mode switch, and `NvBlockSwComponentType` interaction.

Each communication paradigm can be applied to intra-partition software-component distribution (which includes both intra-task and inter-task distribution, within the same Partition), inter-Partition software-component distribution, and inter-ECU software-component distribution. Intra-task communication occurs between runnable entities that are mapped to the same OS task whereas inter-task communication occurs between runnable entities mapped to different tasks of the same Partition and can therefore involve a context switch. Inter-Partition communication occurs between runnable entities in components mapped to different partitions of the same ECU and therefore involve a context switch and crossing a protection boundary (memory protection, timing protection, isolation on a core). Inter-ECU communication occurs between runnable entities in components that have been mapped to different ECUs and so is inherently concurrent and involves potentially unreliable communication.

Details of the communication paradigms that are supported by the RTE are contained in Section 4.3.

2.2.3.2 Communication Modes

The RTE supports two modes for sender-receiver communication:

- **Explicit** — A component uses explicit RTE API calls to send and receive data elements [SRS_Rte_00098].
- **Implicit** — The RTE automatically reads a specified set of data elements before a runnable is invoked and automatically writes (a different) set of data elements after the runnable entity has terminated [SRS_Rte_00128] [SRS_Rte_00129].

The term “implicit” is used here since the runnable does not actively initiate the reception or transmission of data.

Implicit and explicit communication is considered in greater detail in Section 4.3.1.5.

2.2.3.3 Static Communication

[SWS_Rte_06026] ⌈ The RTE shall support static communication only. ⌋ *(SRS_Rte_00025)*

Static communication includes only those communication connections where the source(s) and destination(s) of all communication is known at the point the RTE is generated. [SRS_Rte_00025]. This includes also connections which are subject to variability because the variant handling concept of AUTOSAR does only support the selection of connectors from a superset of possible connectors to define a particular variant.
Dynamic reconfiguration of communication is not supported due to the run-time and code overhead which would therefore limit the range of devices for which the RTE is suitable.

2.2.3.4 Multiplicity

As well as point to point communication (i.e. “1:1”) the RTE supports communication connections with multiple providers or requires:

- When using sender-receiver communication, the RTE supports both “1:n” (single sender with multiple receivers) [SRS_Rte_00028] and “n:1” (multiple senders and a single receiver) [SRS_Rte_00131] communication with the restriction that multiple senders are not allowed for `mode switch notifications`, see metamodel restrictions [SWS_Rte_02670].

  The execution of the multiple senders or receivers is not coordinated by the RTE. This means that the actions of different software-components are independent – the RTE does not ensure that different senders transmit data simultaneously and does not ensure that all receivers read data or receive events simultaneously.

- When using client-server communication, the RTE supports “n:1” (multiple clients and a single server) [SRS_Rte_00029] communication. The RTE does *not* support “1:n” (single client with multiple servers) client-server communication.

Irrespective of whether “1:1”, “n:1” or “1:n” communication is used, the RTE is responsible for implementing the communication connections and therefore the AUTOSAR software-component is unaware of the configuration. This permits an AUTOSAR software-component to be redeployed in a different configuration without modification.

2.2.4 Concurrency

AUTOSAR software-components have no direct access to the OS and hence there are no “tasks” in an AUTOSAR application. Instead, concurrent activity within AUTOSAR is based around `RunnableEntity`s within components that are invoked by the RTE.

The AUTOSAR VFB specification [1] defines a runnable entity as a “sequence of instructions that can be started by the Run-Time Environment”. A component provides usually one[3] or more runnable entities [SRS_Rte_00031] and each runnable entity has exactly one entry point. An entry point defines the *symbol* within the software-component’s code that provides the implementation of a runnable entity.

The RTE is responsible for invoking runnable entities – AUTOSAR software-components are not able to (dynamically) create private threads of control. Hence, all activity within an AUTOSAR application is initiated by the triggering of runnable entities by the RTE as a result of `RTEEvent`s.

An `RTEEvent` encompasses all possible situations that can trigger execution of a runnable entity by the RTE. The different classes of `RTEEvent` are defined in Section 5.7.5.

The RTE supports runnable entities in any component that has an AUTOSAR interface - this includes AUTOSAR software-components and basic software modules.[4]

Runnable entities are divided into multiple categories with each category supporting different facilities. The categories supported by the RTE are described in Section 4.2.2.3.

2.3 The RTE Generator

The RTE generator is one of a set of tools[5] that create the realization of the AUTOSAR virtual function bus for an ECU based on information in the *ECU Configuration Description*. The RTE Generator is responsible for creating the AUTOSAR software-component API functions that link AUTOSAR software-components to the OS and manage communication between AUTOSAR software-components and between AUTOSAR software-components and basic software modules.

Additionally the RTE Generator creates both the *Basic Software Scheduler* and the *Basic Software Scheduler* API functions for each particular instance of a *Basic Software Module*.

The RTE generation process for SWCs has two main phases:

[3] There are use cases where a SWC might exist without any RunnableEntity.

[4] The OS and COM are basic software modules but present a *standardized interface* to the RTE and have no AUTOSAR interface. The OS and COM therefore do not have runnable entities.

[5] The RTE generator works in conjunction with other tools, for example, the OS and COM generators, to fully realize the AUTOSAR VFB.

- **RTE Contract phase** – a limited set of information about a component, principally the AUTOSAR interface definitions, is used to create an application header file for a component type. The application header file defines the “contract” between component and RTE.
- **RTE Generation phase** - all relevant information about components, their deployment to ECUs and communication connections is used to generate the RTE and optionally the Ioc configuration [4]. One RTE is generated for each ECU in the system.

The two-phase development model ensures that the RTE generated application header files are available for use for source-code AUTOSAR software-components as well as object-code AUTOSAR software-components with both types of component having access to all definitions created as part of the RTE generation process.

The RTE generation process, and the necessary inputs in each phase, are considered in more detail in chapter 3.

2.4 Design Decisions

This section details decisions that affect both the general direction that has been taken as well as the actual content of this document.

1. The role of this document is to specify RTE behavior, not RTE implementation. Implementation details should not be considered to be part of the RTE software specification unless they are explicitly marked as RTE requirements.
2. An AUTOSAR system consists of multiple ECUs each of which contains an RTE that may have been generated by different RTE generators. Consequently, the specification of how RTEs from multiple vendors interoperate is considered to be within the scope of this document.
3. The RTE does not have sufficient information to be able to derive a mapping from runnable entity to OS task. The decision was therefore taken to require that the mapping be specified as part of the RTE input.
4. Support for C++ is provided by making the C RTE API available for C++ components rather than specifying a completely separate object-oriented API. This decision was taken for two reasons; firstly the same interface for the C and C++ simplifies the learning curve and secondly a single interface greatly simplifies both the specification and any subsequent implementations.
5. There is no support within the specification for Java.
6. The AUTOSAR meta-model is a highly expressive language for defining systems however for reasons of practicality certain restrictions and constraints have been placed on the use of the meta-model. The restrictions are described in Appendix A.

3 RTE Generation Process

This chapter describes the methodology of the RTE and Basic Software Scheduler generation. For a detailed description of the overall AUTOSAR methodology refer to methodology document [6].

[SWS_Rte_02514] ⌈ The RTE generator shall produce the same RTE API, RTE code, SchM API and SchM code when the input information is the same. ⌋*(SRS_Rte_00065)*

The RTE Generator gets involved in the AUTOSAR Methodology several times in different roles. Technically the RTE Generator can be implemented as one tool which is invoked with options to switch between the different roles. Or the RTE Generator could be a set of separate tools. In the following section the individual applications of the RTE Generator are described based on the roles that are take, not necessarily the actual tools.

The RTE Generator is used in different roles for the following phases:

- RTE Contract Phase
- Basic Software Scheduler Contract Phase
- PreBuild Data Set Contract Phase
- Basic Software Scheduler Generation Phase
- RTE Generation Phase
- PreBuild Data Set Generation Phase
- PostBuild Data Set Generation Phase

RTE Generator for Software-Components

In Figure 3.1 the overall AUTOSAR Methodology wrt. Application SW-Components and the RTE Generator.

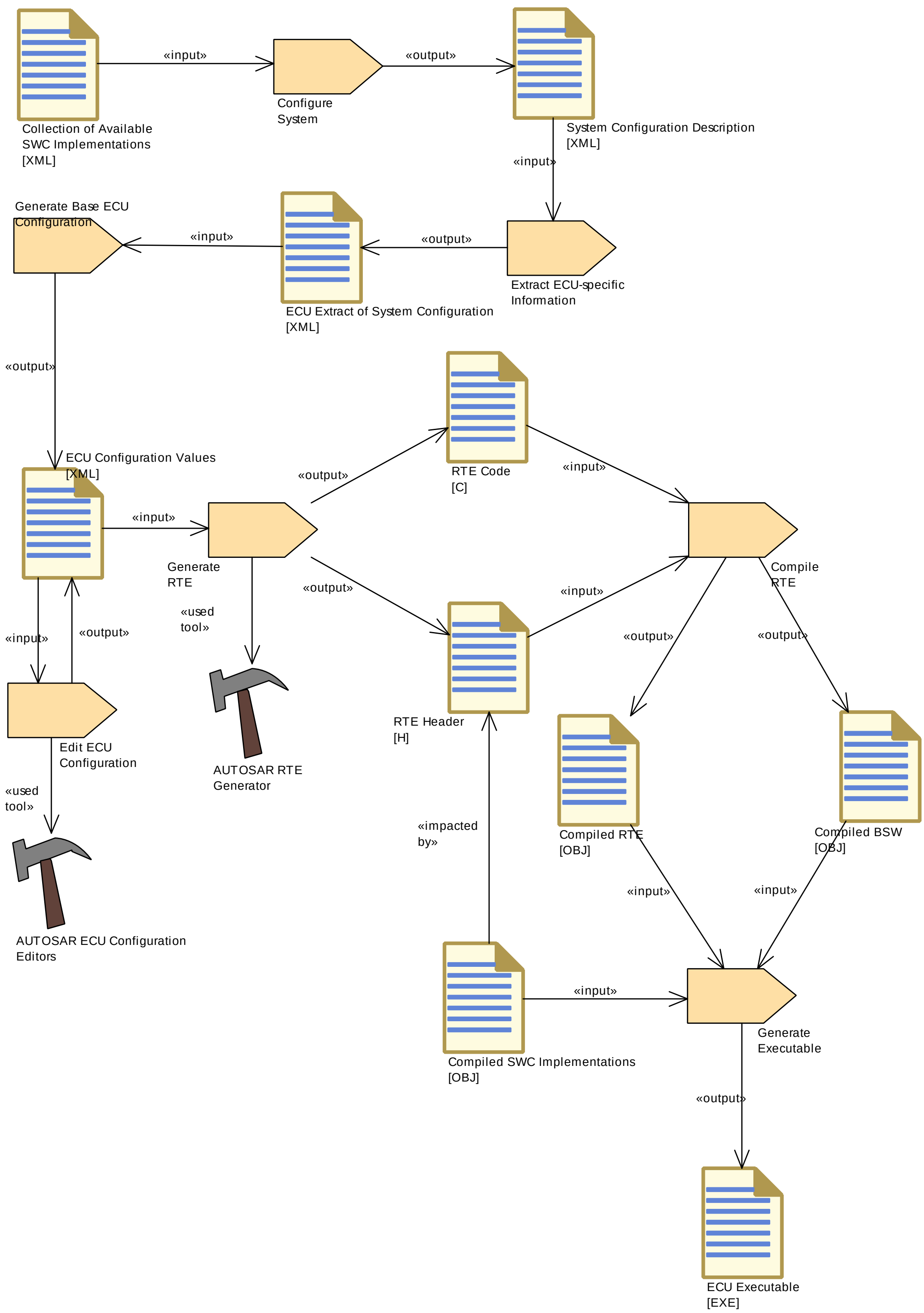


Figure 3.1: System Build Methodology

The whole vehicle functionality is described with means of `CompositionSwComponents`, `SwComponentPrototypes` and `AtomicSwComponents` [2]. In the `CompositionSwComponent` descriptions the connections between the software-components' ports are also defined. Such a collection of software-components connected to each other, without the mapping on actual ECUs, is called the VFB view.

During the 'Configure System' step the needed software-components, the available ECUs and the System Constraints are resolved into a System Configuration Description. Now the `SwComponentPrototype`s and thus the associated `AtomicSwComponent`s are mapped on the available ECUs.

Since in the VFB view the communication relationships between the `AtomicSwComponent`s have been described and the mapping of each `SwComponentPrototype`s and `AtomicSwComponent`s to a specific ECU has been fixed, the communication matrix can be generated. In the `SwComponentType Description` (using the format of the AUTOSAR Software Component Template [2]) the data that is exchanged through ports is defined in an abstract way. Now the 'System Configuration Generator' needs to define system signals (including the actual signal length and the frames in which they will be transmitted) to be able to transmit the application data over the network. COM signals that correspond to the system signals will be later used by the 'RTE Generator' to actually transmit the application data.

In the next step the 'System Configuration Description' is split into descriptions for each individual ECU. During the generation of the Ecu Extract also the hierarchical structure of the `CompositionSwComponent`s of the VFB view is flattened and the `SwComponentPrototype`s of the ECU Extract represent actual instances. The Ecu Extract only contains information necessary to configure one ECU individually and it is fed into the ECU Configuration for each ECU.

[SWS_Rte_05000] ⌈ The RTE is configured and generated for each ECU instance individually. ⌋*(SRS_Rte_00021)*

The 'ECU Configuration Editors' (see also Section 3.3) are working iteratively on the 'ECU Configuration Values' until all configuration issues are resolved. There will be the need for several configuration editors, each specialized on a specific part of ECU Configuration. So one editor might be configuring the COM stack (not the communication matrix but the interaction of the individual modules) while another editor is used to configure the RTE.

Since the configuration of a specific Basic-SW module is not entirely independent from other modules there is the need to apply the editors several times to the 'ECU Configuration Values' to ensure all configuration parameters are consistent.

Only when the configuration issues are resolved the 'RTE Generator' will be used to generate the actual RTE code (see also Section 3.4.2) which will then be compiled and linked together with the other Basic-SW modules and the software-components code.

The 'RTE Generator' needs to cope with many sources of information since the necessary information for the RTE Generator is based on the 'ECU Configuration Values' which might be distributed over several files and itself references to multiple other AUTOSAR descriptions.

[SWS_Rte_08769] ⌈ RTE Generator shall support for reading single files and of sets of files that are stored in a file system. The tool shall provide a mechanism to select a specific file and sets of files in the file system. ⌋*(SRS_Rte_00048)*

An AUTOSAR XML description can be shipped in several files. Some files could contain data types others could contain interfaces, etc.

[SWS_Rte_08770] ⌈ An RTE Generator tools SHALL support the merging of AUTOSAR models that have been split up and stored in multiple partial models while reading an set of files. Thereby the to be supported minimum granularity of an AUTOSAR model is defined by ≪atpSplitable≫. The Merging of a model also includes the resolution of references. The RTE Generator SHALL be able to read the submodels in any order. There is no preference. ⌋*(SRS_Rte_00048)*

[SWS_Rte_08771] ⌈ RTE Generator SHALL support the interpretation and creation of AUTOSAR XML descriptions. These descriptions SHALL be 'well-formed' and 'valid' as defined by the XML recommendation, W3C XML 1.1 Specification, whether used with or without the document's corresponding AUTOSAR XML schema(s). In other words: Even if the tool does not use standard XML mechanisms for validating the XML descriptions it SHALL ensure that the XML descriptions can be successfully validated against the AUTOSAR XML schema. ⌋*(SRS_Rte_00048)*

[SWS_Rte_08772] ⌈ If an RTE Generator wants to validate an AUTOSAR XML description against an AUTOSAR schema, it SHALL provide the necessary schema files in its own resources.

An RTE Generator shall use the SYSTEM-Identifier in the xsi:schemaLocation to identify an appropriate schema file. ⌋*(SRS_Rte_00048)*

[SWS_Rte_08773] ⌈ RTE Generator shall provide a serialization for XML. ⌋*(SRS_Rte_00048)*

[SWS_Rte_08774] ⌈ RTE Generator shall not change model content passed to the Generator ⌋*(SRS_Rte_00048)*

[SWS_Rte_08775] ⌈ An RTE Generator MAY support the AUTOSAR extension mechanism `SDG`s if applicable.

If the RTE Generator does not need the additional information for its intended purpose it SHALL ignore the irrelevant extensions `SDG`s. ⌋*(SRS_Rte_00048)*

[SWS_Rte_08776] ⌈ An RTE Generator may use well structured error messages. ⌋*(SRS_Rte_00048)*

The following list is a collection of proposed information items in particular applicable to log files used for exchanging information about errors.

- **ErrorCode** – A symbolic name for the message text
- **StandardErrorCode** – The reference to the AUTOSAR error code

- **ConstraintCode** – Reference to the semantic constraint mentioned in the AUTOSAR template specification.
- **Signature** – Signature of the message for duplicate checks
- **Timestamp** – A time stamp for the message
- **ShortName** – A unique identification which allows to refer to particular error messages
  This can also be used to establish references between error messages, e.g. for screening and also to trace back to root cause
- **Desc** – The human readable message text
- **Component** – Such information item may help the user to locate the problem in the model
- **BaseUrl** – An url for a base directory which can be used as basis for file references in a log file. This is typically the root direactory of a project structure.
- **ColumNumber** – The column of the error position
- **LineNumber** – The line number of the error position
- **LongName** – The title of the error message
- **ObjectCategory** – The category of for example the involved ApplicationPrimitveDataType (e.g.VALUE)
- **PrimaryErrorReference** – Reference to the root cause if applicable
- **ScopeEntryReference** – Reference to a scoping message if applicable
- **Object** – The shortName based reference to the AUTOSAR element which caused the error
- **ToolName** – The name of the tool which reported the error
- **ToolVersion** – The version of the tools which reported the error
- **IncidentUrl** – The Url which refers to the artifact in which the error occurs
- **Value** – The actual found value which caused the problem

This is just a rough sketch of the main steps necessary to build an ECU with AUTOSAR and how the RTE is involved in this methodology. For a more detailed description of the AUTOSAR Methodology please refer to the methodology document [6]. In the next sections the steps with RTE interaction are explained in more detail.

RTE Generator for Basic Software Scheduler

In Figure 3.2 the overall AUTOSAR Methodology wrt. Basis Software Scheduler and the RTE Generator interaction.

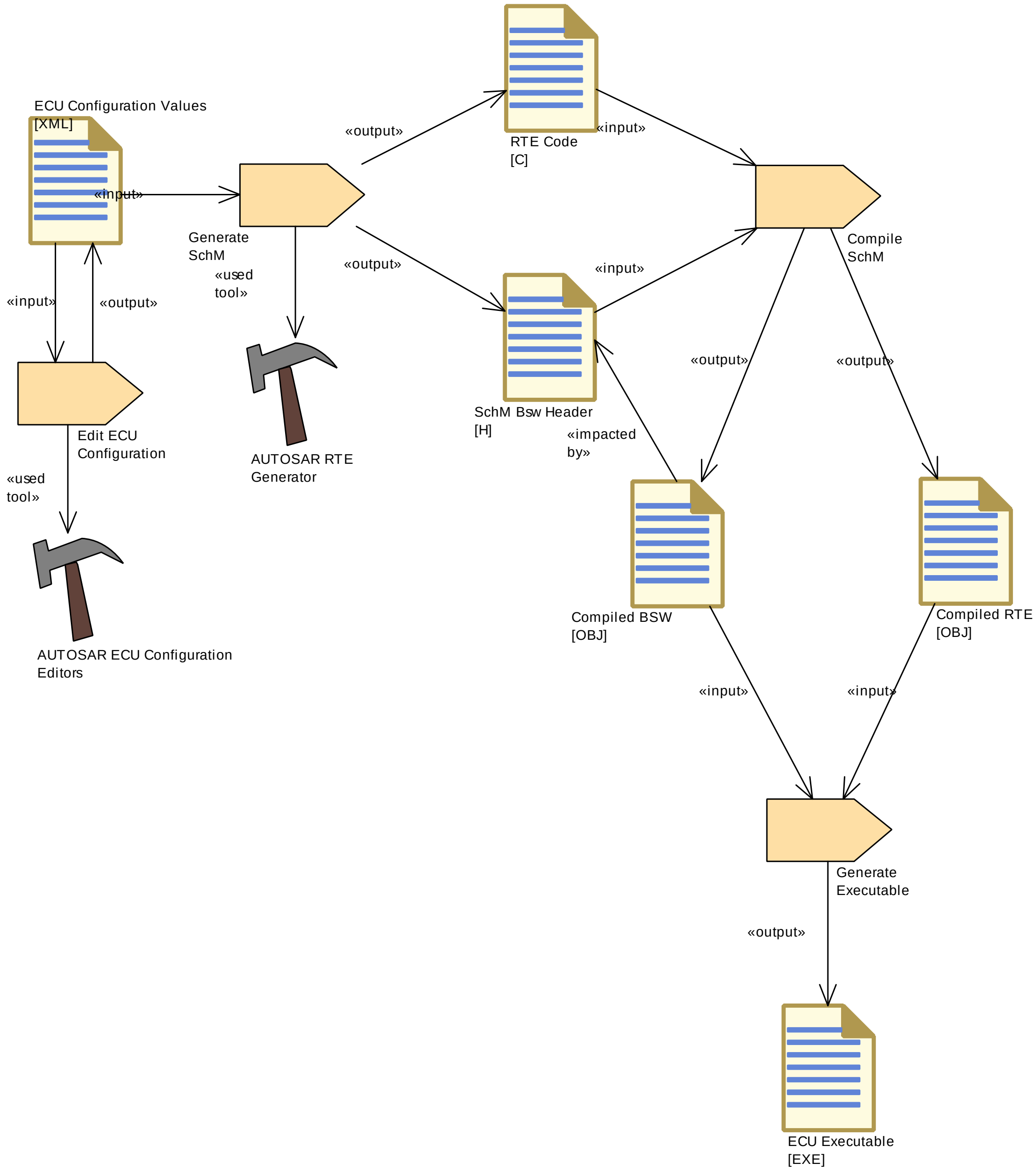


Figure 3.2: Basic Software Scheduler Methodology

The ECU Configuration phase is the start of the Basic Software Scheduler configuration where all the requirements of the different Basic Software Modules are collected. The Input information is provided in the Basic Software Module Descriptions [9] of the individual Basic Software Modules.

The Basic Software Scheduler configuration is then generated into the Basic Software Scheduler code which is compiled and built into the Ecu executable.

3.1 Contract Phase

3.1.1 RTE Contract Phase

To be able to support the AUTOSAR software-component development with RTE-specific APIs the 'Component API' (application header file) is generated from the 'software-component Internal Behavior Description' (see Figure 3.1) by the RTE Generator in the so called 'RTE Contract Phase' (see Figure 3.3).

In the software-component Interface description – which is using the AUTOSAR Software Component Template – at least the AUTOSAR Interfaces of the particular software-component have to be described. This means the software-component Types with Ports and their Interfaces. In the software-component Internal Behavior description additionally the Runnable Entities and the RTE Events are defined. From this information the RTE Generator can generate specific APIs to access the Ports and send and receive data.

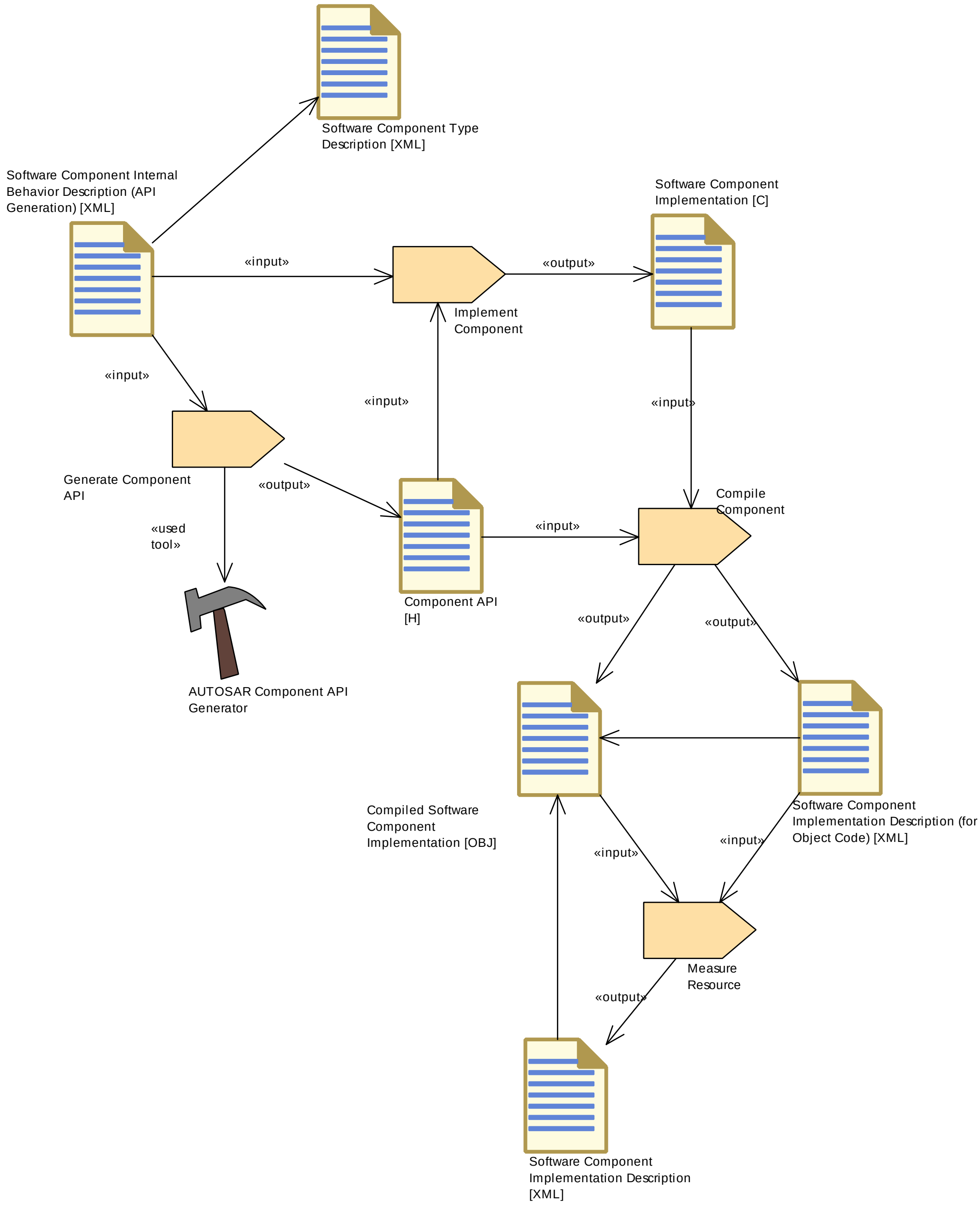


Figure 3.3: RTE Contract Phase

With the generated 'Component API' (application header file) the Software Component developer can provide the Software Component's source code without being concerned as to whether the communication will later be local or using some network(s).

It has to be considered that the AUTOSAR software-component development process is iterative and that the AUTOSAR software-component description might be changed during the development of the AUTOSAR software-component. This requires the application header file to be regenerated to reflect the changes done in the software-component description.

When the software-component has been compiled successfully the 'Component Implementation Description Generation' tool will analyze the resulting object files and enhance the software-component description with the information from the specific implementation. This includes information about the actual memory needs for ROM as well as for RAM and goes into the 'Component Implementation Description' section of the AUTOSAR Software Component Template.

Please note that in case of implemented `PreCompileTime variability` additionally the *PreBuild Data Set Contract Phase* is required 3.2 to be able to compile the software component.

So when a software-component is delivered it will consist of the following parts:

- SW-Component Type Description
- SW-Component Internal Behavior Description
- The actual SW-Component implementation and/or compiled SW-Component
- SW-Component Implementation Description

The above listed information will be needed to provide enough information for the System Generation steps when the whole system is assembled.

3.1.2 Basic Software Scheduler Contract Phase

To be able to support the *Basic Software Module* development with *Basic Software Scheduler* specific APIs the *Module Interlink Header* (6.3.2) and *Module Interlink Types Header* (6.3.1) containing the definitions and declaration for the *Basic Software Scheduler* API related to the single *Basic Software Module* instance is generated by the RTE Generator in the so called '*Basic Software Scheduler Contract Phase*'.

The required input is

- *Basic Software Module Description* and
- *Basic Software Module Internal Behavior* and
- *Basic Software Module Implementation*

Please note that in case of implemented `PreCompileTime variability` additionally the *PreBuild Data Set Contract Phase* is required 3.2 to be able to compile the *Basic Software Module*.

3.2 PreBuild Data Set Contract Phase

In the *RTE PreBuild Data Set Contract Phase* are the *Condition Value Macros* (see 5.3.8.2.2) generated which are required to resolve the implemented `pre-build variability` of a particular software component or *Basic Software Module*.

The particular values are defined via PredefinedVariants. These Predefined-Variant elements containing definition of SwSystemconstValues for SwSystem-consts which shall be applied when resolving the variability during ECU Configuration.

The output of this phase is the *RTE Configuration Header File* 5.3.8. This file is required to compile a particular variant of a software component using PreCompile-Time variability. The *Condition Value Macros* are used for the implementation of PreCompileTime variability with preprocessor statements and therefore are needed to run the C preprocessor resolving the implemented variability.

3.3 Edit ECU Configuration of the RTE

During the configuration of an ECU the RTE also needs to be configured. This is divided into several steps which have to be performed iteratively: The configuration of the RTE and the configuration of other modules.

So first the 'RTE Configuration Editor' needs to collect all the information needed to establish an operational RTE. This gathering includes information on the software-component instances and their communication relationships, the Runnable Entities and the involved RTE-Events and so on. The main source for all this information is the 'ECU Configuration Values', which might provide references to further descriptions like the software-component description or the System Configuration description.

An additional input source is the Specification of Timing Extensions [14]. This template can be used to specify the execution order of runnable entities (see section 'Execution order constraint'). An 'RTE Configuration Editor' can use the information to create and check the configuration of the Rte Event to Os task mapping (see section 8.5.1).

The usage of 'ECU Configuration Editors' covering different parts of the 'ECU Configuration Values' will – if there are no cyclic dependencies which do not converge – converge to a stable configuration and then the ECU Configuration process is finished. A detailed description of the ECU Configuration can be found in [5]. The next phase is the generation of the actual RTE code.

3.4 Generation Phase

After the ECU has been entirely configured the generation of the actual RTE inclusive the *Basic Software Scheduler* part can be performed. Since all the relationships to and from the other Basic-SW modules have been already resolved during the ECU Configuration phase, the generation can be performed in parallel for all modules (see Figure 3.4).

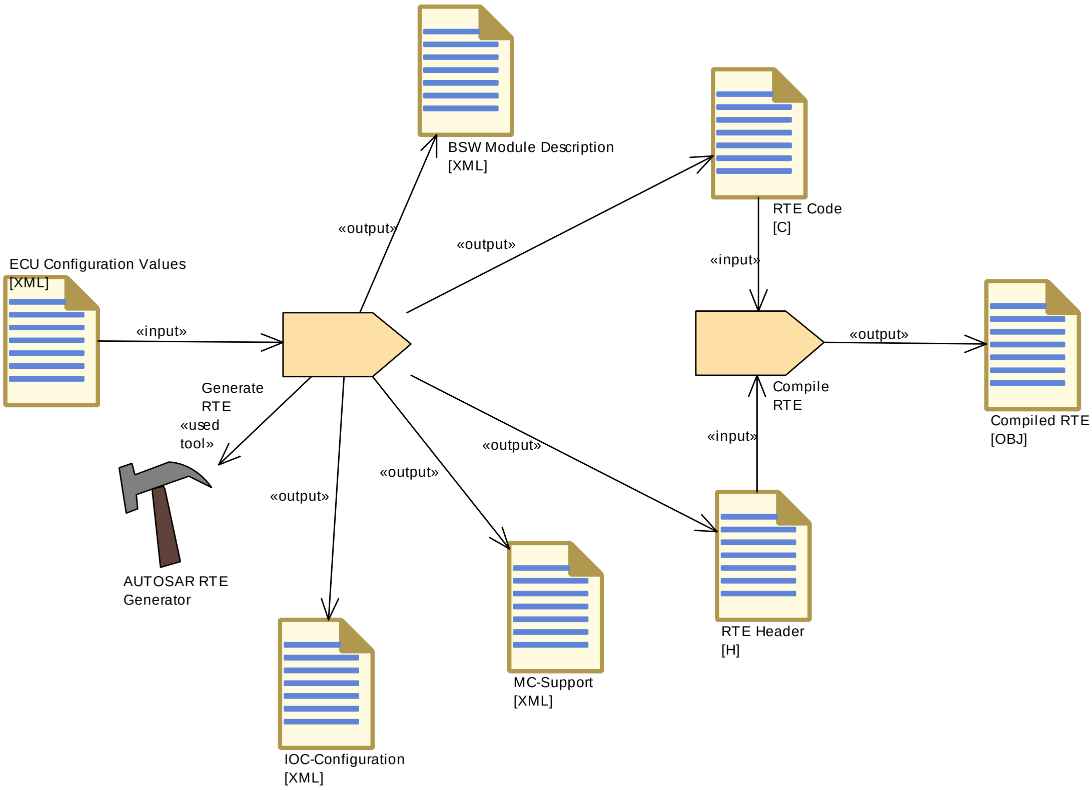


Figure 3.4: RTE Generation Phase

The *Basic Software Scheduler* is a part of the *Rte* and therefore not explicitly shown in figure 3.4.

3.4.1 Basic Software Scheduler Generation Phase

Depending on the complexity of the ECU and the cooperation model of the different software vendors it might be required to integrate the *Basic Software* stand alone without software components.

Therefore the RTE Generator has to support the generation of the *Basic Software Scheduler* without software component related RTE fragments. The *Basic Software Scheduler Generation Phase* is only applicable for software builds which are not containing any kind of software components.

[SWS_Rte_07569] ⌈ In the *Basic Software Scheduler Generation Phase* the RTE Generator shall generate the *Basic Software Scheduler* without the RTE functionality. ⌋ *(SRS_Rte_00221)*

In this case the RTE Generator generates the API for *Basic Software Modules* and the *Basic Software Scheduling* code only. When the input contains software component related information this information raises an error.

For instance:

- *Application Header File*s are not generated for the software components contained in the ECU extract.
- Mapped `RTEEvent`s are not permitted and the runnable calls are not generated into the OS task bodies. Nevertheless all OS task bodies related to the *Basic Software Scheduler* configuration are generated.
- Mode machine instances mapped to the RTE are not supported.

[SWS_Rte_07585] ⌈ In the *Basic Software Scheduler Generation Phase* the RTE Generator shall reject input configuration containing software component related information. ⌋ *(SRS_Rte_00221)*

The RTE Generator in the *Basic Software Scheduler Generation Phase* is also responsible to generate additional artifacts which contribute to the further build, deployment and calibration of the ECU's software.

[SWS_Rte_06725] ⌈ The RTE Generator in *Basic Software Scheduler Generation Phase* shall provide its *Basic Software Module Description* in order to capture the generated RTE's / Basic Software Scheduler attributes. ⌋ *(SRS_Rte_00170, SRS_Rte_00192, SRS_Rte_00233)*

Details about the Basic Software Module Description generation can can be found in section 3.4.3.

[SWS_Rte_06726] ⌈ The RTE Generator in *Basic Software Scheduler Generation Phase* shall provide an *MC-Support* (Measurement and Calibration) description as part of the *Basic Software Module Description*. ⌋ *(SRS_Rte_00153, SRS_Rte_00189)*

Details about the *MC-Support* can be found in section 4.2.8.4.

For software builds which are containing software components the *RTE Generation Phase* 3.4.2 is applicable where the *Basic Software Scheduler* part of the RTE is generated as well.

3.4.2 RTE Generation Phase

The actual AUTOSAR software-components and Basic-SW modules code will be linked together with the RTE and *Basic Software Scheduler* code to build the entire ECU software.

Please note that in case of implemented PreCompileTime variability additionally the *PreBuild Data Set Generation Phase* is required (see section 3.5) to be able to compile the ECU software. Further on in case of implemented post-build variability *PostBuild Data Set Generation Phase* is required (see section 3.6) to be able to link the full ECU software.

The RTE Generator in the *Generation Phase* is also responsible to generate additional artifacts which contribute to the further build, deployment and calibration of the ECU's software.

[SWS_Rte_05086] ⌈ The RTE Generator in Generation Phase shall provide its *Basic Software Module Description* in order to capture the generated RTE's attributes. ⌋ *(SRS_Rte_00170, SRS_Rte_00192, SRS_Rte_00233)*

Details about the Basic Software Module Description generation can can be found in section 3.4.3.

[SWS_Rte_05087] ⌈ The RTE Generator in Generation Phase shall provide an *MC-Support* (Measurement and Calibration) description as part of the *Basic Software Module Description*. ⌋ *(SRS_Rte_00153, SRS_Rte_00189)*

Details about the *MC-Support* can be found in section 4.2.8.4.

[SWS_Rte_05147] ⌈ The RTE Generator in Generation Phase shall provide the configuration for the Ioc module [4] if the Ioc module is used. ⌋ *(SRS_Rte_00196)*

The RTE generates the IOC configurations and uses an implementation specific deterministic generation scheme. This generation scheme can be used by implementations to reuse these IOC configurations (e.g. if the configuration switch strictConfigurationCheck is used).

[SWS_Rte_08400] ⌈ The RTE Generator in Generation Phase shall generate internal ImplementationDataTypes types used for IOC configuration, if the IOC module is used. ⌋ *(SRS_Rte_00210)*

The corresponding C data types will be generated into the *Rte_Type.h*. This *Rte_Type.h* header file will be used by the IOC to get the types for the IOC API.

Changing the RTE generator will require a new IOC configuration generation.

Details about the Ioc module can be found in section 4.3.4.1.

[SWS_Rte_08305] ⌈ The RTE Generator in Generation Phase shall ignore XML-Content categorized as ICS. ⌋ *(SRS_Rte_00233)*

ARPackage with category ICS describes an Implementation Conformance Statement. (See TPS Basic Software Module Description [9] for more details.)

3.4.3 Basic Software Module Description generation

The Basic Software Module Description [9] generated by the RTE Generator in generation phase describes features of the actual RTE code. The following requirements specify which elements of the Basic Software Module Description are mandatory to be generated by the RTE Generator.

3.4.3.1 Bsw Module Description

[SWS_Rte_05165] ⌈ The RTE Generator in Generation Phase shall provide the `BswModuleDescription` element of the Basic Software Module Description for the generated RTE. ⌋*(SRS_Rte_00233)*

[SWS_Rte_08404] ⌈ The RTE `BswModuleDescription` shall be provided in `ARPackage` AUTOSAR_Rte according to AUTOSAR Generic Structure Template [10] (chapter "Identifying M1 elements in packages"). ⌋*(SRS_Rte_00233)*

[SWS_Rte_05177] ⌈ The RTE Generator in Generation Phase shall provide the `BswModuleEntry` and a reference to it from the `BswModuleDescription` in the role `providedEntry` for each *Standardized Interface* provided by the RTE (see Layered Software Architecture [15] page *tz76a* and page *94ju5*). The provided *Standardized Interface*s are the Rte Lifecycle API (section 5.8) and the SchM Lifecycle API (section 6.7). ⌋*(SRS_Rte_00233)*

[SWS_Rte_05179] ⌈ The RTE Generator in Generation Phase shall provide the `BswModuleDependency` in the `BswModuleDescription` with the role `bswModuleDependency` for each callback API provided by the RTE and called by the respective Basic Software Module. The reference from the `BswModuleDependency` to the `BswModuleEntry` shall be in the role `expectedCallback`. The calling Basic Software Module is specified in the attribute `targetModuleId` of the `BswModuleDependency`. ⌋*(SRS_Rte_00233)*

For all the APIs the RTE code is invoking in other Basic Software Modules the dependencies are described via requirement [SWS_Rte_05180].

[SWS_Rte_05180] ⌈ The RTE Generator in Generation Phase shall provide the `BswModuleDependency` in the `BswModuleDescription` with the role `bswModuleDependency` for each API called by the RTE in another Basic Software Module. The reference from the `BswModuleDependency` to the `BswModuleEntry` shall be in the role `requiredEntry`. The called Basic Software Module is specified in the attribute `targetModuleId` of the `BswModuleDependency`. ⌋*(SRS_Rte_00233)*

[SWS_Rte_07085] ⌈ If the Basic Software Module Description for the generated RTE depends from elements in Basic Software Module Descriptions of other Basic Software Modules the RTE Generator shall use the full qualified path name to this elements according the rules in "Identifying M1 elements in packages" of the document AUTOSAR Generic Structure Template [10]. ⌋*(SRS_Rte_00233)*

For instance the description of the the hook function

```
void Rte_Dlt_Task_Activate(TaskType task)
```

for the Dlt needs the `ImplementationDataType` "TaskType" from the OS in order to describe the data type of the `SwServiceArg` "task" in the description of the related `BswModuleEntry`.

In this case the full qualified path name to the `ImplementationDataType` "TaskType" shall be

```
AUTOSAR_OS/ImplementationDataTypes/TaskType
```

The full example about the description is given below:

```xml
<AR-PACKAGE>
  <SHORT-NAME>AUTOSAR_RTE</SHORT-NAME>
  <AR-PACKAGES>
    <AR-PACKAGE>
      <SHORT-NAME>BswModuleEntrys</SHORT-NAME>
      <ELEMENTS>
        <BSW-MODULE-ENTRY>
          <SHORT-NAME>Rte_Dlt_Task_Activate</SHORT-NAME>
          <ARGUMENTS>
            <SW-SERVICE-ARG>
              <SHORT-NAME>task</SHORT-NAME>
              <CATEGORY>TYPE_REFERENCE</CATEGORY>
              <SW-DATA-DEF-PROPS>
                <SW-DATA-DEF-PROPS-VARIANTS>
                  <SW-DATA-DEF-PROPS-CONDITIONAL>
                    <IMPLEMENTATION-DATA-TYPE-REF DEST="IMPLEMENTATION-
                       DATA-TYPE">AUTOSAR_OS/ImplementationDataTypes/
                       TaskType</IMPLEMENTATION-DATA-TYPE-REF>
                  </SW-DATA-DEF-PROPS-CONDITIONAL>
                </SW-DATA-DEF-PROPS-VARIANTS>
              </SW-DATA-DEF-PROPS>
            </SW-SERVICE-ARG>
          </ARGUMENTS>
        </BSW-MODULE-ENTRY>
      </ELEMENTS>
    </AR-PACKAGE>
```

3.4.3.2 Bsw Internal Behavior

[SWS_Rte_05166] ⌈ The RTE Generator in Generation Phase shall provide the `BswInternalBehavior` element in the `BswModuleDescription` of the Basic Software Module Description for the generated RTE. ⌋ *(SRS_Rte_00233)*

[SWS_Rte_05181] ⌈ The RTE Generator in Generation Phase shall provide the `BswCalledEntity` element in the `BswInternalBehavior` for each C-function implementing the lifecycle APIs (section 5.8) and the SchM Lifecycle API (section 6.7). The `BswCalledEntity` shall have a reference to the respective `BswModuleEntry` ([SWS_Rte_05177]) in the role `implementedEntry`. ⌋ *(SRS_Rte_00233)*

[SWS_Rte_05182] ⌈The RTE Generator in Generation Phase shall provide the VariableDataPrototype element in the BswInternalBehavior in the role staticMemory for each variable memory object the RTE allocates. ⌋*(SRS_Rte_00233)*

[SWS_Rte_05183] ⌈ The RTE Generator in Generation Phase shall provide the ParameterDataPrototype element in the BswInternalBehavior in the role constantMemory for each constant memory object the RTE allocates. ⌋*(SRS_Rte_00233)*

3.4.3.3 Bsw Implementation

[SWS_Rte_05167] ⌈ The RTE Generator in Generation Phase shall provide the BswImplementation element and a reference to the BswInternalBehavior of the Basic Software Module Description in the role behavior. ⌋*(SRS_Rte_00233)*

[SWS_Rte_05187] ⌈The RTE Generator in Generation Phase shall provide the programmingLanguage element in the BswImplementation element according to the actual RTE implementation. ⌋*(SRS_Rte_00233)*

[SWS_Rte_05186] ⌈ The RTE Generator in Generation Phase shall provide the swVersion element in the BswImplementation element according to the input information from the RTE Ecu configuration ([SWS_Rte_05184], [SWS_Rte_05185]). ⌋*(SRS_Rte_00233)*

[SWS_Rte_05190] ⌈The RTE Generator in Generation Phase shall provide the arReleaseVersion element in the BswImplementation element according to AUTOSAR release version the RTE Generator is based on. ⌋*(SRS_Rte_00233)*

[SWS_Rte_05188] ⌈The RTE Generator in Generation Phase shall provide the usedCodeGenerator element in the BswImplementation element according to the actual RTE implementation. ⌋*(SRS_Rte_00233)*

[SWS_Rte_05189] ⌈The RTE Generator in Generation Phase shall provide the vendorId element in the BswImplementation element according to the input information from the RTE Ecu configuration (RteCodeVendorId). ⌋*(SRS_Rte_00233)*

The RteCodeVendorId specifies the vendor id of the actual user of the RTE Generator, not the id of the RTE Vendor itself.

[SWS_Rte_05191] ⌈ If the generated RTE code is hardware specific (due to vendor specific optimizations of the RTE Generator) then the reference to the applicable HwElements from the ECU Resource Description [16] shall be provided in the BswImplementation element with the role hwElement. ⌋*(SRS_Rte_00233)*

[SWS_Rte_05192] ⌈The RTE Generator in Generation Phase shall provide the DependencyOnArtifact element in the BswImplementation with the role generatedArtifact for all c- and header-files which are required to compile the Rte code. This does not include other Basic Software modules or Application Software. ⌋*(SRS_Rte_00233)*

Note: The use case is the support of the build-environment (automatic or manual).

Attributes shall be used in this context as follow:

- category shall be used as defined in Generic Structure Template [10] (e.g. SWSRC, SWOBJ, SWHDR)
- domain is optional and can be chosen freely
- revisionLabel shall contain the revision label out of RTE Configuration
- shortLabel is the name of artifact

Details on the description of DependencyOnArtifact can be found in the Generic Structure Template [10].

Additional elements of the *Basic Software Module Description* which shall be exported are specified in later requirements e.g. in section 4.2.8.4.

3.5 PreBuild Data Set Generation Phase

During the *PreBuild Data Set Generation Phase* are the *Condition Value Macros* (see 5.3.8.2.2) generated which are required to resolve the implemented pre-build variability of the software components, generated RTE and *Basic Software Scheduler*.

The particular values are defined via the EcucVariationResolver configuration selecting PredefinedVariants. These PredefinedVariant elements containing definition of SwSystemconstValues for SwSystemconsts which shall be applied when resolving the variability during ECU Configuration.

The values of the *Condition Value Macros* are the results of evaluated ConditionByFormulas of the related VariationPoints. These ConditionByFormulas referencing SwSystemconsts in the formula expressions. It is supported that the assigned SwSystemconstValue might contain again a formula expressions referencing SwSystemconsts. Therefore the input might be a tree of formula expressions and SwSystemconstValues but the leaf SwSystemconstValues are required to be values which are not dependent from other SwSystemconsts to ensure that the evaluation of the tree results in a unique number.

[SWS_Rte_06610] ⌈ The RTE generator shall validate the resolved pre-build variants and check the integrity with regards to the meta model. Any meta model violation shall result in the rejection of the input configuration. ⌋*(SRS_Rte_00018)*

The output of this phase is the *RTE Configuration Header File* 5.3.8.This file is required to compile a particular variant of ECU software including software component code and RTE code using PreCompileTime variability. The *Condition Value Macros* are used for the implementation of PreCompileTime variability with preprocessor statements and therefore are needed to run the C preprocessor resolving the implemented variability.

3.6 PostBuild Data Set Generation Phase

In the optional *PostBuild Data Set Generation Phase* the `PredefinedVariant` values are generated which are required to resolve the implemented `post-build variability` of the software components and generated RTE.

The output of this phase are the *RTE Post Build Variant Sets* 5.3.10. This file is required to link the ECU software and to select a particular PostBuild variant in the generated RTE code during start up when the *Basic Software Scheduler* is initialized.

[SWS_Rte_06611] ⌈ If the DET is enabled then the RTE shall generate validation code which at runtime (i.e. during initialization) validates the resolved post-build variants and check the integrity with regards to the active variants. If a violation is detected the RTE shall report a development error to the DET. To execute this validation RTE initialization will get a pointer to the `RtePostBuildVariantConfiguration` instance to allow it to validate the selected variant. ⌋*(SRS_Rte_00191)*

[SWS_Rte_06612] ⌈ The RTE generator shall create an RTE Post Build Data Set configuration (i.e. Rte_PBcfg.c) representing the collection of `PredefinedVariant` definitions (typically for each subsystem and/or system configuration) providing and defining the post build variants of the RTE. ⌋*(SRS_Rte_00191)*

Note that the Rte_PBcfg.h is generated during the Rte Generation phase. An Rte_PBcfg.c may also have to be generated at that time to reserve memory (with default values).

Additional details about these configuration files are described in section 5.3.10.

An RTE variant can consist of a collection of `PredefinedVariant`s. Each `PredefinedVariant` contains a collection of `PostBuildVariantCriterionValue`s which assigns a value to a specific `PostBuildVariantCriterion` which in turn is used to resolve the variability at runtime by evaluating a `PostBuildVariantCondition`. Different `PredefinedVariant`s could assign different values to the same `PostBuildVariantCriterion` and as such create conflicts for a specific `PostBuildVariantCriterionValueSet`. It is allowed to have different assignments if these assignment assign the same value.

[SWS_Rte_06613] ⌈ The RTE Generator shall reject configurations where different `PredefinedVariant`s assign different values to the same `PostBuildVariantCriterion` for the same `RtePostBuildVariantConfiguration`. ⌋*(SRS_Rte_00018, SRS_Rte_00191)*

[SWS_Rte_06814] ⌈ The RTE Generator shall reject configurations where multiple post build variant instances of `ParameterDataPrototype`s are used but where not exactly one instance in one `RtePostBuildVariantConfiguration` is selected. ⌋*(SRS_Rte_00018, SRS_Rte_00191)*

Further information can be found in section 4.2.8.3.7.

3.7 RTE Configuration interaction with other BSW Modules

The generated RTE interacts heavily with other AUTOSAR Basic Software Modules like Com and Os. The configuration values for the different BSW Modules are stored in individual structures of ECU Configuration it is however essential that the common used values are synchronized between the different BSW Module's configurations. AUTOSAR does not provide a standardized way how the individual configurations can be synchronized, it is assumed that during the generation of the BSW Modules the input information provided to the individual BSW Module is in sync with the input information provided to other (dependent) BSW Modules.

The AUTOSAR BSW Module code-generation methodology is heavily relying on the logical distinction between Configuration editors and configuration generators. These tools do not necessarily have to be implemented as two separate tools, it just shall be possible to distinguish the different roles the tools take during a certain step in the methodology.

For the RTE it is assumed that tool support for the resolution of interactions between the Rte and other BSW Modules is needed to allow an efficient configuration of the Rte. It is however not specified how and in which tools this support shall be implemented.

The RTE Generator in Generation Phase needs information about other BSW Module's configurations based on the configuration input of the Rte itself (there are references in the configuration of the Rte which point to configuration values of other BSW Modules). If during RTE Generation Phase the provided input information is inconsistent wrt. the Rte input the Rte Generator will have to consider the input as invalid configuration.

[SWS_Rte_05149] ⌈ The RTE Generator in Generation Phase shall consider errors in the Rte configuration input information as invalid configuration. ⌋*(SRS_Rte_00018)*

Due to implementation freedom of the RTE Generator it is possible to correct / update provided input configurations of other BSW Modules based on the RTE configuration requirements. But to allow a stable build process it is also possible to disallow such an update behavior.

[SWS_Rte_05150] ⌈ If the external configuration switch `strictConfigurationCheck` is set to *true* the Rte Generator shall not create or modify any configuration input. ⌋*(SRS_Rte_00065)*

If the external configuration switch `strictConfigurationCheck` (see [SWS_Rte_05148]) is set to *false* the Rte Generator may update the input configuration information of the Rte and other BSW Modules.

Example: If the Rte configuration is referencing an `OsTask` which is not configured in the provided Os configuration, the RTE Generator would behave like:

- In case [SWS_Rte_05150] applies: Only show an error message.
- Otherwise: Possible behavior: Show a warning message and modify the Os configuration to contain the `OsTask` which is referred to by the Rte configuration (Of course the Os configuration of this new `OsTask` needs to be refined afterwards).

4 RTE Functional Specification

4.1 Architectural concepts

4.1.1 Scope

In this section the concept of an AUTOSAR software-component and its usage within the RTE is introduced.

The AUTOSAR Software Component Template [2] defines the kinds of software-components within the AUTOSAR context. These are shown in Figure 4.1. The abstract SwComponentType can not be instantiated, so there can only be either a CompositionSwComponentType, a ParameterSwComponentType, or a specialized class ApplicationSwComponentType, ServiceProxySwComponentType, SensorActuatorSwComponentType, NvBlockSwComponentType, ServiceSwComponentType, ComplexDeviceDriverSwComponentType, or EcuAbstractionSwComponentType of the abstract class AtomicSwComponentType.

In the following document the term AtomicSwComponentType is used as collective term for all the mentioned non-abstract derived meta-classes.

The SwComponentType is defining the type of an AUTOSAR software-component which is independent of any usage and can be potentially re-used several times in different scenarios. In a composition the types are occurring in specific roles which are called SwComponentPrototypes. The prototype is the utilization of a type within a certain scenario. In AUTOSAR any SwComponentType can be used as a type for a prototype.

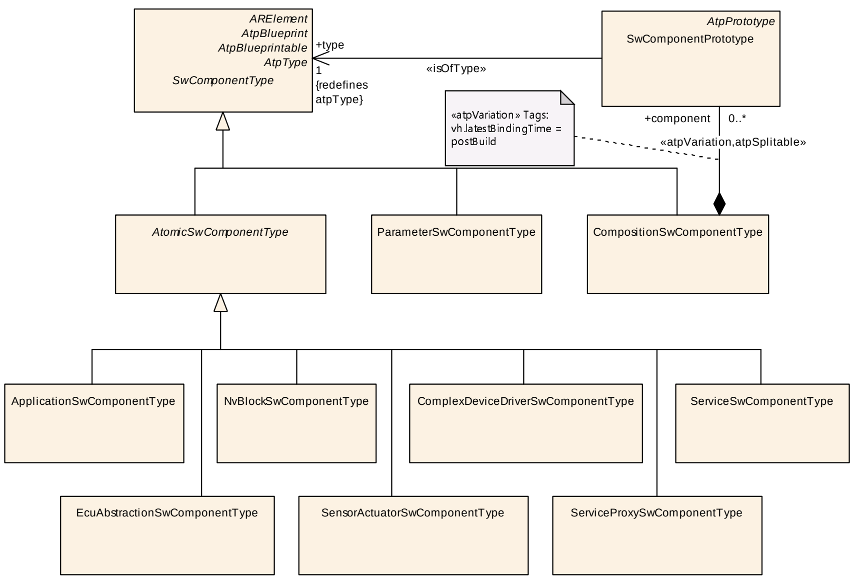


Figure 4.1: AUTOSAR software-component classification

The AUTOSAR software-components shown in Figure 4.1 are located above and below the RTE in the architectural Figure 4.2.

Below the RTE there are also software entities that have an AUTOSAR Interface. These are the AUTOSAR services, the ECU Abstraction and the Complex Device Drivers. For these software not only the AUTOSAR Interface will be described but also information about their internal structure will be available in the Basic Software Module Description.

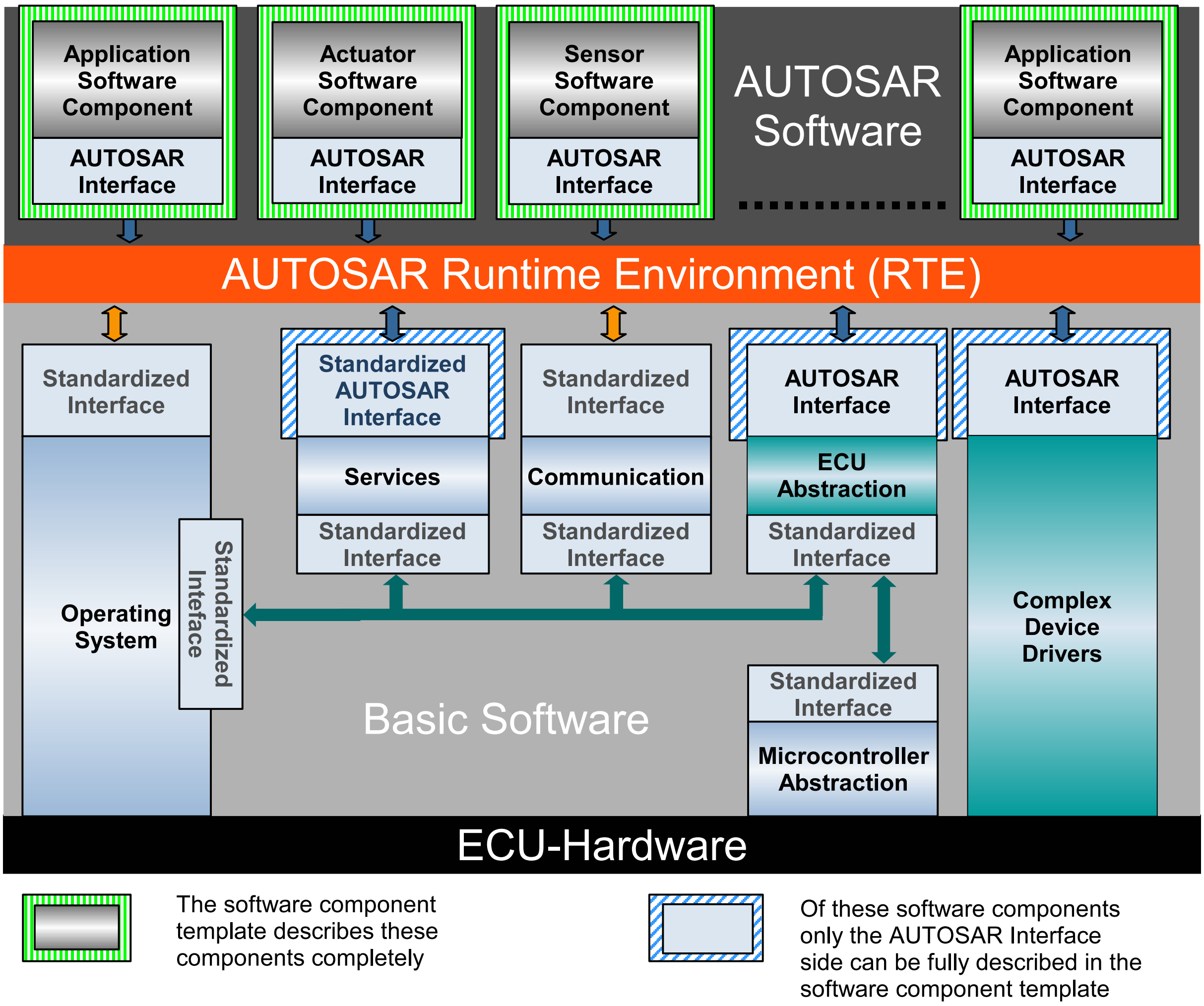


Figure 4.2: AUTOSAR ECU architecture diagram

In the next sections the different AUTOSAR software-components kinds will be described in detail with respect to their influence on the RTE.

4.1.2 RTE and Data Types

The AUTOSAR Meta Model defines `ApplicationDataType`s and `ImplementationDataType`s. A `AutosarDataPrototype` can be typed by an `ApplicationDataType` or an `ImplementationDataType`. But the RTE Generator only implements `ImplementationDataType`s as C data types and uses these C data types to type the RTE API which is related to `DataPrototype`s. Therefore it is required in the input configuration that every `ApplicationDataType` used for the typing of a

DataPrototype which is relevant for RTE generation is mapped to an ImplementationDataType with a DataTypeMap. Which DataTypeMap is applicable for an particular software component respectively Basic Software Module is defined by the DataTypeMappingSets referenced by the InternalBehavior.

[SWS_Rte_07028] ⌈ The RTE Generator shall reject input configurations containing a AutosarDataPrototype which influences the generated RTE and which is typed by an ApplicationDataType not mapped to an ImplementationDataType. ⌋ *(SRS_Rte_00018)*

Nevertheless a subset of the attributes given by the ApplicationDataTypes are relevant for the RTE generator for instance

- to create the McSupportData (see section 4.2.8.4) information
- to calculate the conversion formula in case of *Data Conversion* (see section 4.3.5 and 4.3.7)
- to calculate numerical representation of values required for the RTE code but defined in the physical representation (e.g. initialValues and invalidValues).

[SWS_Rte_01374] ⌈ When a value is required for the RTE code and is provided as an ApplicationValueSpecification, if there is an applicable ConstantSpecificationMapping then the RTE Generator shall use the ValueSpecification referenced by its implConstant as the definitive numerical representation of the value regardless of any compuMethod. ⌋*(SRS_Rte_00180, SRS_Rte_00182)*

[SWS_Rte_07038] ⌈ When a value is required for the RTE code and is provided as an ApplicationValueSpecification, if there is no applicable ConstantSpecificationMapping then the RTE Generator shall calculate the numerical representation according to the conversion defined by an compuMethod. This shall be supported for categorys VALUE, VAL_BLK, STRUCTURE, ARRAY, and BOOLEAN. In case of category VAL_BLK, STRUCTURE and ARRAY, this applies only for the primitive leaf elements. If there is no CompuMethod provided the conversion is treated like an CompuMethod of category IDENTICAL. ⌋*(SRS_Rte_00180, SRS_Rte_00182)*

In [SWS_Rte_01374] and [SWS_Rte_07038], an "applicable ConstantSpecificationMapping" is one that is aggregated by the relevant SwComponentType and which references the ApplicationValueSpecification in its applConstant.

4.1.3 RTE and AUTOSAR Software-Components

The description of an AUTOSAR software-component is divided into the sections

- hierarchical structure
- ports and interfaces
- internal behavior

- implementation

which will be addressed separately in the following sections.

[SWS_Rte_07196] ⌈ The RTE Generator shall respect the precedence of data properties defined via SwDataDefProps as defined in the *Software Component Template* [2]. ⌋*()*

Requirement [SWS_Rte_07196] means that:

1. SwDataDefProps defined on ApplicationDataType which may be overwritten by
2. SwDataDefProps defined on ImplementationDataType which may be overwritten by
3. SwDataDefProps defined on AutosarDataPrototype which may be overwritten by
4. SwDataDefProps defined on InstantiationDataDefProps which may be overwritten by
5. SwDataDefProps defined on AccessPoint respectively Argument which may be overwritten by
6. SwDataDefProps defined on FlatInstanceDescriptor which may be overwritten by
7. SwDataDefProps defined on McDataInstance

The SwDataDefProps defined on McDataInstance are not relevant for the RTE generation but rather the documentation of the generated RTE.

Especially the attributes swAddrMethod, swCalibrationAccess, swImplPolicy and dataConstr do have an impact on the generated RTE. In the following document only the attribute names are mentioned with the semantic that this refers to the most significant one.

4.1.3.1 Hierarchical Structure of Software-Components

In AUTOSAR the structure of an E/E-system is described using the AUTOSAR Software Component Template and especially the mechanism of compositions. Such a Top Level Composition assembles subsystems and connects their ports.

Of course such a composition utilizes a lot of hierarchical levels where compositions instantiate other composition types and so on. But at some low hierarchical level each composition only consists of AtomicSwComponentType instances. And those instances of AtomicSwComponentTypes are what the RTE is going to be working with.

4.1.3.2 Ports, Interfaces and Connections

Each AUTOSAR software-component (SwComponentType) can have ports (PortPrototype). An AUTOSAR software-component has provide ports (PPortPrototype) and/or has require ports (RPortPrototype) to communicate with other AUTOSAR software-components. The requiredInterface or providedInterface (PortInterface) determines if the port is a sender/receiver or a client/server port. The attribute isService is used with AUTOSAR Services (see section 4.1.5).

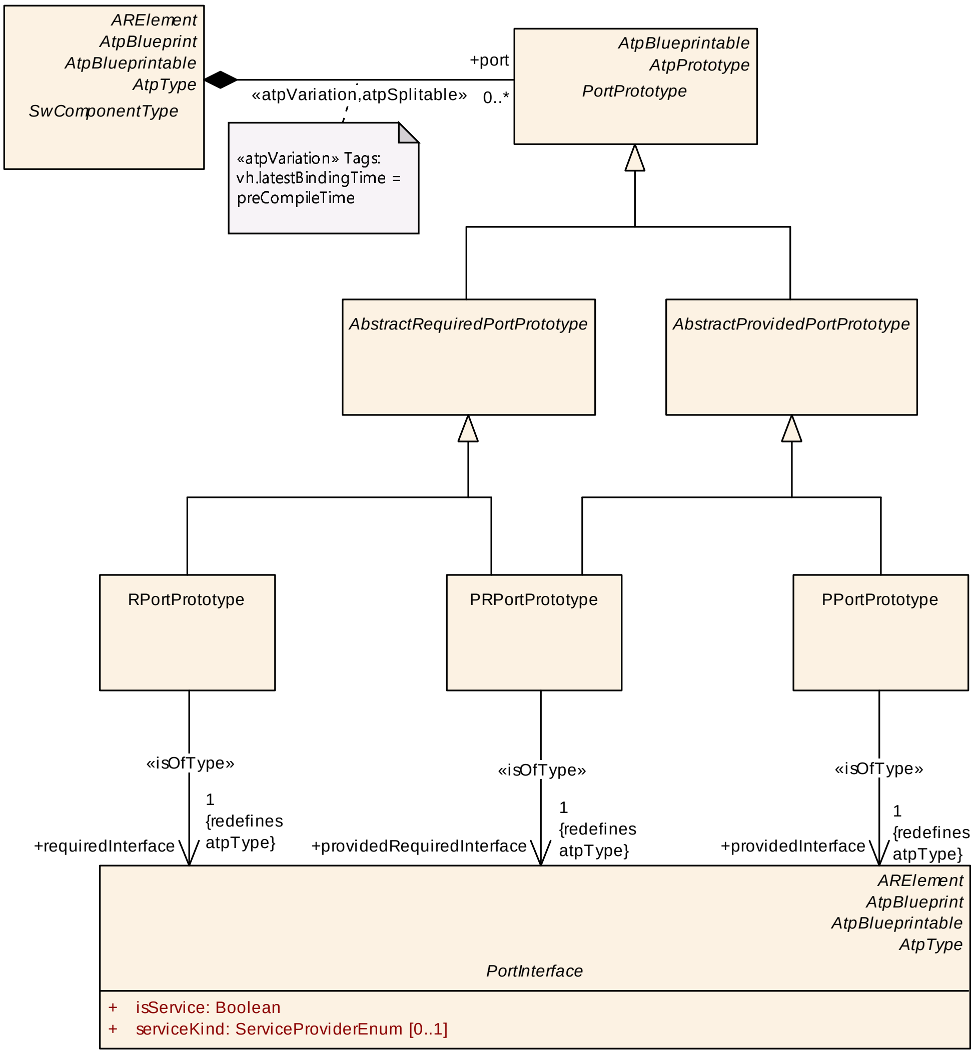


Figure 4.3: Software-Components and Ports

When compositions are built of instances the ports can be connected either within the composition or made accessible to the outside of the composition. For the connections inside a composition the AssemblySwConnector is used, while the DelegationSwConnector is used to connect ports from the inside of a composition to the outside. Ports not connected will be handled according to the requirement [SRS_Rte_00139].

The next step is to map the SW-C instances on ECUs and to establish the communication relationships. From this step the actual communication is derived, so it is now fixed if a connection between two instance's ports is going to be over a communication bus or locally within one ECU.

[SWS_Rte_02200] ⌈ The RTE shall implement the communication paths specified by the ECU Configuration description. ⌋*(SRS_Rte_00027)*

[SWS_Rte_02201] ⌈ The RTE shall implement the semantic of the communication attributes given by the AUTOSAR software-component description. The semantic of the given communication mechanism shall not change regardless of whether the communication partner is located on the same partition, on another partition of the same ECU or on a remote ECU, or whether the communication is done by the RTE itself or by the RTE calling COM or IOC. ⌋*(SRS_Rte_00027)*

E.g., according to [SWS_Rte_02200] and [SWS_Rte_02201] the RTE is not permitted to change the semantic of an asynchronous client to synchronous because both client and server are mapped to the very same ECU.

4.1.3.3 Internal Behavior

Only for `AtomicSwComponentType`s the internal structure is exposed in the `SwcInternalBehavior` description. Here the definition of the `RunnableEntity`s and used `RTEEvent`s is done (see Figure 4.4).

The AUTOSAR MetaModel enforces that there is at most one `SwcInternalBehavior` per `AtomicSwComponentType`

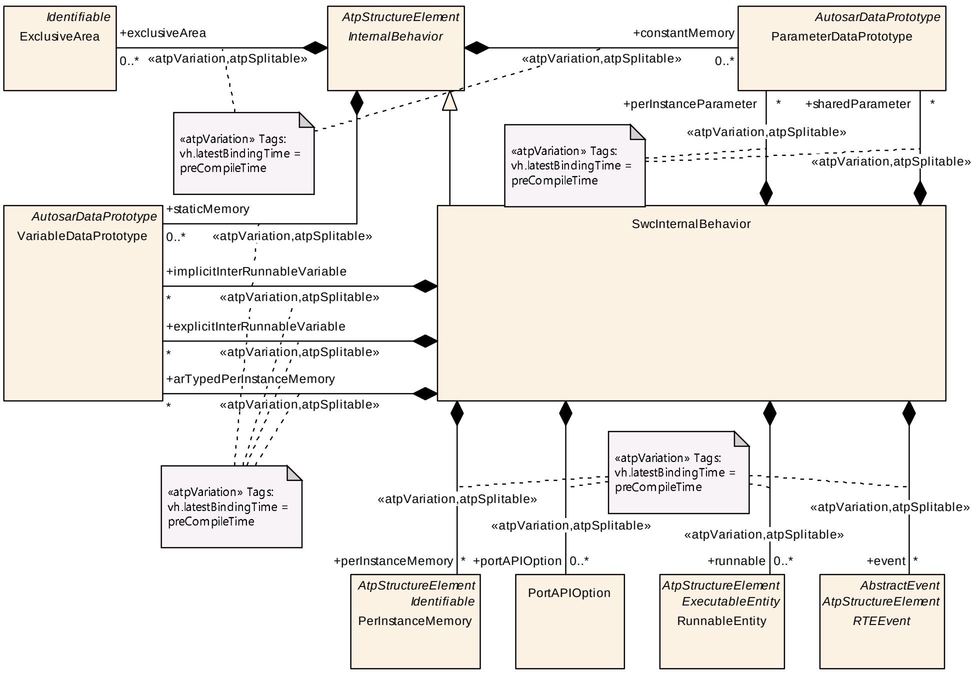


Figure 4.4: Software-component internal behavior

RunnableEntitys (also abbreviated simply as Runnable) are the smallest code fragments that are provided by AUTOSAR software-components and those basic software modules that implement *AUTOSAR Interface*s. They are represented by the meta-class RunnableEntity, see Figure 4.5.

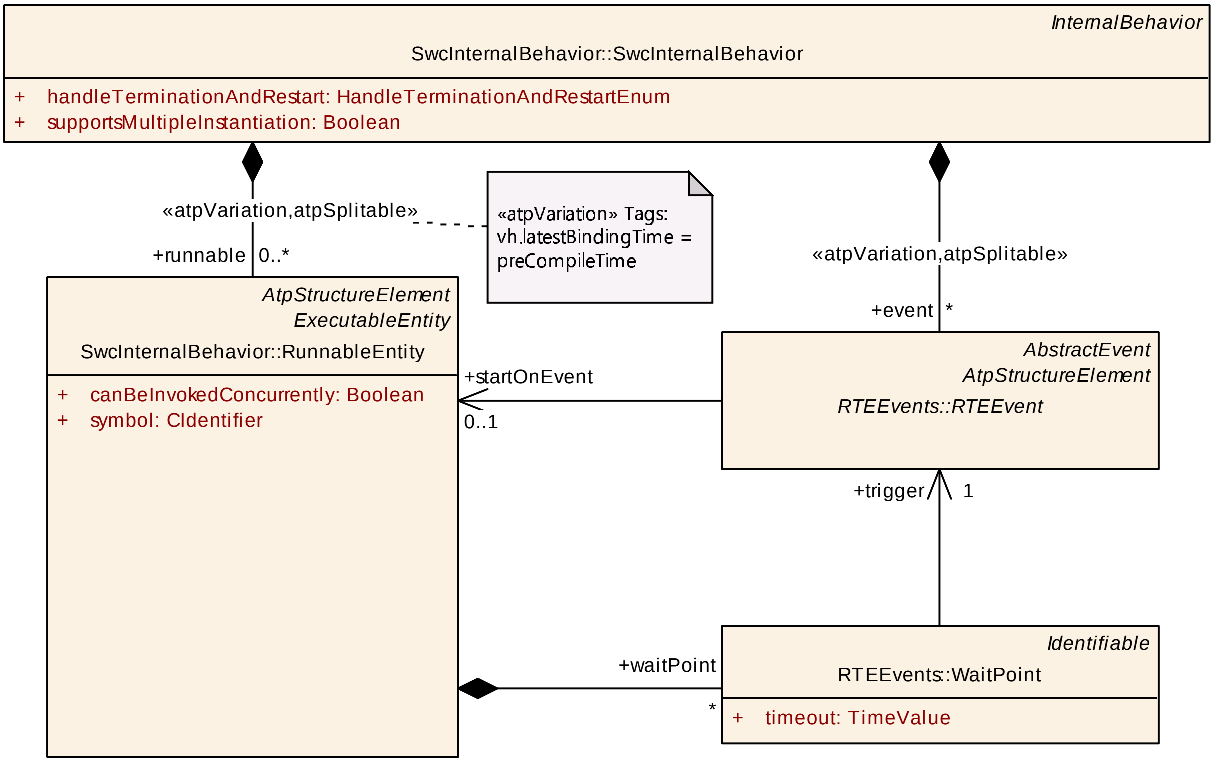


Figure 4.5: Software-component runnable entity, wait points and RTE Events

In general, software components are composed of multiple RunnableEntitys in order to accomplish servers, receivers, feedback, etc.

[SWS_Rte_02202] ⌈ The RTE shall support multiple RunnableEntitys in AUTOSAR software-components. ⌋ *(SRS_Rte_00031)*

RunnableEntitys are executed in the context of an OS task, their execution is triggered by RTEEvents. Section 4.2.2.3 gives a more detailed description of the concept of RunnableEntitys, Section 4.2.2.6 discusses the problem of mapping RunnableEntitys to OS tasks. RTEEvents and the activation of RunnableEntitys by RTEEvents is treated in Section 4.2.2.4.

[SWS_Rte_02203] ⌈ The RTE shall trigger the execution of RunnableEntitys in accordance with the connected RTEEvent. ⌋ *(SRS_Rte_00072)*

[SWS_Rte_02204] ⌈ The RTE Generator shall reject configurations where an RTEEvent instance which can start a RunnableEntity is not mapped to an OS task. The only exceptions are RunnableEntitys that are invoked by a direct function call. ⌋ *(SRS_Rte_00049, SRS_Rte_00018)*

[SWS_Rte_07347] ⌈ The RTE Generator shall reject configurations where RunnableEntitys of a SW-C are mapped to tasks of different partitions. ⌋ *(SRS_Rte_00036, SRS_Rte_00018)*

[SWS_Rte_02207] ⌈ The RTE shall respect the configured execution order of RunnableEntitys within one OS task. ⌋ *(SRS_Rte_00070)*

[SWS_Rte_08768] ⌈ The RTE generator shall reject configuration where the scope of a VariableAccess is violated by the system and/or ECU configuration. ⌋ *(SRS_Rte_00018)*

[SWS_Rte_CONSTR_09081] Mapping to partition vs the value of VariableAccess.scope ⌈ For every connection between SwComponentPrototypes mapped to different partitions the value of VariableAccess.scope shall not be set to VariableAccessScopeEnum.communicationIntraPartition. ⌋ *()*

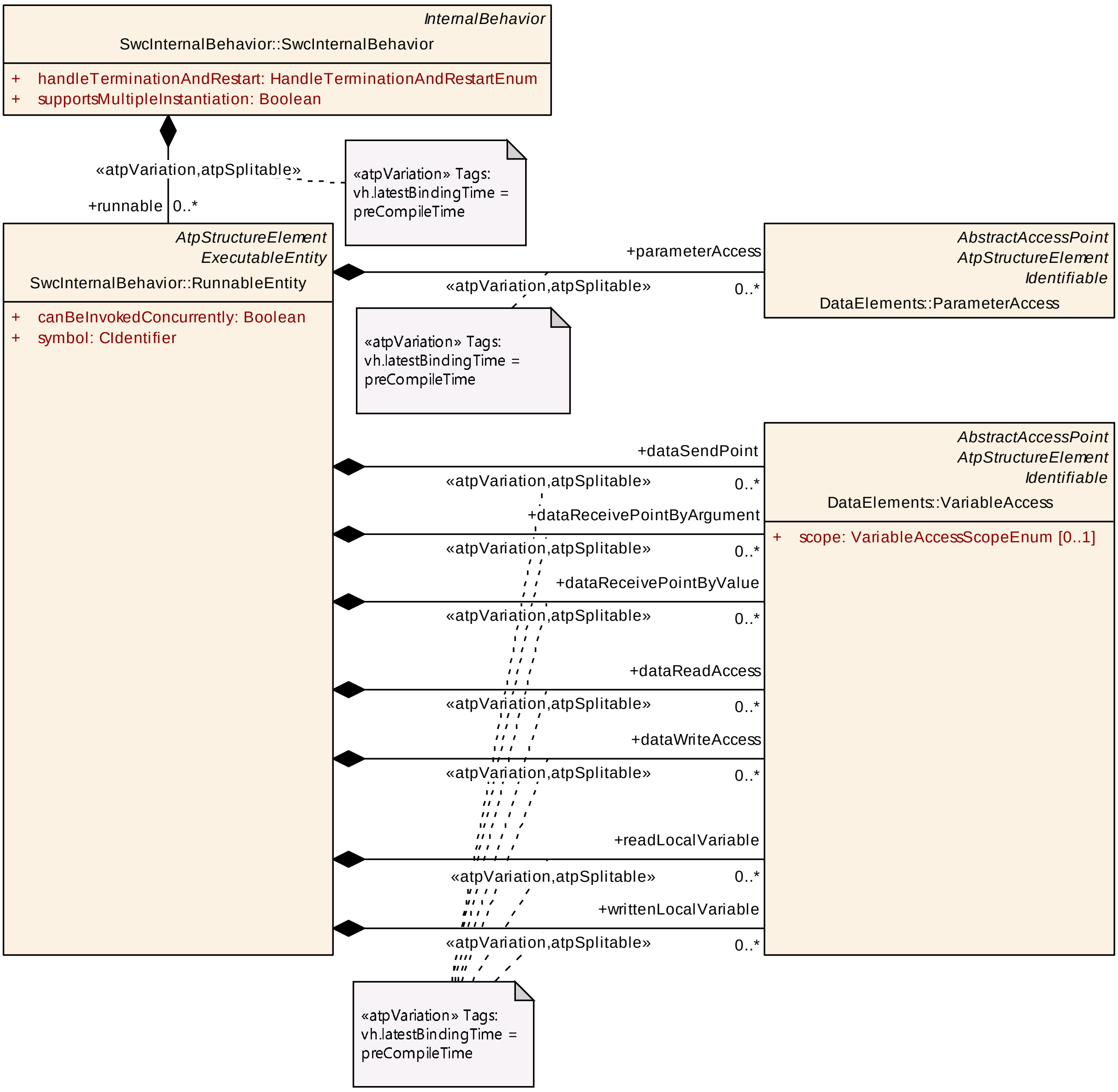


Figure 4.6: Software-component runnable entity and data accesses

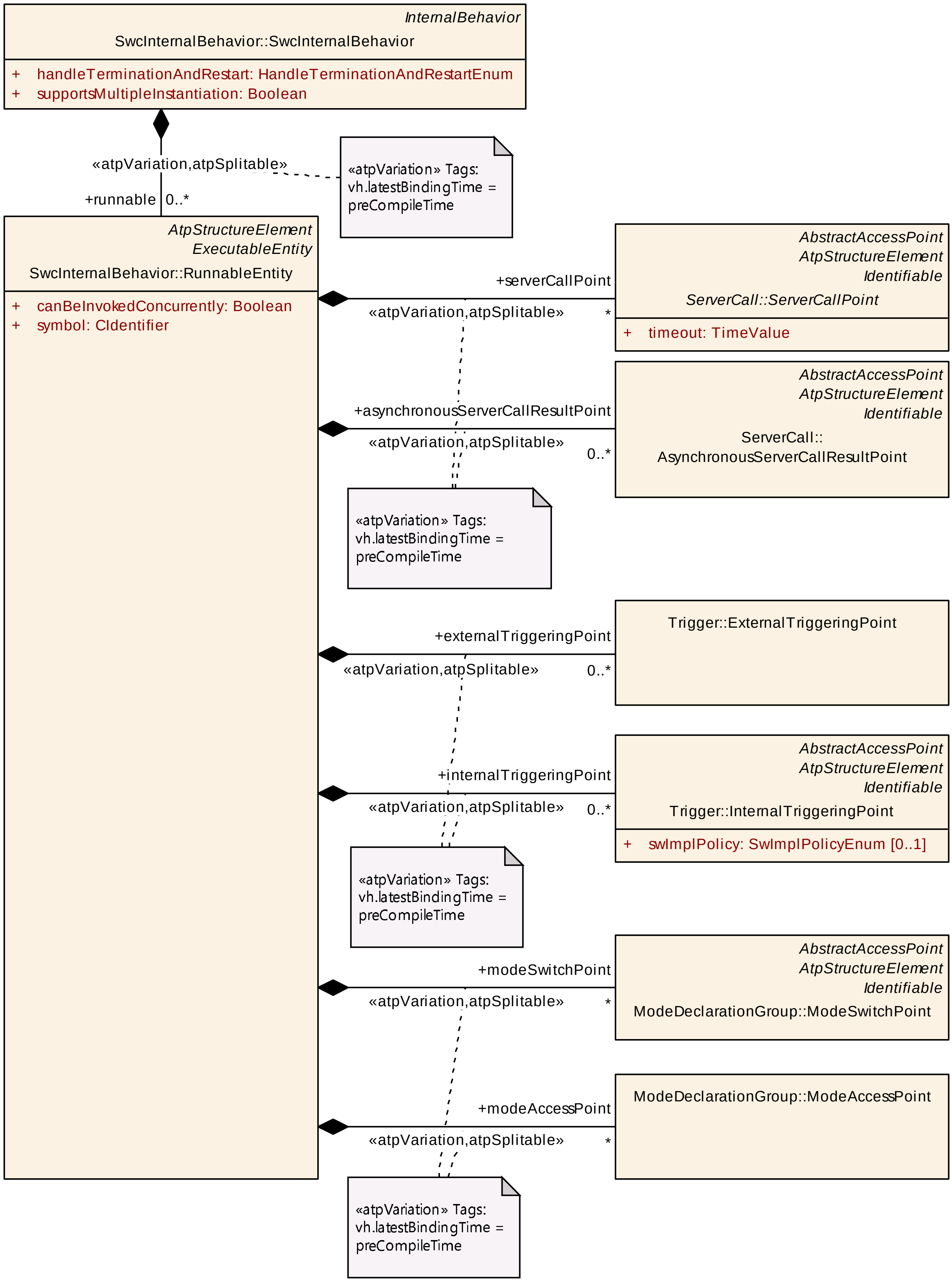


Figure 4.7: Software-component runnable entity and server invocation, trigger, and mode switches

With the information from SwcInternalBehavior a part of the setup of the AUTOSAR software-component within the RTE and the OS can already be configured. Furthermore, the information (description) of the structure (ports, interfaces) and the internal behavior of an AUTOSAR software component are sufficient for the *RTE Contract Phase*.

However, some detailed information is still missing and this is part of the Implementation description.

4.1.3.4 Implementation

In the Implementation description an actual implementation of an AUTOSAR software-component is described including the memory consumption (see Figure 4.8).

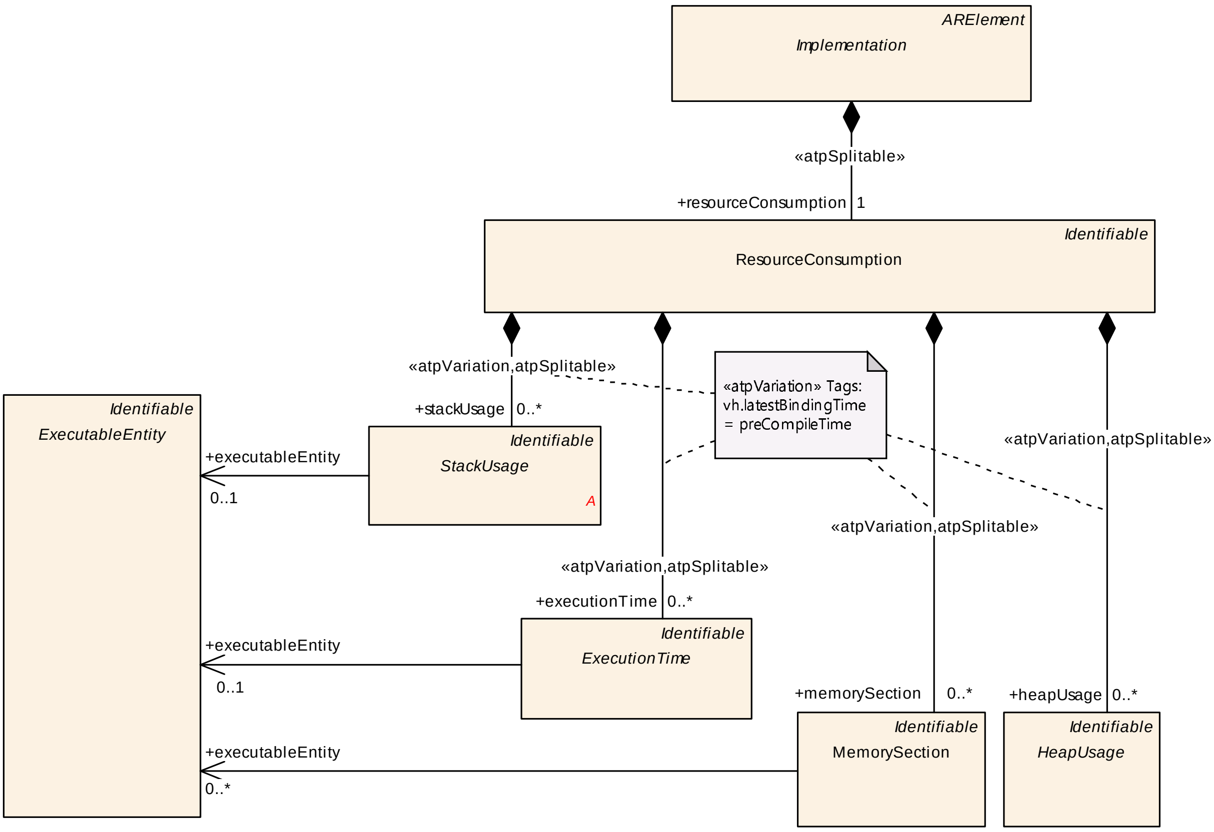


Figure 4.8: Software-component resource consumption

Note that the information from the Implementation part are only required for the *RTE Generation Phase*, if at all.

4.1.4 Instantiation

4.1.4.1 Scope and background

Generally spoken, the term *instantiation* refers to the process of deriving specific instances from a model or template. But, this process can be accomplished on different levels of abstraction. Therefore, the instance of the one level can be the model for the next.

With respect to AUTOSAR four modeling levels are distinguished. They are referred to as the levels $M3$ to $M0$.

The level $M3$ describes the concepts used to derive an AUTOSAR meta model of level $M2$. This meta model at level $M2$ defines a language in order to be able to describe specific attributes of a model at level $M1$, e.g., to be able to describe an specific type of an AUTOSAR software component. E.g., one part of the AUTOSAR meta model is called *Software Component Template* or *SW-C-T* for short and specified in [2]. It is discussed more detailed in section 4.1.3.

At level $M1$ engineers will use the defined language in order to design components or interfaces or compositions, say to describe an specific *type* of a *LightManager*. Hereby, e.g., the descriptions of the (atomic) software components will also contain an internal behavior as well as an implementation part as mentioned in section 4.1.3.

Those descriptions are input for the RTE Generator in the so-called 'Contract Phase' (see section 3.1.1). Out of this information specific APIs (in a programming language) to access ports and interfaces will be generated.

Software components generally consist of a set of Runnable Entities. They can now specifically be described in a programming language which can be refered to as "implementation". As one can see in section 4.1.3 this "implementation" then corresponds exactly to one implementation description as well as to one internal behavior description.

$M0$ refers to a specific running instance on a specific car.

Objects derived from those specified component types can only be executed in a specific run time environment (on a specific target). The objects embody the real and running implementation and shall therefore be referred to as software component instances (on modeling level $M0$). E.g., there could be two component instances derived from the same component type *LightManager* on a specific *light controller* ECU each responsible for different lights. Making instances means that it should be possible to distinguish them even though the objects are descended from the same model.

With respect to this more narrative description the *RTE* as the *run time environment* shall enable the process of instantiation. Thereby the term *instantiation* throughout the document shall refer to the process of deriving and providing explicit particular descriptions of all occuring instances of all types. Therefore, this section will address the problems which can arise out of the instantiation process and will specify the needs for AUTOSAR components and the AUTOSAR RTE respectively.

4.1.4.2 Concepts of instantiation

Regardless of the fact that the (aforementioned) instantiation of AUTOSAR software components can be generally achieved on a per-system basis, the RTE Generator restricts its view to a per-ECU customization (see [SWS_Rte_05000]).

Generally, there are two different kinds of instantiations possible:

- single instantiation – which refers to the case where only *one* object or AUTOSAR software component instance will be derived out of the AUTOSAR software component description
- multiple instantiation – which refers to the case where *multiple* objects or AUTOSAR software component instances will be derived out of the AUTOSAR software component description

[SWS_Rte_02001] ⌈ The RTE Generator shall be able to instantiate one or more AUTOSAR software component instances out of a single AUTOSAR software component description. ⌋*(SRS_Rte_00011)*

[SWS_Rte_02008] ⌈ The RTE Generator shall evaluate the attribute *supportsMultipleInstantiation* of the *SwcInternalBehavior* of an AUTOSAR software component description. ⌋*(SRS_Rte_00011)*

[SWS_Rte_02009] ⌈ The RTE Generator shall reject configurations where multiple instantiation is required, but the value of the attribute *supportsMultipleInstantiation* of the *SwcInternalBehavior* of an AUTOSAR software component description is set to *FALSE*. ⌋*(SRS_Rte_00011, SRS_Rte_00018)*

4.1.4.3 Single instantiation

Single instantiation refers to the easiest case of instantiation.

To be instantiated merely means that the code and the corresponding data of a particular `RunnableEntity` are embedded in a runtime context. In general, this is achieved by the context of an OS task (see example 4.1).

Example 4.1

Runnable entity `R1` called out of a task context:

```
TASK(Task1){
    ...
    R1();
    ...
}
```

Since the single instance of the software component is unambigous per se no additional concepts have to be added.

4.1.4.4 Multiple instantiation

[SWS_Rte_02002] ⌈ Multiple objects instantiated from a single AUTOSAR software component (type) shall be identifiable without ambiguity. ⌋*(SRS_Rte_00011)*

There are two *principle* ways to achieve this goal –

- by code duplication (of runnable entities)
- by code sharing (of reentrant runnable entities)

For now it was decided to solely concentrate on code sharing and not to support code duplication.

[SWS_Rte_03015] ⌈ The RTE only supports multiple objects instantiated from a single AUTOSAR software component by code sharing, the RTE doesn't support code duplication. ⌋*(SRS_Rte_00011, SRS_Rte_00012)*

Multiple instances can share the same code, if the code is reentrant. For a multi core controller, the possibility to share code between the cores depends on the hardware.

Example 4.2 is similar to the example 4.1, but for a software-component that support multiple instantiations, and where two instances have their `R1` `RunnableEntity` mapped to the same task.

Example 4.2

Runnable entity `R1` called for two instances out of the same task context:

```
TASK(Task1){
    ...
    R1(instance1);
    R1(instance2);
    ...
}
```

The same code for `R1` is shared by the different instances.

4.1.4.4.1 Reentrant code

In general, side effects can appear if the same code entity is invoked by different threads of execution running, namely tasks. This holds particularly true, if the invoked code entity inherits a state or memory by the means of static variables which are visible to all instances. That would mean that all instances are coupled by those static variables.

Thus, they affect each other. This would lead to data consistency problems on one hand. On the other – and that is even more important – it would introduce a new communication mechanism to AUTOSAR and this is forbidden. AUTOSAR software components can only communicate via ports.

To be complete, it shall be noted that a calling code entity also inherits the reentrancy problems of its callee. This holds especially true in case of recursive calls.

4.1.4.4.2 Unambiguous object identification

[SWS_Rte_02015] ⌈ The instantiated AUTOSAR software component objects shall be unambiguously identifiable by an *instance handle*, if multiple instantiation by sharing code is required. ⌋*(SRS_Rte_00011, SRS_Rte_00012)*

4.1.4.4.3 Multiple instantiation and Per-instance memory

An AUTOSAR SW-C can define internal memory only accessible by a SW-C instance itself. This concept is called PerInstanceMemory. The memory can only be accessed by the runnable entities of this particular instance. That means in turn, other instances don't have the possibility to access this memory.

PerInstanceMemory API principles are explained in Section 5.2.5.

The API for PerInstanceMemory is specified in Section 5.6.15.

4.1.5 RTE and AUTOSAR Services

According to the AUTOSAR glossary [11] "an AUTOSAR service is a logical entity of the Basic Software offering general functionality to be used by various AUTOSAR software components. The functionality is accessed via standardized AUTOSAR interfaces".

Therefore, AUTOSAR services provide standardized AUTOSAR Interfaces: ports typed by standardized `PortInterface`s.

When connecting AUTOSAR service ports to ports of AUTOSAR software components the RTE maps standard RTE API calls to the symbols defined in the RTE input (i.e. XML) for the AUTOSAR service runnables of the BSW. The key technique to distinguish ECU dependent identifiers for the AUTOSAR services is called "port-defined argument values", which is described in Section 4.3.2.4. Currently "port-defined argument values" are only supported for client-server communication. It is not possible to use a pre-defined symbol for sending or receiving data.

The RTE does not pass an instance handle to the *C*-based API of AUTOSAR services since the latter are single-instantiatable (see [SWS_Rte_03806]).

As displayed on figure 4.2, there can be direct interactions between the RTE and some Basic Software Modules. This is the case of the Operating System, the AUTOSAR Communication, and the NVRAM Manager.

4.1.6 RTE and ECU Abstraction

The *ECU Abstraction* provides an interface to physical values for AUTOSAR software components. It abstracts the physical origin of signals (their pathes to the ECU hardware ports) and normalizes the signals with respect to their physical appearance (like specific values of current or voltage).

See the AUTOSAR ECU architecture in figure 4.2. From an architectural point of view the ECU Abstraction is part of the *Basic Software* layer and offers AUTOSAR interfaces to AUTOSAR software components.

Seen from the perspective of an RTE, regular AUTOSAR ports are connected. Without any restrictions all communication paradigms specified by the AUTOSAR Virtual Functional Bus (VFB) shall be applicable to the ports, interfaces and connections – sender-receiver just as well as client-server mechanisms.

However, ports of the ECU Abstraction shall always only be connected to ports of specific AUTOSAR software components: sensor or actuator software components. In this sense they are tightly coupled to a particular ECU Abstraction.

Furthermore, it must not be possible (by an RTE) to connect AUTOSAR ports of the ECU Abstraction to AUTOSAR ports of any AUTOSAR component located on a remote ECU (see [SWS_Rte_02051].

This means, e.g., that sensor-related signals coming from the ECU Abstraction are always received by an AUTOSAR sensor component located on the same ECU. The AUTOSAR sensor component will then process the received signal and deploy it to other AUTOSAR components regardless of whether they are located on the same or any remote ECU. This applies to actuator-related signals accordingly, however, the opposite way around.

[SWS_Rte_02050] ⌈ The RTE Generator shall generate a communication path between connected ports of AUTOSAR sensor or actuator software components and the ECU Abstraction in the exact same manner like for connected ports of AUTOSAR software components. ⌋*()*

[SWS_Rte_02051] ⌈ The RTE Generator shall reject configurations which require a communication path from a AUTOSAR software component to an ECU Abstraction located on a remote ECU. ⌋*(SRS_Rte_00062, SRS_Rte_00018)*

Further information about the ECU Abstraction can be found in the corresponding specification document [17].

4.1.7 RTE and Complex Device Driver

A Complex Device Driver has an AUTOSAR Interface, therefore the RTE can deal with the communication on the Complex Device Drivers ports. The Complex Device Driver is allowed to have code entities that are not under control of the RTE but yet still may use the RTE API (e.g. ISR2, BSW main processing functions).

4.1.8 Basic Software Scheduler and Basic Software Modules

4.1.8.1 Description of a Basic Software Module

The description of a Basic Software Module is divided into the sections

- interfaces
- internal behavior
- implementation

For further details see document [9].

4.1.8.2 Basic Software Interfaces

The interface of a *Basic Software Module* is described with *Basic Software Module Entries* (*BswModuleEntry*). For the functionality of the *Basic Software Scheduler* only *BswModuleEntry*s from *BswCallType SCHEDULED* are relevant. Nevertheless for optimization purpose the analysis of the full call tree might be required which requires the consideration of all *BswModuleEntry*'s

4.1.8.3 Basic Software Internal Behavior

The *Basic Software Internal Behavior* specifies the behavior of a BSW module or a BSW cluster w.r.t. the code entities visible by the BSW Scheduler. For the *Basic Software Scheduler* mainly *Basic Software Schedulable Entities* (*BswSchedulableEntity*'s) are relevant. These are *Basic Software Module Entities*, which are designed for control by the *Basic Software Scheduler*. *Basic Software Schedulable Entities* are implementing main processing functions. Furthermore all *Basic Software Schedulable Entities* are allowed to use exclusive areas and for call tree analysis all *Basic Software Module Entities* are relevant.

[SWS_Rte_07514] ⌈ The *Basic Software Scheduler* shall support multiple *Basic Software Module Entities* in *AUTOSAR Basic Software Modules*. ⌋*(SRS_Rte_00211, SRS_Rte_00213, SRS_Rte_00216)*

[SWS_Rte_07515] ⌈ The *Basic Software Scheduler* shall trigger the execution of *Schedulable Entity*'s in accordance with the connected *BswEvent*. ⌋*(SRS_Rte_00072)*

[SWS_Rte_07516] ⌈ The RTE Generator shall reject configurations where an *BswEvent* which can start a *Schedulable Entity* is not mapped to an OS task. The exceptions are *BswEvent* that are implemented by a direct function call. ⌋*(SRS_Rte_00049, SRS_Rte_00018)*

[SWS_Rte_07517] ⌈ The RTE Generator shall respect the configured execution order of *Schedulable Entities* within one OS task. ⌋*(SRS_Rte_00219)*

[SWS_Rte_07518] ⌈ The RTE shall support the execution sequences of *Runnable Entities* and *Schedulable Entities* within the same OS task in an arbitrarily configurable order. ⌋*(SRS_Rte_00219)*

4.1.8.4 Basic Software Implementation

The implementation defines further details of the implantation of the *Basic Software Module*. The *vendorApiInfix* attribute is of particular interest, because it defines the name space extension for multiple instances of the same basic software module. Further on the category of the `codeDescriptor` specifies if the *Basic Software Module* is delivered as source code or as object.

4.1.8.5 Multiple Instances of Basic Software Modules

In difference to the multiple instantiation concept of software components, where the same component code is used for all component instances, basic software modules are multiple instantiated by creation of own code per instance in a different name space. The attribute *vendorApiInfix* allows to define name expansions required for global symbols.

4.1.8.6 AUTOSAR Services / ECU Abstraction / Complex Device Drivers

AUTOSAR Services, *ECU Abstraction* and *Complex Device Drivers* are hybrid of AUTOSAR software-component and *Basic Software Module*. These kinds of modules might use *AUTOSAR Interfaces* to communicate via RTE as well as C-API to directly access other *Basic Software Modules*. Caused by the structure of the *AUTOSAR Meta Model* some entities of the 'C' implementation have to be described twice; on the one hand by the means of the *Software Component Template* [2] and on the other hand by the means of the *Basic Software Module Description Template* [9]. Further on the dualism of port based communication between software component and non-port based communication between *Basic Software Modules* requires in some cases the coordination and synchronization between both principles. The information about elements belonging together is provided by the so called *SwcBswMapping*.

4.1.8.6.1 RunnableEntity / BswModuleEntity mapping

A *Runnable Entity* which is mapped to a *Basic Software Module Entity* has to be treated as one common entity. This means it describes an entity which can use the features of a *Runnable Entity* and a *Basic Software Module Entity* as well. For instance it supports to use the port based API as well as *Basic Software Scheduler* API in one C function.

4.1.8.6.2 Synchronized ModeDeclarationGroupPrototype

Two synchronized *ModeDeclarationGroupPrototype* are resulting in the implementation of one common `mode machine instance`. Consequently the call of the belonging `Rte_Switch` API and the `SchM_Switch` API are having the same effect. For optimization purpose the `Rte_Switch` API might just refer to the `SchM_Switch` API.

4.1.8.6.3 Synchronized Trigger

Two synchronized *Trigger* are behaving like one common *Trigger*. Consequently the call of the belonging `Rte_Trigger` API and the `SchM_Trigger` API are having the same effect. For optimization purpose the `Rte_Trigger` API might just refer to the `SchM_Trigger` API.

4.2 RTE and Basic Software Scheduler Implementation Aspects

4.2.1 Scope

This section describes some specific implementation aspects of an AUTOSAR RTE and the Basic Software Scheduler. It will mainly address

- the mapping of logical concepts (e.g., Runnable Entities, BSW Schedulable Entities) to technical architectures (namely, the AUTOSAR OS)
- the decoupling of pending interrupts (in the Basic Software) and the notification of AUTOSAR software components
- data consistency problems to be solved by the RTE

Therefore this section will also refer to aspects of the interaction of the AUTOSAR RTE and Basic Software Scheduler and the two modules of the AUTOSAR Basic Software with standardized interfaces (see Figure 4.9):

- the module *AUTOSAR Operating System* [18, 4]
- the module *AUTOSAR COM* [19, 3]

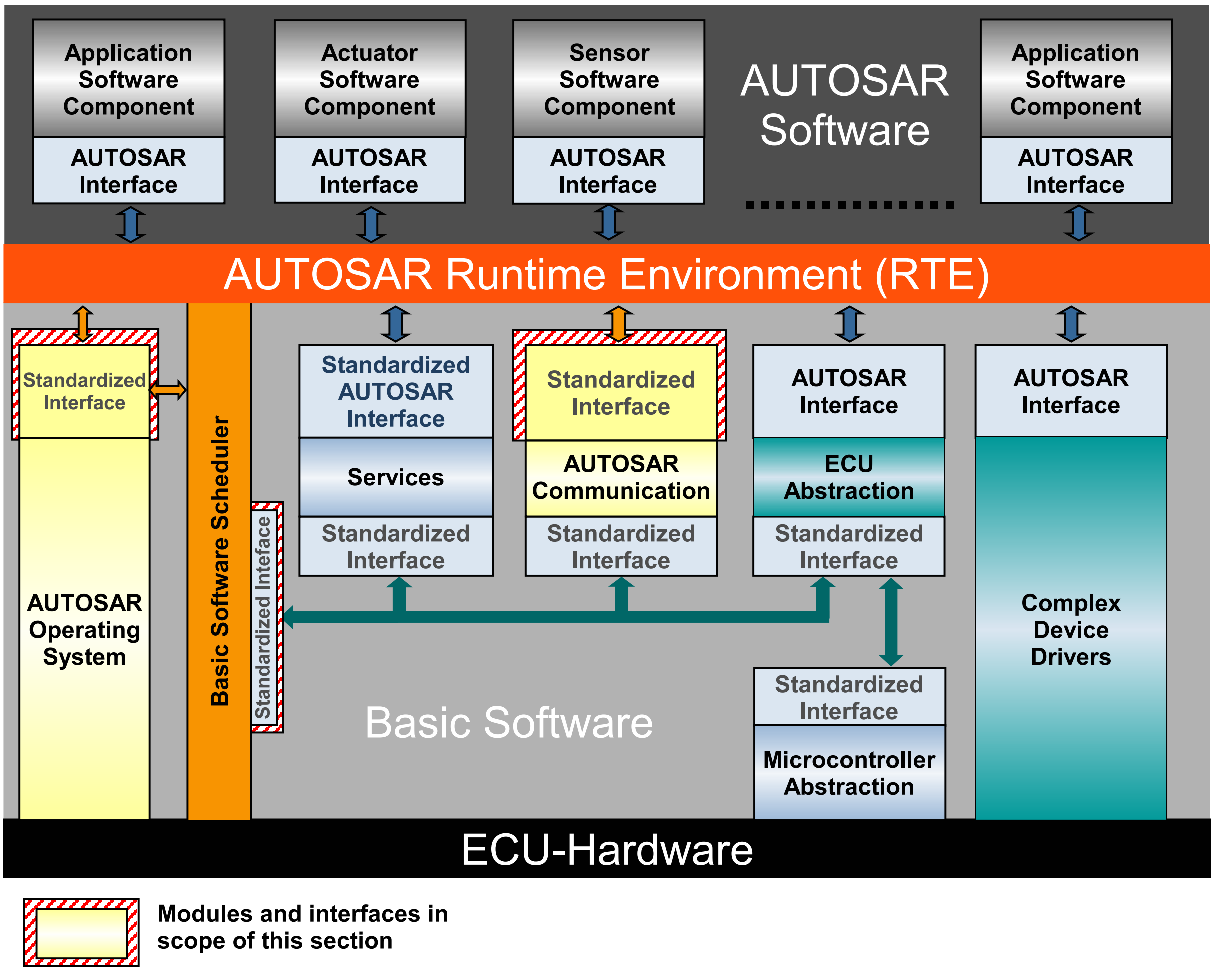


Figure 4.9: Scope of the section on Basic Software modules

Having a standardized interface means *first* that the modules do not provide or request services for/of the *AUTOSAR software components* located above the RTE. They do not have ports and therefore cannot be connected to the aforementioned AUTOSAR software components. AUTOSAR OS as well as AUTOSAR COM are simply invisible for them.

Secondly AUTOSAR OS and AUTOSAR COM are used by the RTE in order to achieve the functionality requested by the AUTOSAR software components. The AUTOSAR COM module is used by the RTE to route a signal over ECU boundaries, but this mechanism is hidden to the sending as well as to the receiving AUTOSAR software component. The AUTOSAR OS module is used for two main purposes. First, OS is used by the RTE to route a signal over core and partition boundaries. Secondly, the AUTOSAR OS module is used by the RTE in order to properly schedule the single Runnables in the sense that the RTE Generator generates Task-bodies which contain then the calls to appropriate Runnables.

In this sense the RTE shall also *use* the available means to convert interrupts to notifications in a task context or to guarantee data consistency.

With respect to this view, the RTE is *thirdly* **not** a generic abstraction layer for AUTOSAR OS and AUTOSAR COM. It is generated for a specific ECU and offers the same *interface* to the AUTOSAR Software Components as the VFB. It implements the functionality of the VFB using modules of the Basic Software, including a specific implementation of AUTOSAR OS and AUTOSAR COM.

The *Basic Software Scheduler* offers services to integrate *Basic Software Modules* for all modules of all layers. Hence, the *Basic Software Scheduler* provides the following functions:

- embed *Basic Software Modules* implementations into the *AUTOSAR OS* context
- trigger `BswSchedulableEntity`s of the *Basic Software Modules*
- apply data consistency mechanisms for the *Basic Software Modules*

The integrator's task is to apply given means (of the AUTOSAR OS) in order to assemble BSW modules in a well-defined and efficient manner in a project specific context.

This also means that the BSW Scheduler only uses the AUTOSAR OS. It is not in the least a competing entity for the AUTOSAR OS scheduler.

[SWS_Rte_02250] ⌈ The RTE shall only use the AUTOSAR OS, AUTOSAR COM, AUTOSAR Efficient COM for Large Data, AUTOSAR Transformer and AUTOSAR NVRAM Manager in order to provide the RTE functionality to the AUTOSAR components. ⌋ *(SRS_Rte_00020)*

[SWS_Rte_07519] ⌈ The *Basic Software Scheduler* shall only use the *AUTOSAR OS* in order to provide the *Basic Software Scheduler* functionality to the *Basic Software Modules*. ⌋ *()*

[SWS_Rte_06200] ⌈ The RTE Generator shall construct task bodies for those tasks which contain `RunnableEntity`s. ⌋ *(SRS_Rte_00049)*

[SWS_Rte_06201] ⌈ The RTE Generator shall construct task bodies for those tasks which contain *Basic Software Schedulable Entities*. ⌋ *(SRS_Rte_00049)*

The information for the construction of task bodies has to be given by the ECU Configuration description. The mapping of *Runnable Entities* to tasks is given as an input by the ECU Configuration description. The RTE Generator does not decide on the mapping of `RunnableEntity`s to tasks.

[SWS_Rte_04557] ⌈ The RTE Generator shall wrap each each definition of a task body with the *Memory Mapping*.

```
#define OS_START_SEC_<sadm>
#include "Os_MemMap.h"

<task body definition>

#define OS_STOP_SEC_<sadm>
#include "Os_MemMap.h"
```

where <sadm> is the shortName of the SwAddrMethod, if configured in *OsMemoryMappingCodeLocationRef* of the according OsTask. If *OsMemoryMappingCodeLocationRef* is not defined , <sadm> shall be CODE_<Taskname>. ⌋*(SRS_Rte_00049, SRS_BSW_00351)*

Note: Requirement [SWS_Rte_04557] is an exception to [SWS_Rte_05088].

[SWS_Rte_02254] ⌈ The RTE Generator shall reject configurations where input information is missing regarding the mapping of BswEvents to OS tasks and RTEEvents (which trigger runnables) to OS tasks. ⌋*(SRS_Rte_00049, SRS_Rte_00018)*

Note: Not in all cases an event to task mapping is required. For example runnables which shall be called via direct function call need no event to task mapping.

[SWS_Rte_08417] ⌈ The RTE Generator shall reject configurations where input information is missing regarding the construction of tasks bodies. ⌋*(SRS_Rte_00049, SRS_Rte_00018)*

There are use cases (e.g. a set of tasks with defined call order on different partitions) where another task needs to be explicitly activated when the current task terminates.

With the configuration of RteOsTaskChains it's possible to configure the intended task chain behavior for such cases.

[SWS_Rte_04558] ⌈ In case an OsTask is referenced by an RtePredecessorOsTaskRef the RTE shall emit in the according task body a ChainTask call to the OsTask given as RteSuccessorOsTaskRef at the location in the task body where the task terminates. ⌋*(SRS_Rte_00049)*

[SWS_Rte_04559] ⌈ The RTE shall activate the chaining OsTask (defined by RtePredecessorOsTaskRef) instead the chained OsTask (RteSuccessorOsTaskRef) if the RTE needs to activate an OsTask to activate ExecutableEntitys. ⌋*(SRS_Rte_00049)*

Example 4.3

```
...
TASK(Task_Core1_10ms)
{

  /../

  ChainTask(Task_Core2_10ms)
}
...
```

[SWS_Rte_CONSTR_04558] ⌈ An OsTask shall be part of at most one task chain. Hence, an OsTask shall be referenced by at most one RtePredecessorOsTaskRef and by at most one RteSuccessorOsTaskRef. ⌋*(SRS_Rte_00049)*

[SWS_Rte_CONSTR_04559] ⌈ The configuration of RteOsTaskChains shall not define circular chains. ⌋*(SRS_Rte_00049)*

Note: For instance a configuration where T1 chains T2 and T2 chains T1 is not permitted.

4.2.2 OS

This section describes the interaction between the RTE + Basic Software Scheduler and the AUTOSAR OS. The interaction is realized via the standardized interface of the OS - the AUTOSAR OS API. See Figure 4.9.

The OS is statically configured by the ECU Configuration. The RTE generator however may be allowed to create tasks and other OS objects, which are necessary for the runtime environment (see [SWS_Rte_05150]). The mapping of `RunnableEntity`s and *BSW Schedulable Entities* to OS tasks is not the job of the RTE generator. This mapping has to be done in a configuration step before, in the RTE-Configuration phase. The RTE generator is responsible for the generation of OS task bodies, which contain the calls for the `RunnableEntity`s and *BSW Schedulable Entities*. The `RunnableEntity`s and *BSW Schedulable Entities* themselves are OS independent and are not allowed to use OS service calls. The RTE and *Basic Software Scheduler* have to encapsulate such calls via the standardized RTE API respectively *Basic Software Scheduler* API.

4.2.2.1 OS Objects

Tasks

- The RTE generator has to create the task bodies, which contain the calls of the `RunnableEntity`s and `BswSchedulableEntity`s. Note that the term *task body* is used here to describe a piece of code, while the term *task* describes a configuration object of the OS.
- The RTE and *Basic Software Scheduler* controls the task activation/resumption either directly by calling OS services like `SetEvent()` or `ActivateTask()` or indirectly by initializing OS alarms or starting Schedule-Tables for time-based activation of `RunnableEntity`s. If the task terminates, the generated taskbody also contains the calls of `TerminateTask()` or `ChainTask()`.
- The RTE generator does **not** create tasks. The mapping of `RunnableEntity`s and `BswSchedulableEntity`s to tasks is the input to the RTE generator and is therefore part of the RTE Configuration.
- The RTE configurator has to allocate the necessary tasks in the OS configuration.

OS applications

- AUTOSAR OS has in R4.0 a new feature called Inter-OS-Application Communication (IOC). IOC is generated by the OS based on the configuration partially generated by the RTE. The appropriate objects (OS-Applications) are generated by the OS, and are used by RTE to for task/runnable mapping.

Events

- The RTE and *Basic Software Scheduler* may use OS Events for the implementation of the abstract RTEEvents and BswEvents.
- The RTE and *Basic Software Scheduler* therefore may call the OS service functions SetEvent(), WaitEvent(), GetEvent() and ClearEvent().
- The used OS Events are part of the input information of the RTE generator.
- The RTE configurator has to allocate the necessary events in the OS configuration.

Resources

- The RTE and *Basic Software Scheduler* may use OS Resources (standard or internal) e.g. to implement data consistency mechanisms.
- The RTE and *Basic Software Scheduler* may call the OS services GetResource() and ReleaseResource().
- The used Resources are part of the input information of the RTE generator.
- The RTE configurator has to allocate the necessary resources (all types of resources) in the OS configuration.

Interrupt Processing

- An alternative mechanism to get consistent data access is disabling/enabling of interrupts. The AUTOSAR OS provides different service functions to handle interrupt enabling/disabling. The RTE may use these functions and must **not** use compiler/processor dependent functions for the same purpose.

Alarms

- The RTE may use Alarms for timeout monitoring of asynchronous client/server calls. The RTE is responsible for Timeout handling.
- The RTE and *Basic Software Scheduler* may setup cyclic alarms for periodic triggering of RunnableEntitys and BswSchedulableEntitys (RunnableEntity activation via RTEEvent TimingEvent respectively BswSchedulableEntity activation via BswEvent BswTimingEvent)
- The RTE and *Basic Software Scheduler* therefore may call the OS service functions GetAlarmBase(), GetAlarm(), SetRelAlarm(), SetAbsAlarm() and CancelAlarm().
- The used Alarms are part of the input information of the RTE generator.
- The RTE configurator has to allocate the necessary alarms in the OS configuration.

Schedule Tables

- The RTE and *Basic Software Scheduler* may setup schedule tables for cyclic task activation (e.g. `RunnableEntity` activation via `RTEEvent TimingEvent`)
- The used schedule tables are part of the input information of the RTE generator.
- The RTE configurator has to allocate the necessary schedule tables in the OS configuration.

Common OS features

Depending on the global scheduling strategy of the OS, the RTE can make decisions about the necessary data consistency mechanisms. E.g. in an ECU, where all tasks are non-preemptive - and as the result also the global scheduling strategy of the complete ECU is non-preemptive - the RTE may optimize the generated code regarding the mechanisms for data consistency.

Hook functions

The AUTOSAR OS Specification defines hook functions as follows:

A Hook function is implemented by the user and invoked by the operating system in the case of certain incidents. In order to react to these on system or application level, there are two kinds of hook functions.

- **application-specific:** Hook functions within the scope of an individual OS Application.
- **system-specific:** Hook functions within the scope of the complete ECU (in general provided by the integrator).

If no memory protection is used (scalability classes SCC1 and SCC2) only the system-specific hook functions are available.

In the SRS the requirements to implement the system-specific hook functions were rejected [RTE00001], [RTE00101], [RTE00102] and [RTE00105], as well as the application-specific hook functions [RTE00198]. The reason for the rejection is the system (ECU) global scope of those functions. The RTE is not the only user of those functions. Other BSW modules might have requirements to use hook functions as well. This is the reason why the RTE is not able to generate these functions without the necessary information of the BSW configuration.

It is intended that the implementation of the hook functions is done by the system integrator and NOT by the RTE generator.

4.2.2.2 Basic Software Schedulable Entities

`BswSchedulableEntity`s are *Basic Software Module Entities*, which are designed for control by the BSW Scheduler. `BswSchedulableEntity`s are implementing main processing functions. The configuration of the *Basic Software Scheduler* allows mapping of BswSchedulableEntitys to both types; basic tasks and extended tasks.

BswSchedulableEntitys not mapped to a RunnableEntity are not allowed to enter a wait state. Therefore such BswSchedulableEntitys are comparable to RunnableEntitys of category 1. BswSchedulableEntitys mapped to a RunnableEntity can enter wait states by usage of the RTE API and such BswSchedulableEntitys have to be treated according the classification of the mapped RunnableEntity. The mapping of BswSchedulableEntitys to a RunnableEntitys is typically used for *AUTOSAR Services*, *ECU Abstraction* and *Complex Device Drivers*. See sections 4.1.8.6.

4.2.2.3 Runnable Entities

The following section describes the RunnableEntitys, their categories and their task-mapping aspects. The prototypes of the functions implementing RunnableEntitys are described in section 5.7

Runnable Entities are the schedulable parts of SW-Cs. *Runnable Entities* are either mapped to tasks or activated by direct function calls in the context of other Rte APIs, for instance server runnables that are invoked via direct function calls.

The mapping must be described in the ECU Configuration Description. This configuration - or just the RTE relevant parts of it - is the input of the RTE generator.

All RunnableEntitys are activated by the RTE as a result of an RTEEvent. Possible activation events are described in the meta-model by using RTEEvents (see section 4.2.2.4).

If no RTEEvent specifies a particular RunnableEntity in the role startOnEvent then the RunnableEntity is never activated by the RTE. Please note that a RunnableEntity may be mapped to a BswSchedulableEntity as described in section 4.2.2.2 which may lead to activations by the BSW Scheduler.

The categories of RunnableEntitys are described in [2].

RunnableEntitys and BswSchedulableEntitys are generalized by ExecutableEntitys.

4.2.2.4 RTE Events

The meta model describes the following RTE events:

Abbreviation	Name
T	TimingEvent
BG	BackgroundEvent
DR	DataReceivedEvent (S/R Communication only)
DRE	DataReceiveErrorEvent (S/R Communication only)

DSC	DataSendCompletedEvent (explicit S/R Communication only)
DWC	DataWriteCompletedEvent (implicit S/R Communication only)
OI	OperationInvokedEvent (C/S Communication only)
ASCR	AsynchronousServerCallReturnsEvent (C/S communication only)
MS	SwcModeSwitchEvent
MSA	ModeSwitchedAckEvent
MME	SwcModeManagerErrorEvent
ETO	ExternalTriggerOccurredEvent
ITO	InternalTriggerOccurredEvent
I	InitEvent
THE	TransformerHardErrorEvent

Table 4.1: Abbreviations of RTEEvents

According to the meta model each kind of RTEEvent can either

ACT activate a RunnableEntity, or

WUP wakeup a RunnableEntity at its WaitPoints

The meta model makes no restrictions which kind of RTEEvents are referred by WaitPoints. As a consequence RTE API functions would be necessary to set up the WaitPoints for each kind of RTEEvent.

Nevertheless in some cases it seems to make no sense to implement all possible combinations of the general meta model. E.g. setting up a WaitPoint, which should be resolved by a cyclic TimingEvent . Therefore the RTE SWS defines some restrictions, which are also described in section A.

The meta model also allows, that the same RunnableEntity can be triggered by several RTEEvents. For the current approach of the RTE and restrictions see section 4.2.6.

	T	BG	DR	DRE	DSC	DWC	OI	ASCR
ACT	x	x	x	x	x	x	x	x
WUP			x		x			x
	MS	**MSA**	**MME**	**ETO**	**ITO**	**I**	**THE**	
ACT	x	x	x	x	x	x	x	
WUP		x						

Table 4.2: *activation of* RunnableEntity depended on the kind of RTEEvent

The table 4.2 shows, that *activation of RunnableEntity* is possible for each kind of RTEEvent. For RunnableEntity activation, no explicit RTE API in the to be activated RunnableEntity is necessary. The RTE itself is responsible for the activation of the RunnableEntity depending on the configuration in the SW-C Description.

If the RunnableEntity contains a WaitPoint, it can be resolved by the assigned RTEEvent(s). Entering the WaitPoint requires an explicit call of a RTE API function. The RTE (together with the OS) has to implement the WaitPoint inside this RTE API.

The following list shows which RTE API function has to be called to set up WaitPoints.

- DataReceivedEvent: Rte_Receive()
- DataSendCompletedEvent: Rte_Feedback()
- ModeSwitchedAckEvent: Rte_SwitchAck()
- AsynchronousServerCallReturnsEvent: Rte_Result()

[SWS_Rte_01292] ⌈ When a DataReceivedEvent references a RunnableEntity and a required VariableDataPrototype and no WaitPoint references the DataReceivedEvent, the RunnableEntity shall be activated when the data is received. [SWS_Rte_01135]. ⌋*(SRS_Rte_00072)*

Requirement [SWS_Rte_01292] merely affects when the runnable is activated – an API call should still be created, according to requirement [SWS_Rte_01288], [SWS_Rte_01289], and [SWS_Rte_07395] as appropriate, to actually read the data.

4.2.2.5 BswEvents

The meta model describes the following BswEvents.

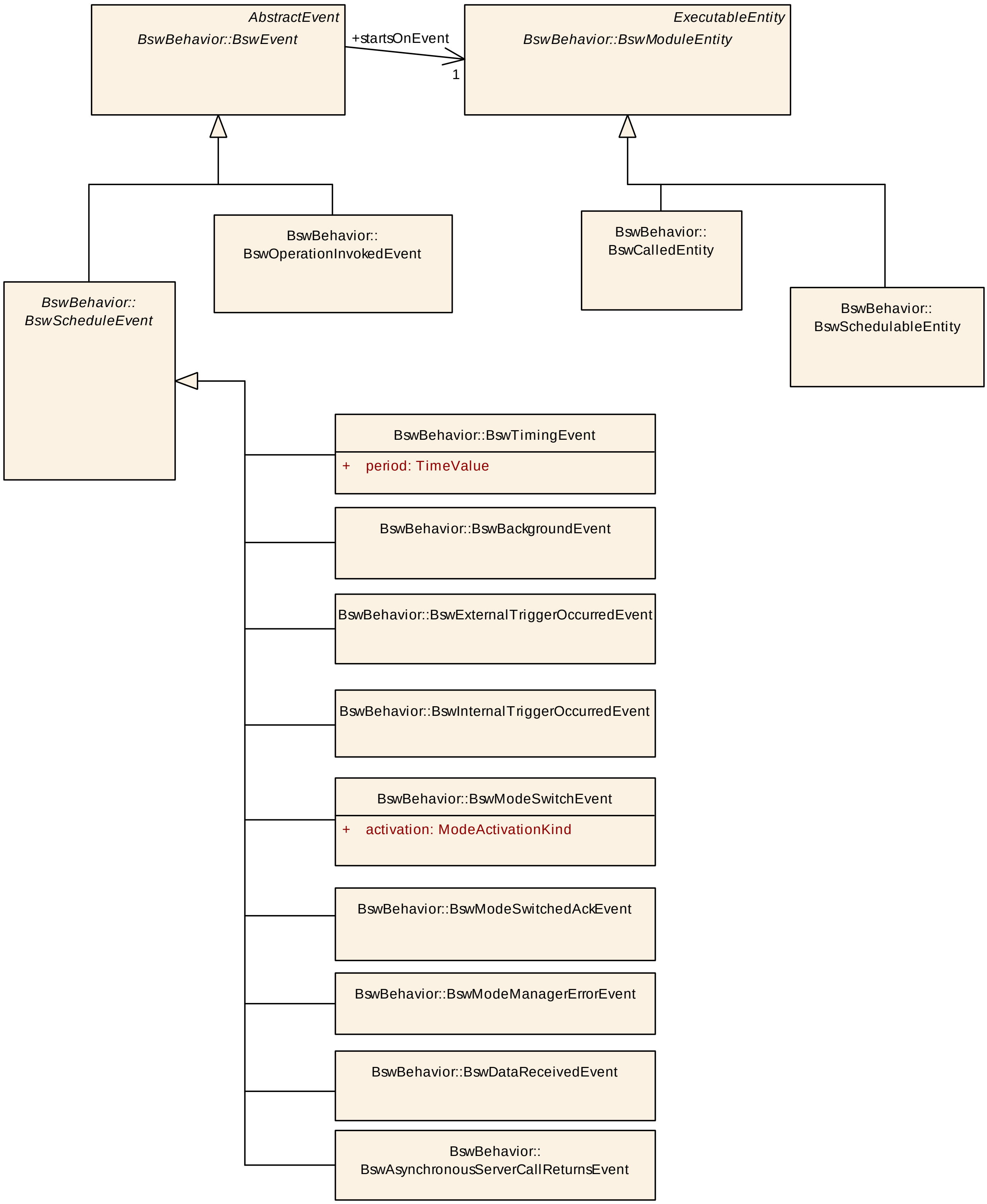


Figure 4.10: Different kinds of `BswEvent`s

Similar to RTEEvents the *activation of Basic Software Schedulable Entities* is possible for each kind of BswEvent. For of BswSchedulableEntitys activation, no explicit *Basic Software Scheduler* API in the to be activated BswSchedulableEntity is necessary. The *Basic Software Scheduler* itself is responsible for the activation of the BswSchedulableEntity depending on the configuration in the *Basic Software Module Description*. In difference to RTEEvents, none of the BswEvents support WaitPoints. For more details see document [9].

4.2.2.6 Mapping of Runnable Entities and Basic Software Schedulable Entities to tasks (informative)

One of the main requirements of the RTE generator is "Construction of task bodies" [SRS_Rte_00049]. The necessary input information e.g. the mapping of RunnableEntitys and BswSchedulableEntity to tasks must be provided by the ECU configuration description.

The ECU configuration description (or an extract of it) is the input for the RTE Generator (see Figure 3.4). It is also the purpose of this document to define the necessary input information. Therefore the following scenarios may help to derive requirements for the ECU Configuration Template as well as for the RTE-generator itself.
Note: The scenarios do not cover all possible combinations.

The RTE-Configurator uses parts of the ECU Configuration of other BSW Modules, e.g. the mapping of RunnableEntitys to OsTasks. In this configuration process the RTE-Configurator expects OS objects (e.g. Tasks, Events, Alarms...) which are used in the generated RTE and *Basic Software Scheduler*.

Some figures for better understanding use the following conventions:

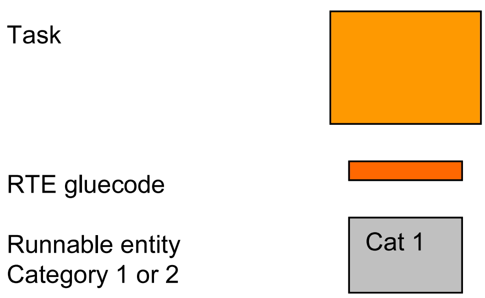


Figure 4.11: Element description

Note: The following examples are only showing RunnableEntitys. But taking the categorization of BswSchedulableEntitys defined in section 4.2.2.2 into account, the scenarios are applicable for BswSchedulableEntitys as well.

Note: The implementations described in this section are *examples only* and are presented for information only. The examples **must not be viewed as specification of**

implementation. The intention is to serve as examples of one possible implementation and not as specification of the only permitted implementation.

4.2.2.6.1 Scenario for mapping of RunnableEntitys to tasks

The different properties of RunnableEntitys with respect to data access and termination have to be taken into account when discussing possible scenarios of mapping RunnableEntitys to tasks.

- RunnableEntitys using VariableAccesses in the dataReadAccess or dataWriteAccess roles (implicit read and send) have to terminate.
- RunnableEntitys of category 1 can be mapped either to basic or extended tasks. (see next subsection).
- RunnableEntitys using at least one WaitPoint are of category 2.
- RunnableEntitys of category 2 that contain WaitPoints will be typically mapped to extended tasks.
- RunnableEntitys that contain a SynchronousServerCallPoint generally have to be mapped to extended tasks.
- RunnableEntitys that contain a SynchronousServerCallPoint can be mapped to basic tasks if no timeout monitoring is required and the server runnable is on the same partition.
- RunnableEntitys that contain a SynchronousServerCallPoint can be mapped to basic tasks if the server runnable is invoked directly and is itself of category 1.

Note that the runnable to task mapping scenarios supported by a particular RTE implementation might be restricted.

4.2.2.6.1.1 Scenario 1

Runnable entity category 1A: "runnable1"

- Ports: only S/R with VariableAccesses in the dataReadAccess or dataWriteAccess role
- RTEEvents: TimingEvent
- no sequence of RunnableEntitys specified
- no VariableAccess in the dataSendPoint role
- no WaitPoint

Possible mappings of "runnable1" to tasks:

Basic Task

If only one of those kinds of RunnableEntitys is mapped to a task (task contains only one RunnableEntity), or if multiple RunnableEntitys with the same activation period are mapped to the same task, a basic task can be used. In this case, the execution order of the RunnableEntitys within the task is necessary. In case the RunnableEntitys have different activation periods, the RTE has to provide the glue-code to guarantee the correct call cycle of each RunnableEntity.

The ECU Configuration-Template has to provide the sequence of RunnableEntitys mapped to the same task, see RtePositionInTask.

Figure 4.12 shows the possible mappings of RunnableEntitys into a basic task. If and only if a sequence order is specified, more than one RunnableEntity can be mapped into a basic task.

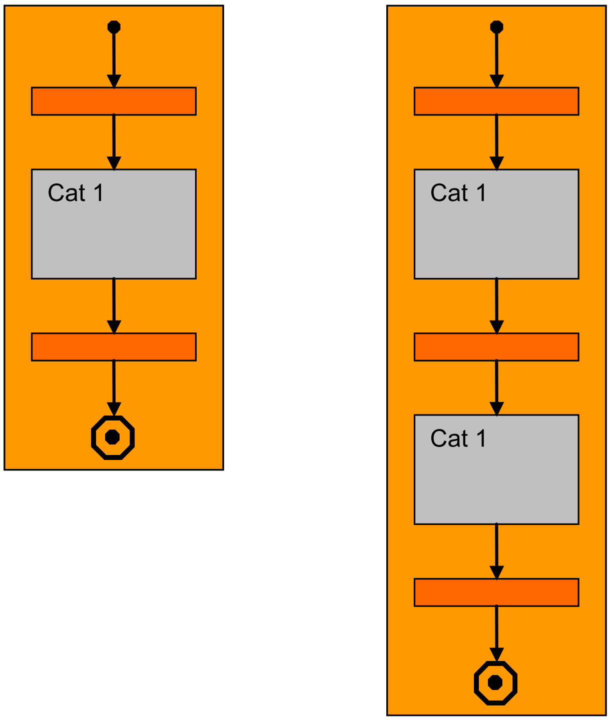


Figure 4.12: Mapping of Category 1 RunnableEntitys to Basic Tasks

Extended Task

If more than one RunnableEntity is mapped to the same task and the special condition (same activation period) does not fit, an extended task is used.

If an extended task is used, the entry points to the different RunnableEntitys might be distinguished by evaluation of different OS events. In the scenario above, the different activation periods may be provided by different OS alarms. The corresponding OS events have to be handled inside the task body. Therefore the RTE-generator needs for each task the number of assigned OS Events and their names.

The ECU Configuration has to provide the OS events assigned to the RTEEvents triggering the RunnableEntitys that are mapped to an extended task, see RteUsedOsEventRef.

Figure 4.13 shows the possible mapping of the multiple RunnableEntitys of category 1 into an Extended Task. Note: The Task does not terminate.

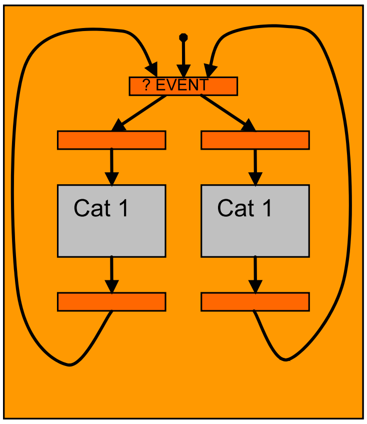


Figure 4.13: Mapping of Category 1 RunnableEntitys to Extended Tasks

For both, basic tasks and extended tasks, the ECU Configuration must provide the name of the task.

The ECU Configuration has to provide the name of the task, see OsTask.

The ECU Configuration has to provide the task type (BASIC or EXTENDED), which can be determined from the presence or absence of OS Events associated with that task, see OsTask.

4.2.2.6.1.2 Scenario 2

Runnable entity category 1B: "runnable2"

- Ports: S/R with VariableAccesses in the dataSendPoint role.
- RTEEvents: TimingEvent
- no WaitPoint

Possible mappings of "runnable2" to tasks:

The following figure shows the different mappings:

- One category 1B runnable
- More than one category 1B runnable mapped to the same basic task with a specified sequence order
- More than one category 1B runnable mapped into an extended task

The gluecode to realize the VariableAccessin the dataReadAccess and dataWriteAccess roles respectively before entering the runnable and after exiting is not necessary.

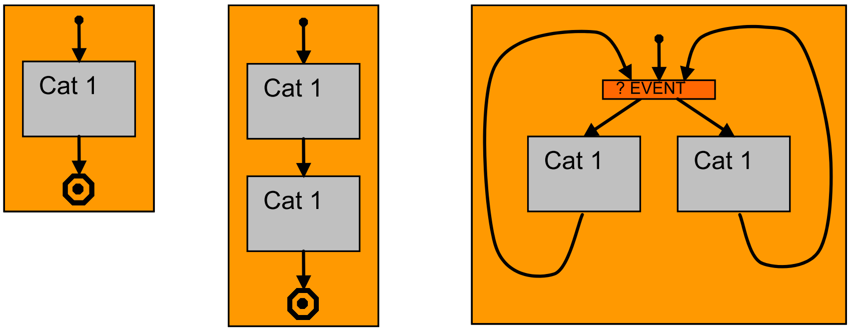


Figure 4.14: Mapping of Category 1 RunnableEntitys using no VariableAccesses in the dataReadAccess or dataWriteAccess role

4.2.2.6.1.3 Scenario 3

Runnable entity category 1A: "runnable3"

- Ports: S/R with VariableAccesses in the dataReadAccess or dataWriteAccess role
- RTEEvents: Runnable is activated by a DataReceivedEvent
- no VariableAccess in the dataSendPoint role
- no WaitPoint

There is no difference between Scenario 1 and 3. Only the RTEEvent that activates the RunnableEntity is different.

4.2.2.6.1.4 Scenario 4

Runnable entity category 2: "runnable4"

- Ports: S/R with VariableAccesses in the dataReceivePointByValue or dataReceivePointByArgument role and WaitPoint (blocking read)
- RTEEvents: WaitPoint referencing a DataReceivedEvent

Runnable is activated by an arbitrary RTEEvent (e.g. by a TimingEvent). When the RunnableEntity has entered the WaitPoint and the DataReceivedEvent occurs, the RunnableEntity resumes execution.

The runnable has to be mapped to an extended task. Normally each category 2 runnable has to be mapped to its own task. Nevertheless it is not forbidden to map multiple category 2 RunnableEntitys to the same task, though this might be restricted by an

RTE generator. Mapping multiple category 2 RunnableEntitys to the same task can lead to big delay times if e.g. a WaitPoint is resolved by the incoming RTEEvent, but the task is still waiting at a different WaitPoint.

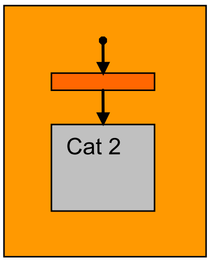


Figure 4.15: Mapping of Category 2 RunnableEntitys to Extended Tasks

4.2.2.6.1.5 Scenario 5

There are two RunnableEntitys implementing a client (category 2) and a server for synchronous C/S communication and the timeout attribute of the ServerCallPoint is 0.

On a single core, there are two ways to invoke a server synchronously:

- Simple function call for intra-partition C/S communication if the canBeInvokedConcurrently attribute of the server runnable is set and if the server runnable is of category 1. In that case the server runnable is executed in the same task context (same stack) as the client runnable that has invoked the server. The client runnable can be mapped to a basic task.
- The server runnable is mapped to its own task. If the canBeInvokedConcurrently attribute is not set, the server runnable must be mapped to a task.

  If the implementation of the synchronous server invocation does not use OS events, the client runnable can be mapped to a basic task and the task of the server runnable must have higher priority than the task of the client runnable. Furthermore, the task to which the client runnable is mapped must be preemptable. This has to be checked by the RTE generator. Activation of the server runnable can be done by ActivateTask() for a basic task or by SetEvent() for an extended task. In both cases, the task to be activated must have higher priority than the task of the client runnable to enforce a task switch (necessary, because the server invocation is synchronous).

4.2.2.6.1.6 Scenario 6

There are two RunnableEntitys implementing a client (category 2) and a server for synchronous C/S communication and the timeout attribute of the ServerCallPoint is greater than 0.

There are again two ways to invoke a server synchronously:

- Simple function call for intra-partition C/S communication if the canBeInvokedConcurrently attribute of the server runnable is set and the server is of category 1. In that case the server runnable is executed in the same task context (same stack) as the client runnable that has invoked the server and no timeout monitoring is performed (see [SWS_Rte_03768]). In this case the client runnable can be mapped to a basic task.
- The server runnable is mapped to its own task. If the canBeInvokedConcurrently attribute is not set, the server runnable must be mapped to a task.

  If the implementation of the timeout monitoring uses OS events, the task of the server runnable must have lower priority than the task of the client runnable and the client runnable must be mapped to an extended task. Furthermore, both tasks must be preemptable[1]. This has to be checked by the RTE generator. The notification that a timeout occurred is then notified to the client runnable by using an OS Event. In order for the client runnable to immediately react to the timeout, a task switch to the client task must be possible when the timeout occurs.

4.2.2.6.1.7 Scenario 7

Runnable entity category 2: "runnable7"

- Ports: only C/S with AsynchronousServerCallPoint and WaitPoint
- RTEEvents: AsynchronousServerCallReturnsEvent (C/S communication only)

The mapping scenario for "runnable7", the client runnable that collects the result of the asynchronous server invocation, is similar to Scenario 4.

4.2.2.7 Monitoring of runnable execution time

This section describes how the monitoring of RunnableEntity execution time can be done.

The RTE doesn't directly support monitoring of RunnableEntitys execution time but the AUTOSAR OS support for monitoring of OsTasks execution time can be used for this purpose.

[1] Strictly speaking, this restriction is not necessary for the task to which the client runnable is mapped. If OS events are used to implement the timeout monitoring and the notification that the server is finished, the RTE API implementation generally uses the OS service WaitEvent, which is a point of rescheduling.

If execution time monitoring of a RunnableEntity is required a possible solution is to map the RunnableEntity alone to an OsTask and to configure the OS to monitor the execution time of the OsTask.

This solution can lead to dispatch to individual OsTasks RunnableEntitys that should be initially mapped to the same OsTask because of for example:

- requirements on execution order of the RunnableEntitys and/or
- requirements on evaluation order of the RTEEvents that activate the RunnableEntitys and
- constraints to have no preemption between the RunnableEntitys

In order to keep the control on the execution order of the RunnableEntitys, the evaluation order of the RTEEvents and the non-preemption between the RunnableEntitys when then RunnableEntitys are individually mapped to several OsTasks for the purpose of monitoring, a possible solution is to replace the calls to the C-functions of the RunnableEntitys by activations of the OsTasks to which the monitored RunnableEntitys are mapped.

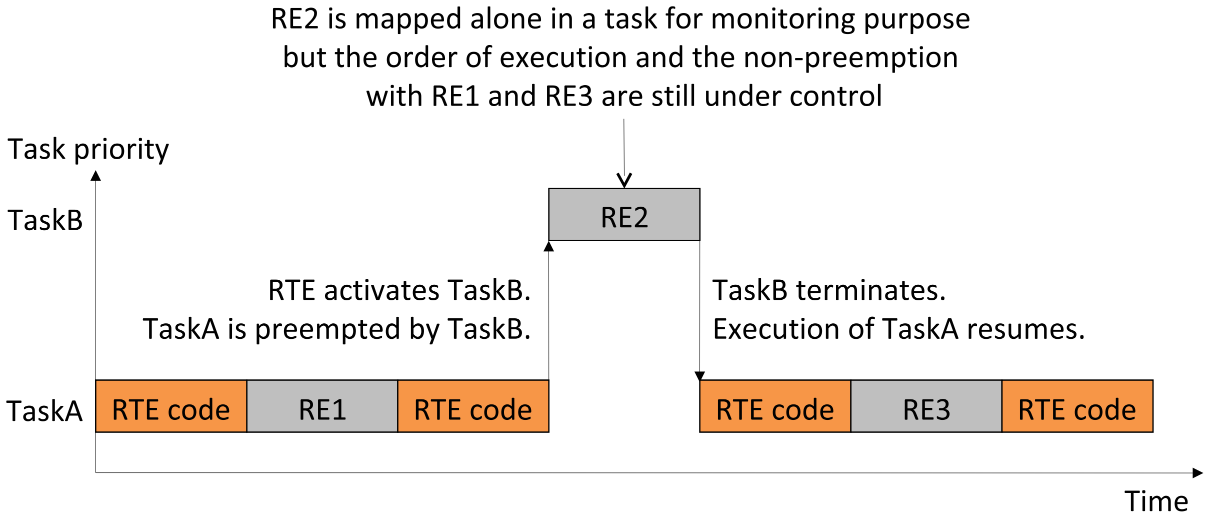


Figure 4.16: Inter task activation and mapping of runnable to individual task for monitoring purpose

This behavior of the RTE can be configured with the attributes RteVirtuallyMappedToTaskRef of the RteEventToTaskMapping. RteVirtuallyMappedToTaskRef references the OsTask in which the execution order of the RunnableEntitys and/or the evaluation order of the RTEEvents are controlled. RteMappedToTaskRef references the individual OsTasks to which the RunnableEntitys are mapped for the purpose of monitoring.

[SWS_Rte_07800] ⌈ The RTE Generator shall respect the configured virtual runnable to task mapping (RteVirtuallyMappedToTaskRef) in the RTE configuration. ⌋*(SRS_Rte_00193)*

Of course this solution requires that the task priorities and scheduling properties are well configured in the OS to allow immediate preemption by the OsTasks to which the monitored RunnableEntitys are mapped. A possible solution is:

- Priority of the OsTask to which the RunnableEntity is mapped is higher than the priority of the OsTask to which the RunnableEntity is virtually mapped and
- the OsTask to which the RunnableEntity is virtually mapped have a full preemptive scheduling or
- the RTE call the OS service Schedule() just after activation of the OsTask to which the RunnableEntity is mapped

Example 1: Without OsEvent

Description of the example:
RunnableEntity RE1 is activated by TimingEvent 100ms T1.
RunnableEntity RE2 is activated by TimingEvent 100ms T2.
RunnableEntity RE3 is activated by TimingEvent 100ms T3.
Execution order of the RunnableEntitys shall be R1, R2 then R3.
RE2 shall be monitored.

Possible RTE configuration:
RE1/T1 is mapped to OsTask TaskA with RtePositionInTask equal to 1.
RE2/T2 is mapped to OsTask TaskB but virtually mapped to TaskA with RtePositionInTask equal to 2.
RE3/T3 is mapped to OsTask TaskA with RtePositionInTask equal to 3.

Possible RTE implementation:
RTE starts cyclic OsAlarm with 100ms period.
This OsAlarm is configured to activate TaskA.
Non preemptive scheduling is configured for Task A.
TaskB priority = TaskA priority + 1

```
void TaskA(void)
{
    RE1();
    ActivateTask(TaskB);
    Schedule();
    RE3();
    TerminateTask();
}

void TaskB(void)
{
    RE2();
    TerminateTask();
}
```

Example 2: With OsEvent

Description of the example:
RunnableEntity RE1 is activated by DataReceivedEvent DR1.
RunnableEntity RE2 is activated by DataReceivedEvent DR2.
RunnableEntity RE3 is activated by DataReceivedEvent DR3.
Evaluation order of the RTEEvents shall be DR1, DR2 then DR3.
All the runnables shall be monitored.

Possible RTE configuration:
RE1 is mapped to OsTask TaskB but virtually mapped to TaskA with a reference to OsEvent EvtA and RtePositionInTask equal to 1.
RE2 is mapped to OsTask TaskC but virtually mapped to TaskA with a reference to OsEvent EvtB and RtePositionInTask equal to 2.
RE3 is mapped to OsTask TaskD but virtually mapped to TaskA with a reference to OsEvent EvtC and RtePositionInTask equal to 3.

Possible RTE implementation:
RTE set EvtA, EvtB and EvtC according to the callbacks from COM.
Full preemptive scheduling is configured for Task A.
TaskB priority = TaskC priority = TaskD priority = TaskA priority + 1

```
void TaskA(void)
{
   EventMaskType Event;

   while(1)
   {
      WaitEvent(EvtA | EvtB | EvtC);
      GetEvent(TaskA, &Event);
      if (Event & EvtA)
      {
         ClearEvent(EvtA);
         ActivateTask(TaskB);
      }
      else if (Event & EvtB)
      {
         ClearEvent(EvtB);
         ActivateTask(TaskC);
      }
      else if (Event & EvtC)
      {
         ClearEvent(EvtC);
         ActivateTask(TaskD);
      }
   }
}

void TaskB(void)
{
   RE1();
   TerminateTask();
}

void TaskC(void)
{
```

```
    RE2();
    TerminateTask();
}

void TaskD(void)
{
    RE3();
    TerminateTask();
}
```

It is also possible to configure the RTE for the monitoring of group of runnable = monitoring of the sum of the runnable execution times.

Example 3: Monitoring of group of runnables

Description of the example:
RunnableEntity RE1 is activated by TimingEvent 100ms T1.
RunnableEntity RE2 is activated by TimingEvent 100ms T2.
RunnableEntity RE3 is activated by TimingEvent 100ms T3.
RunnableEntity RE4 is activated by DataReceivedEvent DR1.
RunnableEntity RE5 is activated by DataReceivedEvent DR2.
RunnableEntity RE6 is activated by DataReceivedEvent DR3.
RunnableEntity RE7 is activated by DataReceivedEvent DR4.
DataReceivedEvent DR2, DR3 and DR4 references the same dataElement. Evaluation order of the RTEEvents shall be T1, T2, T3, DR1, DR2, DR3 then DR4.
RE2 and RE3 shall be monitored as a group.
RE6 and RE7 shall be monitored as a group.

Possible RTE configuration:
RE1 is mapped to OsTask TaskA with a reference to OsEvent EvtA and RtePositionInTask equal to 1.
RE2 is mapped to OsTask TaskB but virtually mapped to TaskA with a reference to OsEvent EvtA and RtePositionInTask equal to 2.
RE3 is mapped to OsTask TaskB but virtually mapped to TaskA with a reference to OsEvent EvtA and RtePositionInTask equal to 3.
RE4 is mapped to OsTask TaskA with a reference to OsEvent EvtB and RtePositionInTask equal to 4.
RE5 is mapped to OsTask TaskA with a reference to OsEvent EvtC and RtePositionInTask equal to 5.
RE6 is mapped to OsTask TaskC but virtually mapped to TaskA with a reference to OsEvent EvtC and RtePositionInTask equal to 6.
RE7 is mapped to OsTask TaskC but virtually mapped to TaskA with a reference to OsEvent EvtC and RtePositionInTask equal to 7.

Possible RTE implementation:
RTE starts cyclic OsAlarm with 100ms period.
This OsAlarm is configured to set EvtA.
RTE set EvtB and EvtC according to the callbacks from COM.
Full preemptive scheduling is configured for Task A.
TaskB priority = TaskC priority = TaskA priority + 1

```
void TaskA(void)
{
   EventMaskType Event;

   while(1)
   {
      WaitEvent(EvtA | EvtB | EvtC);
      GetEvent(TaskA, &Event);
      if (Event & EvtA)
      {
         ClearEvent(EvtA);
         RE1();
         ActivateTask(TaskB);
      }
      else if (Event & EvtB)
      {
         ClearEvent(EvtB);
         RE4();
      }
      else if (Event & EvtC)
      {
         ClearEvent(EvtC);
         RE5();
         ActivateTask(TaskC);
      }
   }
}

void TaskB(void)
{
   RE2();
   RE3();
   TerminateTask();
}

void TaskC(void)
{
   RE6();
   RE7():
   TerminateTask();
}
```

4.2.2.8 TimingEvent activated runnables

A TimingEvent / BswTimingEvent is a recurring RTEEvent / BswEvent which is used to perform recurrent activities in RunnableEntitys or BswSchedulableEntitys.

[SWS_Rte_06728] ⌈ The RTE shall activate RunnableEntitys triggered by a TimingEvent recurring with the effective period time of an TimingEvent for the component instance. ⌋*(SRS_Rte_00237)*

[SWS_Rte_06729] ⌈ The RTE Generator shall determine the effective period time of a TimingEvent from the period attribute of the TimingEvent if no InstantiationRTEEventProps are defined for the TimingEvent of the component instance. ⌋*(SRS_Rte_00237)*

[SWS_Rte_06730] ⌈ The RTE Generator shall determine the effective period time of a TimingEvent from the period attribute of the InstantiationRTEEventProps if InstantiationRTEEventProps are defined for the TimingEvent of the component instance. ⌋*(SRS_Rte_00237)*

Please note the component instance is defined by RteSoftwareComponentInstanceRef of RteSwComponentInstance referring to the SwComponentPrototype. See figure 8.2.

4.2.2.9 Synchronization of TimingEvent activated runnables

This section describes how the synchronization of TimingEvent activated RunnableEntitys can be done.

The following cases have to be distinguished:

- the RunnableEntitys are mapped to the same OsTask
- the RunnableEntitys are mapped to different OsTasks in the same OsApplication
- the RunnableEntitys are mapped to different OsTasks in different OsApplications on the same core
- the RunnableEntitys are mapped to different OsTasks in different OsApplications on different cores on the same microcontroler
- the RunnableEntitys are mapped to different OsTasks in different OsApplications on different microcontrolers within the same ECU
- the RunnableEntitys are mapped to different OsTasks in different OsApplications on different microcontrolers within different ECUs

As OsAlarms and OsScheduleTableExpiryPoints are used to implement TimingEvents the following different possible solutions exist to synchronize the RunnableEntitys according to the different cases:

- use the same OsAlarm or OsScheduleTableExpiryPoint to implement all the TimingEvents
- use different OsAlarms or OsScheduleTableExpiryPoints in different OsScheduleTables based on the same OsCounter and start them with absolute start offset to control the synchronization between them

- use different OsScheduleTableExpiryPoints in different explicitely synchronized OsScheduleTables based on different OsCounters but with same period and max value

The choice of the OsAlarms or OsScheduleTableExpiryPoints used to implement the TimingEvents can be configured in the RTE with RteUsedOsAlarmRef or RteUsedOsSchTblExpiryPointRef in the RteEventToTaskMapping.

[SWS_Rte_07804] ⌈ The RTE Generator shall respect the configured OsAlarms (RteUsedOsAlarmRef) and OsScheduleTableExpiryPoints (RteUsedOsSchTblExpiryPointRef) for the implementation of the TimingEvents. ⌋ *(SRS_Rte_00232)*

The choice of the absolute start offset of the OsAlarms and OsScheduleTables can be configured in the RTE with RteExpectedActivationOffset in the RteUsedOsActivation.

[SWS_Rte_07805] ⌈ The RTE Generator shall respect the configured absolute start offset (RteExpectedActivationOffset) when it starts the OsAlarms and OsScheduleTables used for the implementation of the TimingEvents. ⌋ *(SRS_Rte_00232)*

The RTE / *Basic Software Scheduler* is not responsible to synchronize/desynchronize the explicitly synchronized OsScheduleTables. The RTE / *Basic Software Scheduler* is only responsible to start the explicitly synchronized OsScheduleTables. In this case no RteExpectedActivationOffset has to be configured.

4.2.2.10 BackgroundEvent activated Runnable Entities and BasicSoftware Scheduleable Entities

A BackgroundEvent is a recurring RTEEvent / BswEvent which is used to perform background activities in RunnableEntitys or BswSchedulableEntitys. It is similar to a TimingEvent but has no fixed time period and is typically activated only with lowest priority.

A BackgroundEvent triggering can be implemented in two principle ways by the RTE Generator. Either the background activation is done by a real background OS task; or the BackgroundEvents are activated like TimingEvents on a fixed recurrence which is defined by the ECU integrator (see [SWS_Rte_07179] and [SWS_Rte_07180]). The second way might be required to overcome the limitation of a single real background OS task if BackgroundEvents are used in several partitions.

If the background activation is done by a real background OS task, the OS Task has to have the lowest priority on the CPU core (see [SWS_Rte_07181]). If a implementation is used where the OS Task terminates (*BasicTask*) the background OS Task is immediately reactivated after its termination, e.g. by usage of ChainTask call of the OS.

4.2.2.11 InitEvent activated Runnable Entities

An InitEvent which is used to activate RunnableEntitys for initialization purpose in case of start of the RTE or restart of a partition.

[SWS_Rte_06761] ⌈ The RTE shall activate RunnableEntitys triggered by an InitEvent once when Rte_Start is executed. ⌋*(SRS_Rte_00240)*

[SWS_Rte_06762] ⌈ The RTE shall activate RunnableEntitys triggered by an InitEvent once when Rte_RestartPartition is executed for those RunnableEntitys belonging to the restarted partition. ⌋*(SRS_Rte_00240)*

The activation of RunnableEntitys for initialization purpose can basically implemented in two ways. Either the InitEvent is mapped to an OsTask or the InitEvent is mapped to an RteInitializationRunnableBatch.

In case of an OsTask the RunnableEntitys are scheduled once when the related task gets active. In this case the RtePositionInTask decides in which order the RunnableEntitys are scheduled in the whole task. For instance if the InitEvent is mapped after an TimingEvent ans the TimingEvent is already triggered when the OsTask gets active the initialization runnable is called after time periodic runnable. Therefore its in the responsibility of the ECU integrator to ensure the correct and intended order.

In the case the InitEvent is mapped to an RteInitializationRunnableBatch the RunnableEntitys are scheduled when the related Rte_Init function is called. In this case the RtePositionInTask decides in which order in which order the RunnableEntitys are scheduled in the same Rte_Init function.

The triggering of the recurrent RTEEvents is released with the call of Rte_StartTiming.

4.2.3 Activation and Start of ExecutableEntitys

This section defines the activation of ExecutableEntity execution-instances by using a state machine (Fig. 4.17).

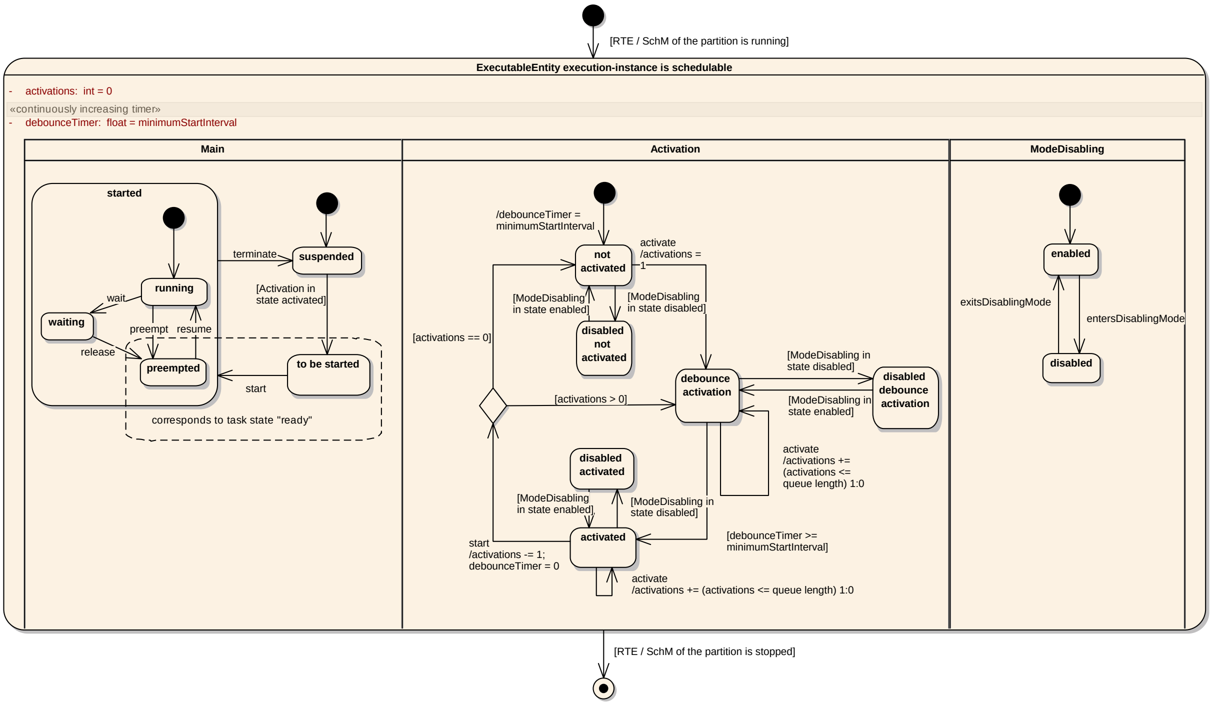


Figure 4.17: General state machine of an ExecutableEntity execution-instance.

An ExecutableEntity execution-instance is one execution-instance of an ExecutableEntity (RunnableEntity or BswSchedulableEntity) with respect to concurrent execution.

For a RunnableEntity with canBeInvokedConcurrently = false or for a BswSchedulableEntity whose referenced BswModuleEntry in the role implementedEntry has a isReentrant attribute set to false, there is only one execution-instance. For a RunnableEntity with canBeInvokedConcurrently = true or for a BswSchedulableEntity whose referenced BswModuleEntry in the role implementedEntry has its isReentrant attribute set to true, there is a well defined number of execution-instances.

E.g., for a server runnable that is executed as direct function call, each ServerCallPoint relates to exactly one ExecutableEntity execution-instance.

The main principles for the activation of runnables are:

- RunnableEntitys are activated by RTEEvents
- BswSchedulableEntitys are activated by BswEvents
- only server runnables (RunnableEntitys activated by an OperationInvokedEvent) are queued. All other ExecutableEntitys are unqueued.

If a RunnableEntity is activated due to several DataReceivedEvents of dataElements with swImplPolicy = queued, it is the responsibility of the RunnableEntity to dequeue all queued data.

- A minimumStartInterval will delay the activation of RunnableEntitys and BswSchedulableEntitys to prevent that a RunnableEntity or a BswSchedulableEntity is started more than once within the minimumStartInterval.

Each ExecutableEntity execution-instance has its own state machine. The full state machine is shown in Fig. 4.17.

Note on Figure 4.17: the debounce timer debounceTimer is an increasing timer. It is local to the ExecutableEntity execution-instance. The activation counter activations is a local integer to count the pending activations. The runnable debounce timer and the activation counter are like the whole state machine just concepts for the specification of the behavior, not for the implementation.

The pending activations are only counted for server runnables when RTE implements a call serialization of their invocation. In all other cases, RTE does not queue activations and the state machine for the activation of ExecutableEntity execution-instances simplifies as shown in Figure 4.18.

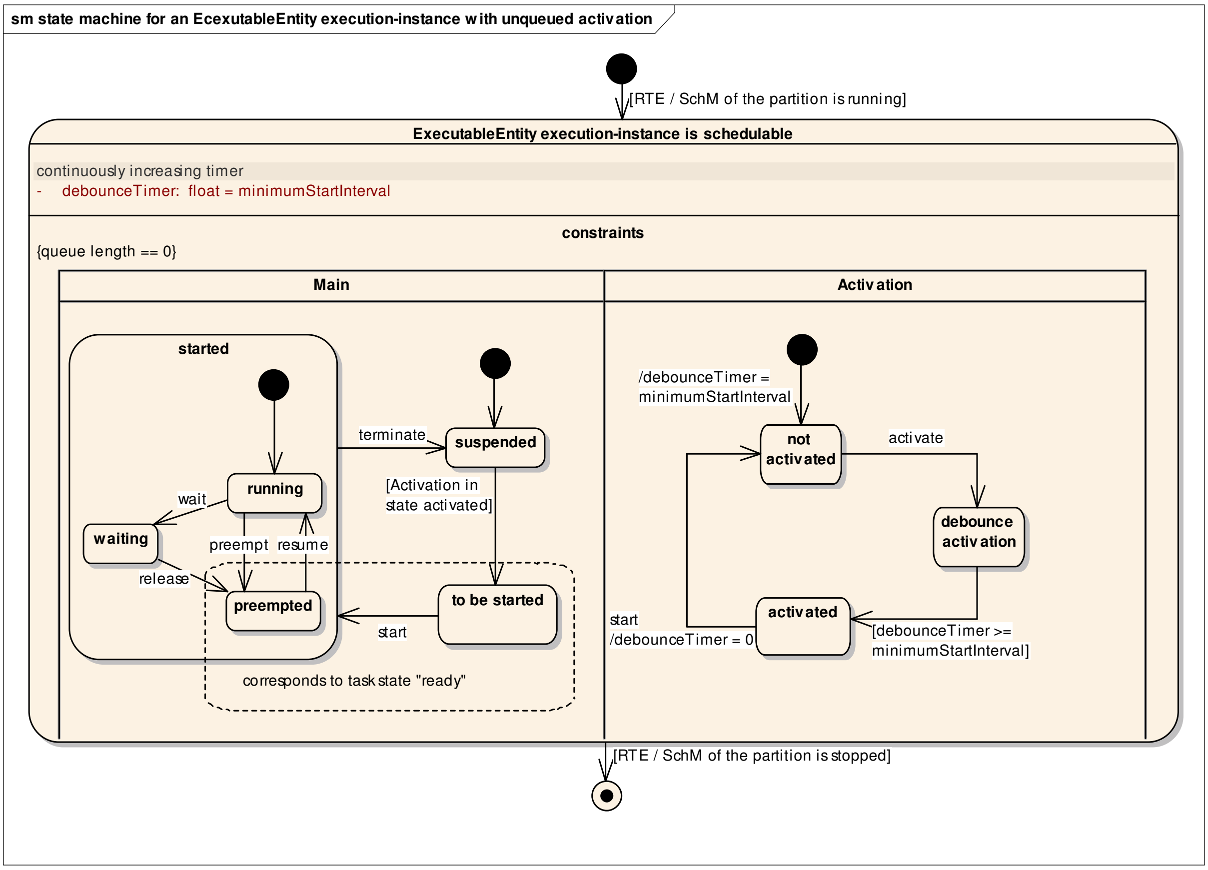


Figure 4.18: Statemachine of an unqueued execution-instance (not a server runnable)

If RTE implements an ExecutableEntity execution-instance by direct function call, as described in section 4.2.3.1, the simplified state machine is shown in Figure 4.21.

The state machine of an ExecutableEntity execution-instance is not identical to that of the task containing the ExecutableEntity execution-instance, but there are dependencies between them. E.g., the ExecutableEntity execution-instance can only be 'running' when the corresponding task is 'running'.

Table 4.3 describes all ExecutableEntity execution-instance states in detail. The ExecutableEntity execution-instance state machine is split in two threads. The Main states describe the real state of the ExecutableEntity execution-instance and the transitions between a suspended and a running ExecutableEntity execution-instance, while the supporting Activation states describe the state of the pending activations by RTEEvents or BswEvents.

ExecutableEntity execution-instance state	**description**
ExecutableEntity execution-instance is schedulable	This super state describes the life time of the state machine. Only when RTE or the SchM that runs the ExecutableEntity execution-instance is started in the corresponding partition, this state machine is active.
ExecutableEntity execution-instance Main states	
suspended	The ExecutableEntity execution-instance is not started and there is no pending request to start the ExecutableEntity execution-instance.
to be started	The ExecutableEntity execution-instance is activated but not yet started. Entering the to be started state, usually implies the activation of a task that starts the ExecutableEntity execution-instance. The ExecutableEntity execution-instance stays in the 'to be started' state, when the task is already running until the gluecode of the task actually calls the function implementing the ExecutableEntity.
running	The function, implementing the ExecutableEntity code is being executed. The task that contains the ExecutableEntity execution-instance is running.
waiting	A task containing the ExecutableEntity execution-instance is waiting at a WaitPoint within the ExecutableEntity.
preempted	A task containing the ExecutableEntity execution-instance is preempted from executing the function that implements the ExecutableEntity.
started	'started' is the super state of 'running', 'waiting' and 'preempted' between start and termination of the ExecutableEntity execution-instance.
ExecutableEntity execution-instance Activation states	
not activated	No RTEEvent / BswEvent requires the activation of the ExecutableEntity execution-instance.
debounce activation	One or more RTEEvents with a startOnEvent relation to the ExecutableEntity execution-instance have occurred [2], but the debounce timer has not yet exceeded the minimumStartInterval. The activation will automatically advance to activated, when the debounce timer reaches the minimumStartInterval.
activated	One or more RTEEvents or BswEvents with a startOnEvent relation to the ExecutableEntity have occurred, and the debounce timer has exceeded the minimumStartInterval. While the activated state is active, the Main state of the ExecutableEntity execution-instance automatically advances from the suspended to the 'to be started' state. For a server runnable where RTE implements a serialization of server calls, an activation counter counts the number of activations. When the ExecutableEntity execution-instance starts, the activation counter will be decremented. When there is still a pending activation, the Activation state will turn to debounce activation and otherwise to no activation.

[2]Note that, e.g., the same OperationInvokedEvent may lead to the activation of different ExecutableEntity execution-instances, depending on the client that caused the event.

Table 4.3: States defined for each ExecutableEntity execution-instance.

Note: For tasks, the equivalent state machine does not distinguish between preempted and to be started. They are subsumed as 'ready'.

ExecutableEntity execution-instance transition	**description of event and actions**
initial transition to 'ExecutableEntity execution-instance is schedulable'	RTE or the SchM that runs the ExecutableEntity execution-instance is being started in the corresponding partition.
termination transition from 'ExecutableEntity execution-instance is schedulable'	RTE or the SchM that runs the ExecutableEntity execution-instance gets stopped in the corresponding partition.
transitions to ExecutableEntity execution-instance Main states	
initial transition to suspended	the suspended state is the initial state of the ExecutableEntity execution-instance Main states.
from started to suspended	The ExecutableEntity execution-instance has run to completion.
from suspended to 'to be started'	This transition is automatically executed, while the Activation state is 'activated'.
from 'to be started' to running	The function implementing the ExecutableEntity is called from the context of this execution-instance.
from preempted to running	A task that is preempted from executing the ExecutableEntity execution-instance changes state from preempted to running.
from running to waiting	The runnable enters a WaitPoint.
from waiting to preempted	The task that contains a runnable waiting at a wait point changes from waiting to preempted.
from running to preempted	A task containing the ExecutableEntity execution-instance gets preempted from executing the function that implements the ExecutableEntity.
transitions to ExecutableEntity execution-instance Activation states	
initial transition to 'not activated'	The 'not activated' state is the initial state of the ExecutableEntity execution-instance Activation states. The debounce timer is set to the minimumStartInterval value, to prevent a delay for the first activation of the ExecutableEntity execution-instance.
from activated to 'not activated'	The function implementing the ExecutableEntity is called from the context of this execution-instance and no further activations are pending. The debounce timer is reset to 0.
from 'not activated' to 'debounce activation'	The occurrence of an RTEEvent or BswEvent requires the activation of the ExecutableEntity execution-instance. A local activation counter is set to 1. If no minimumStartInterval is configured, or the debounce timer has already exceeded the minimumStartInterval, the 'debounce activation' state will be omitted and the transition leads directly to the activated state.

from activated to 'debounce activation'	The function implementing the ExecutableEntity is called from the context of this execution-instance (start), and another activation is pending (only for server runnable). The activation counter is decremented and the debounce timer reset to 0. If no minimumStartInterval is configured, the 'debounce activation' state will be omitted and the transition returns directly at the activated state.
from 'debounce activation' to 'debounce activation'	If RTE implements server call serialization for a server runnable, and an OperationInvokedEvent occurs for the server runnable. The activation counter is incremented (at most to the queue length).
from 'debounce activation' to activated	The debounce timer is expired, debounce timer > minimumStartInterval.
from activated to activated	If RTE implements server call serialization for a server runnable, and an OperationInvokedEvent occurs for the server runnable. The activation counter is incremented (at most to the queue length).

Table 4.4: States defined for each ExecutableEntity execution-instance.

[SWS_Rte_02697] ⌈The activation of ExecutableEntity execution-instances shall behave as described by the state machine in Fig. 4.17, Table 4.3, and Table 4.4. ⌋*(SRS_Rte_00072, SRS_Rte_00160, SRS_Rte_00133, SRS_Rte_00211, SRS_Rte_00214, SRS_Rte_00217, SRS_Rte_00219)*

The RTE will not activate, start or release ExecutableEntity execution-instances of a terminated or restarting partition (see [SWS_Rte_07604]), or when RTE is stopped in that partition (see [SWS_Rte_02538]).

The following examples in Fig. 4.19 and Fig. 4.20 show the different timing situations of the ExecutableEntity execution-instances with or without a minimumStartInterval. The minimumStartInterval can reduce the number of activations by collecting more activating RTEEvents / BswEvents within that interval. No activation will be lost. The activations are just delayed and combined to keep the minimumStartInterval. The started state of the ExecutableEntity execution-instance Main states and the activated state of the Activation states are shown in the figures. Each flash indicates the occurrence of an RTEEvent or BswEvent.

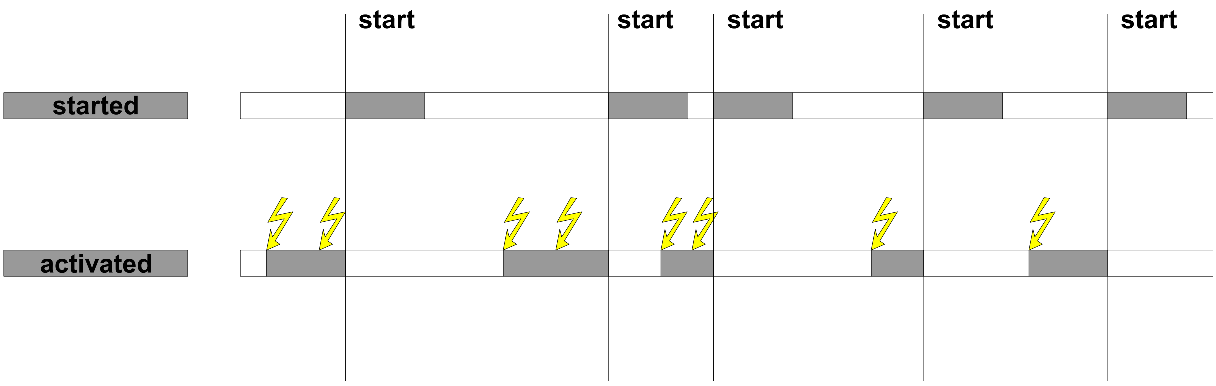


Figure 4.19: Activation of an ExecutableEntity execution-instance without minimumStartInterval

Figure 4.19 illustrates the activation of an ExecutableEntity execution-instance without minimumStartInterval. The execution-instance can only be activated once (does not apply for server runnables). The activation is not queued. The execution-instance can already be activated again when it is still started (see Figure 4.17).

With configuration of the RteEventToTaskMapping such activation can even be used for an immediately restart of the ExecutableEntity before other ExecutableEntitys which are mapped subsequently in the task are getting started.

[SWS_Rte_07061] ⌈ When the parameter RteImmediateRestart / RteBswImmediateRestart is TRUE the RTE shall immediately restart the ExecutableEntity after termination if the ExecutableEntity was activated by this RTEEvent / BswEvent while it was already started. ⌋*(SRS_Rte_00072)*

This can be utilized to spread a long-lasting calculation in several smaller slices with the aim to reduce the maximum blocking time of Tasks in a Cooperative Environment. Typically between each iteration one Schedule Point has to be placed and the number of iteration might depend on operating conditions of the ECU. Further on in a calculation chain the long-lasting calculation shall be completed before consecutive ExecutableEntitys are called.

Example 4.4

Example of RunnableEntity code:

```
LongLastingRunnable()
{
   /* the very long calculation */
   if(!finished)
   {
      /* further call is required to complete the calculation*/
      Rte_IrTrigger_LongLastingCalculation_ProceedCalculation();
   }
}
```

Therefore the ExecutableEntity with a long lasting calculation issues a trigger as long as the calculation is not finished. These trigger activates the ExecutableEntity again. The first activation of the ExecutableEntity might be triggered by another RTEEvent / BswEvent.

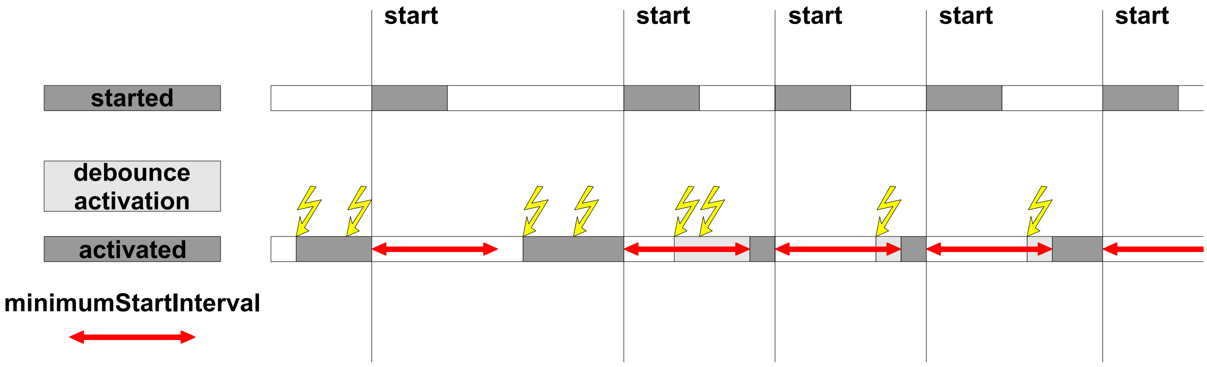


Figure 4.20: Activation of an ExecutableEntity with a minimumStartInterval

Figure 4.20 illustrates the activation of an ExecutableEntity with a minimumStartInterval. (Here no execution-instances have to be distinguished, there is only one.) The red arrows in this figure indicate the minimumStartInterval after each start of the ExecutableEntity. An RTEEvent or BswEventwithin this minimumStartInterval leads to the debounce activation state. When the minimumStartInterval ends, the debounce activation state changes to the activated state.

When a data received event activates a runnable when it is still running, it might be that the data is already dequeued during the current execution of the runnable. Still, the runnable will be started again. So, it is possible that a runnable that is activated by a data received event finds an empty receive queue.

4.2.3.1 Activation by direct function call

In many cases, ExecutableEntity execution-instances can be implemented by RTE by a direct function call if allowed by the canBeInvokedConcurrently. In these cases, the activation and start of the ExecutableEntity execution-instance collapse to one event. The states ‘to be started’, ‘debounce activation’, and ‘activated’ are passed immediately.

Obviously, debounce activation is not possible (see meta model restriction [SWS_Rte_02733]).

There is one ExecutableEntity execution-instance per call point, trigger point, mode switch point, etc.. The state chart simplifies as shown in Figure 4.21.

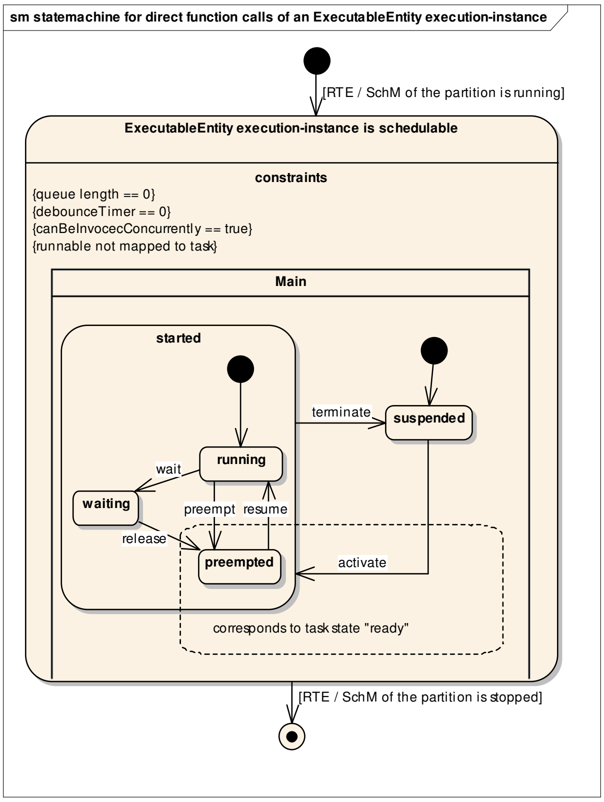


Figure 4.21: State machine of an ExecutableEntity execution-instance that is implemented by direct function calls.

A triggered ExecutableEntity is activated at least by one ExternalTriggerOccurredEvent or InternalTriggerOccurredEvent. In some cases, the *Trigger Event Communication* or the *Inter Runnable Triggering* is implemented by RTE generator as a direct function call of the triggered ExecutableEntity by the triggering ExecutableEntity.

An on-entry ExecutableEntity, on-transition ExecutableEntity, on-exit ExecutableEntity or a ModeSwitchAck ExecutableEntity might be executed in the context of the Rte_Switch API if an asynchronous mode switch procedure is implemented.

A server runnable is exclusively activated by OperationInvokedEvents and implements the server in client server communication. In some cases, the client server communication is implemented by RTE as a direct function call of the server by the client.

4.2.3.2 Activation Offset for RunnableEntitys and BswSchedulableEntitys

In order to allow optimizations (smooth cpu load, mapping of RunnableEntitys and BswSchedulableEntitys with different periods in the same task to avoid data sharing, etc.), the RTE has to handle the activation offset information from a task shared reference point only for time trigger RunnableEntitys and BswSchedulableEntitys. The maximum period of a task can be calculated automatically as the greatest common divisor (GCD) of all runnables period and offset.It is assumed that the runnables worst case execution is less than the GCD. In case of the worst case execution is greater than the GCD, the behavior becomes undefined.

[SWS_Rte_07000] ⌈ The RTE shall respect the configured activation offset of RunnableEntitys mapped within one OS task. ⌋*(SRS_Rte_00161)*

[SWS_Rte_07520] ⌈ The *Basic Software Scheduler* shall respect the configured activation offset of BswSchedulableEntitys mapped within one OS task. ⌋*(SRS_Rte_00212)*

[SWS_Rte_CONSTR_09010] Worst case execution time shall be less than the GCD ⌈ The RunnableEntitys or BswSchedulableEntitys worst case execution time shall be less than the GCD of all BswSchedulableEntitys and RunnableEntitys period and offset in activation offset context for RunnableEntitys and BswSchedulableEntitys. ⌋*()*

Note: The following examples are showing RunnableEntitys only. Nevertheless it is applicable for BswSchedulableEntitys or a mixture of RunnableEntitys and BswSchedulableEntitys as well.

Example 1:
This example describes 3 runnables mapped in one task with an activation offset defined for each runnables.

Runnable	Period	Activation Offset
R1	100ms	20ms
R2	100ms	60ms
R3	100ms	100ms

Table 4.5: Runnables timings

The runnables R1, R2 and R3 are mapped in the task T1 at 20 ms which is the GCD of all runnables period and activation offset.

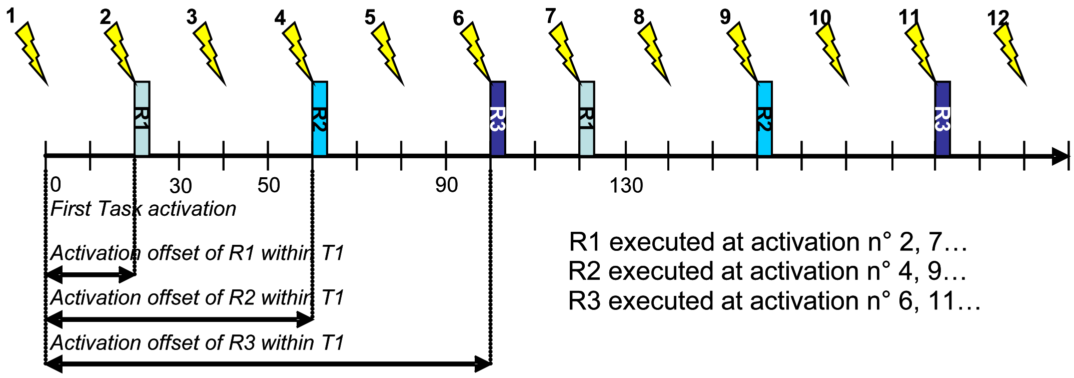


Figure 4.22: Example of activation offset for runnables

Example 2:
This example describes 4 runnables mapped in one task with an activation offset and position in task defined for each runnables.

Runnable	Period	Position in task	Activation Offset
R1	50ms	1	0ms
R2	100ms	2	0ms
R3	100ms	3	70ms
R4	50ms	4	20ms

Table 4.6: Runnables timings with position in task

The runnables R1, R2, R3 and R4 are mapped in the task T1 at 10 ms which is the GCD of all runnables period and activation offset.

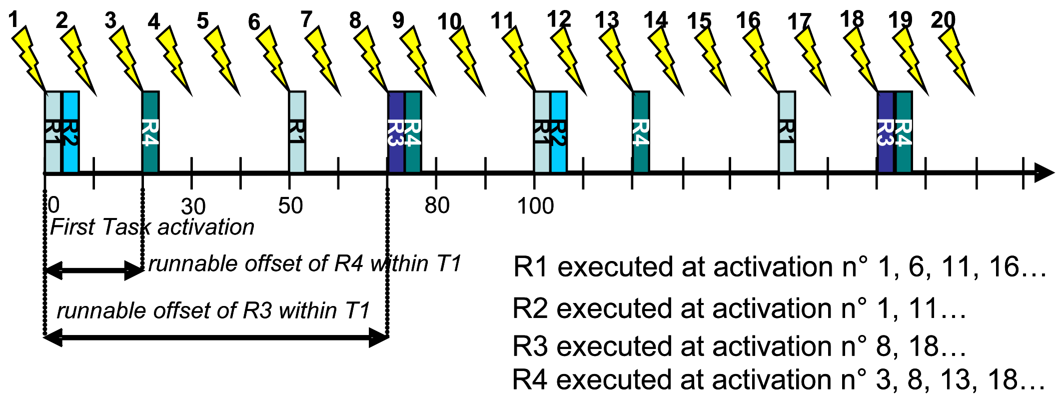


Figure 4.23: Example of activation offset for runnables with position in task

4.2.3.3 Provide activating RTE event

It is possible to define the activation of one runnable entity by several RTE events. But when the runnable entity is invoked by the RTE it is shall be possible to query which of the RTE events actually triggered the execution of this runnable entity run.

Contract Phase:

The provide activating event feature is enabled if the runnable entity has at least one activationReason defined.

[SWS_Rte_08051] ⌈ If the provide activating event feature is enabled, the RTE generator in contract phase shall generate the runnable entity signature according to [SWS_Rte_01126] and [SWS_Rte_08071]. ⌋*(SRS_Rte_00238)*

[SWS_Rte_08052] ⌈ If the provide activating event feature is enabled, the RTE generator in contract phase shall generate the type Rte_ActivatingEvent_<name> (activation vector), where <name> is the symbol describing the runnable entity's entry point, to store the activation bits. Based on the highest value of ExecutableEntityActivationReason.bitPosition for this runnable entity the type shall be either uint8, uint16, or uint32 so that the highest value of bitPosition fits into the data type. ⌋*(SRS_Rte_00238)*

Note that it is considered an invalid configuration if ExecutableEntityActivationReason.bitPosition has a value higher than 31 (see [constr_1226] in software component template [2])

[SWS_Rte_08053] ⌈ If the provide activating RTE event feature is enabled, the RTE generator in contract phase shall generate for each ExecutableEntityActivationReason of one executable entity a definition to provide the specific bit position in the Rte_ActivatingEvent_<name> data type:

```
#define Rte_ActivatingEvent_<name>_<activation> xxU
```

The value of xx is defined by the bitPosition xx = 2^bitPosition. ⌋*(SRS_Rte_00238)*

Example: runnable entity symbol = "greek" and has 3 ExecutableEntityActivationReasons aggregated. Those are referenced by 4 RTE events:

- RTEEvent: "alpha" symbol: aleph
- RTEEvent: "beta" symbol: beth
- RTEEvent: "gamma" symbol: gimel
- RTEEvent: "delta" symbol: gimel

This will result in a unit8 Rte_ActivatingEvent_<name> data type: typedef uint8 Rte_ActivatingEvent_greek and 3 definitions:

- #define Rte_ActivatingEvent_greek_aleph 01U
- #define Rte_ActivatingEvent_greek_beth 02U
- #define Rte_ActivatingEvent_greek_gimel 04U

Generation Phase:

[SWS_Rte_08054] ⌈ If the provide activating RTE event feature is enabled, the RTE shall collect the activating RTE events, which have the `activationReasonRepresentation` reference defined, in the context of the OS task the runnable entity is mapped to in an activation vector at the corresponding bit position as defined in [SWS_Rte_08053]. ⌋*(SRS_Rte_00238)*

[SWS_Rte_08055] ⌈ If the provide activating RTE event feature is enabled, the RTE shall provide the collected activating RTE events (activation vector) to the runnable entity API when the runnable entity is "started". The activation vector shall be reset immediately after it has been provided. ⌋*(SRS_Rte_00238)*

Since it is possible that there is a time gap between the activation and the execution (start) of a runnable entity the subsequent activations are summed up and provided with the start of the runnable entity.

Activations during the execution of a runnable entity are collected for the next start of that runnable entity.

4.2.4 Interrupt decoupling and notifications

4.2.4.1 Basic notification principles

Several BSW modules exist which contain functionality which is not directly activated, triggered or called by AUTOSAR software-components but by other circumstances, like digital input port level changes, complex driver actions, CAN signal reception, etc. In most cases interrupts are a result of those circumstances. For a definition of interrupts, see the VFB [1].

Several of these BSW functionalities create situations, signalled by an interrupt, when AUTOSAR SW-Cs have to be involved. To inform AUTOSAR software components of those situations, runnables in AUTOSAR software components are activated by notifications. So interrupts that occur in the basic software have to be transformed into notifications of the AUTOSAR software components. Such a transformation has to take place at RTE level **at the latest**! Which interrupt is connected to which notification is decided either during system configuration/generation time or as part of the design of Complex Device Drivers or the Microcontroller Abstraction Layer.

This means that runnables in AUTOSAR SW-Cs have to be activated or "waiting" cat2 runnables in extended tasks have to be set to "ready to run" again. In addition some event specific data may have to be passed.

There are two different mechanisms to implement these notifications, depending on the kind of BSW interfaces.

1. **BSW with Standardized interface**. Used with COM and OS.
   Basic-SW modules with Standardized interfaces cannot create RTEEvents. So another mechanism must be chosen: "**callbacks**"
   The typical callback realization in a C/C++ environment is a function call.

2. **BSW with AUTOSAR interface**: Used in all the other BSW modules.
   Basic-SW modules with AUTOSAR-Interfaces have their interface specified in an AUTOSAR BSW description XML file which contains signal specifications according to the AUTOSAR specification. The BSW modules can employ RTE API calls like Rte_Send – see 5.6.5). `RTEEvent`s may be connected with the RTE API calls, so realizing AUTOSAR SW-C activation.

Note that an AUTOSAR software component can send a notification to another AUTOSAR software component or a BSW module only via an AUTOSAR interface.

4.2.4.2 Interrupts

The AUTOSAR concept as stated in the VFB specification [1] does not allow AUTOSAR software components to run in interrupt context. Only the Microcontroller Abstraction Layer, Complex Device Drivers and the OS are allowed to directly interact with interrupts and implement interrupt service routines (see Requirement [SRS_BSW_00164]. This ensures hardware independence and determinism.

If AUTOSAR software components were allowed to run in interrupt context, one AUTOSAR software component could block the entire system schedule for an unacceptably long period of time. But the main reason is that AUTOSAR software components are supposed to be independent of the underlying hardware so that exchangeability between ECUs can be ensured. The schedule of an ECU is more predictable and better testable if the timing effects of interrupts are restricted to the basic software of that ECU.

Furthermore, AUTOSAR software components are not allowed to explicitly block interrupts as a means to ensure data consistency. They have to use RTE functions for this purpose instead, see Section 4.2.5.

4.2.4.3 Decoupling interrupts on RTE level

Runnables in AUTOSAR SW-Cs may be running as a consequence of an interrupt but **not** in interrupt context, which means not within an interrupt service routine! Between the interrupt service routine and an AUTOSAR SW-C activation there must always be a decoupling instance. AUTOSAR SW-C runnables are only executed in the context of tasks.

The decoupling instance is latest in the RTE. For the RTE there are several options to realize the decoupling of interrupts. Which option is the best depends on the configuration and implementation of the RTE, so only examples are given here.

Example 1:

Situation:

- An interrupt routine calls an RTE callback function

Intention:

- Start a runnable

RTE job:

- RTE starts a task containing the runnable activation code by using the `ActivateTask()`" OS service call.
- Other more sophisticated solutions are possible, e.g. if the task containing the runnable is activated periodically.

Example 2:

Situation:

- An interrupt routine calls an RTE callback function

Intention:

- Make a runnable wake up from a wait point

RTE job:

- RTE sets an OS event

These scenarios described in the examples above not only hold for RTE callback functions but for other RTE API functions as well.

[SWS_Rte_03600] ⌈ The RTE shall prevent runnable entities of AUTOSAR software-components to run in interrupt context. ⌋*(SRS_Rte_00099)*

4.2.4.4 RTE and interrupt categories

Since category 1 interrupts are not under OS control the RTE has absolutely no possibility to influence their execution behavior. So no category 1 interrupt is allowed to reach RTE. This is different for interrupt of category 2.

[SWS_Rte_03594] ⌈ The RTE Generator shall reject the configuration if a `SwcBswRunnableMapping` associates a `BswInterruptEntity` with a `RunnableEntity` and the attribute `interruptCategory` of the `BswInterruptEntity` is equal to `cat 1`. ⌋*(SRS_Rte_00018, SRS_Rte_00099)*

[SWS_Rte_CONSTR_09012] Category 1 interrupts shall not access the RTE. ⌈ Category 1 interrupts shall not access the RTE. ⌋*()*

4.2.4.5 RTE and Basic Software Scheduler and `BswExecutionContext`

The RTE and *Basic Software Scheduler* do support the invocation `triggered ExecutableEntity` via direct function call in some special cases. Nevertheless it shall be prevented that an ExecutableEntity from a particular execution context calls a triggered ExecutableEntity witch requires an execution context with more permissions.

The constraint [constr_4086] in document [9] describes the possible invocation of ExecutableEntitys by direct function call dependent from BswExecutionContext.

This applies to the invocation of a triggered ExecutableEntity by the SchM_Trigger, SchM_ActMain or Rte_Trigger APIs, or to the invocation of an on-entry ExecutableEntity, on-transition ExecutableEntity, on-exit ExecutableEntity or ModeSwitchAck ExecutableEntity by the SchM_Switch or Rte_Switch APIs.

4.2.4.5.1 Interrupt decoupling for COM

COM callbacks are used to inform the RTE about something that happened independently of any RTE action. This is often interrupt driven, e.g. when a data item has been received from another ECU or when a S/R transmission is completed.
It is the RTE's job e.g. to create RTEEvents from the interrupt.

[SWS_Rte_03530] ⌈ The RTE shall provide callback functions to allow COM to signal COM events to the RTE. ⌋*(SRS_Rte_00072, SRS_Rte_00099)*

[SWS_Rte_03531] ⌈ The RTE shall support runnable activation by COM callbacks. ⌋ *(SRS_Rte_00072, SRS_Rte_00099)*

[SWS_Rte_03532] ⌈ The RTE shall support category 2 runnables to wake up from a wait point as a result of COM callbacks. ⌋*(SRS_Rte_00072, SRS_Rte_00099)*

See RTE callback API in chapter 5.9.

4.2.5 Data Consistency

4.2.5.1 General

Concurrent accesses to shared data memory can cause data inconsistencies. In general this must be taken into account when several code entities accessing the same data memory are running in different contexts - in other words when systems using parallel (multicore) or concurrent (singlecore) execution of code are designed. More general: Whenever task context-switches occur and data is shared between tasks, data consistency is an issue.

AUTOSAR systems use operating systems according to the AUTOSAR-OS specification which is derived from the OSEK-OS specification. The Autosar OS specification defines a priority based scheduling to allow event driven systems. This means that tasks with higher priority levels are able to interrupt (preempt) tasks with lower priority level.

The "lost update" example in Figure 4.24 illustrates the problem for concurrent read-modify-write accesses:

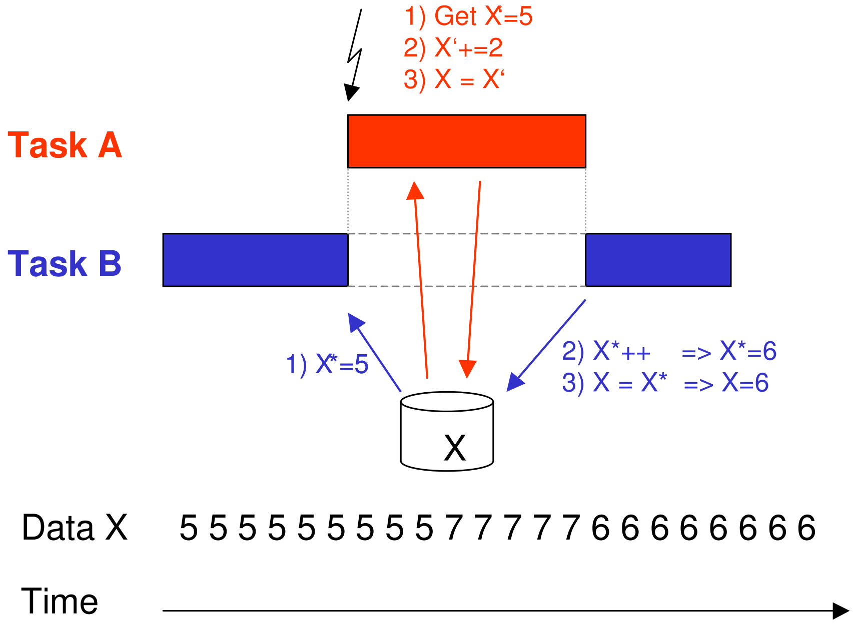


Figure 4.24: Data inconsistency example - lost update

There are two tasks. Task A has higher priority than task B. A increments the commonly accessed counter X by 2, B increments X by 1. So in both tasks there is a read (step1) – modify (step2) – write (step3) sequence. If there are no atomic accesses (fully completed read-modify-write accesses without interruption) the following can happen:

1. Assume X=5.
2. B makes read (step1) access to X and stores value 5 in an intermediate store (e.g. on stack or in a CPU register).
3. B cannot continue because it is preempted by A.
4. A does its read (step1) – modify (step2) – write (step3) sequence, which means that A reads the actual value of X, which is 5, increments it by 2 and writes the new value for X, which is 7. (X=5+2)
5. A is suspended again.
6. B continues where it has been preempted: with its modify (step2) and write (step3) job. This means that it takes the value 5 form its internal store, increments it by one to 6 and writes the value 6 to X (X=5+1).
7. B is suspended again.

The correct result after both Tasks A and B are completed should be X=8, but the update of X performed by task A has been lost.

4.2.5.2 Communication Patterns

In AUTOSAR systems the RTE has to take care that a lot of the communication is not corrupted by data consistency problems. RTE Generator has to apply suitable means if required.

The following communication mechanisms can be distinguished:

- Communication within one atomic AUTOSAR SW-C:
  Communication between Runnables of one atomic AUTOSAR SW-C running in different task contexts where communication between these Runnables takes place via commonly accessed data. If the need to support data consistency by the RTE exists, it must be specified by using the concepts of "ExclusiveAreas" or "InterRunnableVariables" only.

- Intra-partition communication between AUTOSAR SW-Cs:
  Sender/Receiver (S/R) communication between Runnables of different AUTOSAR SW-Cs using *implicit* or *explicit* data exchange can be realized by the RTE through commonly accessed RAM memory areas. Data consistency in Client/Server (C/S) communication can be put down to the same concepts as S/R communication. Data access collisions must be avoided. The RTE is responsible for guaranteeing data consistency.

- Inter-Partition communication
  The RTE has to guarantee data consistency. The different possibilities provided to the RTE for the communication between partitions are discussed in section 4.3.4.

- Intra-ECU communication between AUTOSAR SW-Cs and BSW modules with AUTOSAR interfaces:
  This is a special case of the above two.

- Inter ECU communication
  COM has to guarantee data consistency for communication between ECUs on complete path between the COM modules of different ECUs. The RTE on each ECU has to guarantee that no data inconsistency might occur when it invokes COM send respectively receive calls supplying respectively receiving data items which are concurrently accessed by application via RTE API call, especially when queueing is used since the queues are provided by the RTE and not by COM.

[SWS_Rte_03514] ⌈ The RTE has to guarantee data consistency for communication via AUTOSAR interfaces. ⌋*(SRS_Rte_00032)*

4.2.5.3 Concepts

In the AUTOSAR SW-C Template [2] chapter "Interaction between runnables within one component", the concepts of

1. ExclusiveAreas (see section 4.2.5.5 below)

2. InterRunnableVariables (see section 4.2.5.6 below)

are introduced to allow the user (SW-Designer) to specify where the RTE shall guarantee data consistency for AUTOSAR SW-C internal communication and execution circumstances. This is discussed in more detail in next sections.

Additionally exclusive areas are also available for *Basic Software Modules* to protect access to module internal data. See [9]. The exclusive areas for *Basic Software Modules* are handled by the *Basic Software Scheduler*.

The AUTOSAR SW-C template specification [2] also states that AUTOSAR SW-Cs may define `PerInstanceMemory` or `arTypedPerInstanceMemory`, allowing reservation of static (permanent) need of global RAM for the SW-C. Nothing is specified about the way Runnables might access this memory. RTE only provides a reference to this memory (see section 5.6) but doesn't guarantee data consistency for it.

The implementer of an AUTOSAR SW-C has to take care by himself that accesses to RAM reserved as PerInstanceMemory out of Runnables running in different task contexts don't cause data inconsistencies. On the other hand this provides more freedom in using the memory.

4.2.5.4 Mechanisms to guarantee data consistency

ExclusiveAreas and InterRunnableVariables are only mentioned in association with AUTOSAR SW-C internal communication. Nevertheless the data consistency mechanisms behind can be applied to communication between AUTOSAR SW-Cs or between AUTOSAR SW-Cs and BSW modules too. Everywhere where the RTE has to guarantee data consistency.

The data consistency guaranteeing mechanisms listed here are derived from AUTOSAR SW-C Template and from further discussions. There might be more (see section 4.3.4 for the mechanisms involved for `inter-partition` communication).
The RTE has the responsibility to apply such mechanisms if required. The details how to apply the mechanisms are left open to the RTE supplier.

Mechanisms:

- ***Sequential scheduling strategy***
  The activation code of Runnables is sequentially placed in one task so that no interference between them is possible because one Runnable is only activated after the termination of the other. Data consistency is guaranteed.
- ***Interrupt blocking strategy***
  Interrupt blocking can be an appropriate means if collision avoidance is required for a very short amount of time. This might be done by disabling respectively suspending all interrupts, Os interrupts only or - if hardware supports it - only of some interrupt levels. In general this mechanism must be applied with care

because it might influence SW in tasks with higher priority too and the timing of the complete system.

- ***Usage of OS resources***
  Usage of OS resources. Advantage in comparison to Interrupt blocking strategy is that less SW parts with higher priority are blocked. Disadvantage is that implementation might consume more resources (code, runtime) due to the more sophisticated mechanism. Appropriateness of this mechanism may vary depending on the number of OSs/cores and/or the number of available resources.

- ***Task blocking strategy***
  Mutual task preemption is prohibited. This might be reached e.g. by assigning same priorities to affected tasks, by assigning same internal OS resource to affected tasks or by configuring the tasks to be non-preemptive. This mechanism may be inappropriate in multi-partitioned systems.

- ***Copy strategy***
  Idea: The RTE creates copies of data items so that concurrent accesses in different task contexts cannot collide because some of the accesses are redirected to the copies.

  How it can work:

  – Application for ***read*** *conflicts*:
    For all readers with lower priority than the writer a *read copy* is provided.

    Example:
    There exist Runnable R1, Runnable R2, data item X and a copy data item X*. When Runnable R1 is running in higher priority task context than R2, and R1 is the only one writing X and R2 is reading X it is possible to guarantee data consistency by making a copy of data item X to variable X* **before** activation of R2 and redirecting write access from X to X* or the read access from X to X* for R2.

  – Application for ***write*** *conflicts*:
    If one or more data item receiver with a higher priority than the sender exist, a *write copy* for the sender is provided.

    Example:
    There exist Runnable R1, Runnable R2, data item X and copy data item X*. When Runnable R1 (running in lower priority task context than R2) is writing X and R2 is reading X, it is possible to guarantee data consistency by making a copy of data item X to data item X* **before** activation of R1 together with redirecting the write access from X to X* for R1 or the read access from X to X* for R2.

  Usage of this copy mechanism may make sense if one or more of the following conditions hold:

  - This copy mechanism can handle those cases when only one instance does the data write access.
  - R2 is accessing X several times.
  - More than one Runnable R2 has read (resp. write) access to X.
  - To save runtime is more important than to save code and RAM.
  - Additional RAM requirements to hold the copies is acceptable.

Further issues to be taken into account:

  - AUTOSAR SW-Cs provided as source code and AUTOSAR SW-Cs provided as object code may or have to be handled in different ways. The redirecting mechanism for source code could use macros for C and C++ very efficiently whereas object-code AUTOSAR SW-Cs most likely are forced to use references.

Note that the copy strategy is used to guarantee data consistency for implicit sender-receiver communication (VariableAccesses in the dataReadAccess or dataWriteAccess role) and for AUTOSAR SW-C internal communication using InterRunnableVariables with implicit behavior.

4.2.5.5 Exclusive Areas

The concept of ExclusiveArea is more a working model. It's not a concrete implementation approach, although concrete possible mechanisms are listed in AUTOSAR SW-C template specification [2].

Focus of the ExclusiveArea concept is to block potential concurrent accesses to get data consistency. ExclusiveAreas implement critical section

*ExclusiveArea*s are associated with RunnableEntitys. The RTE is forced to guarantee data consistency when the RunnableEntity runs in an ExclusiveArea. A RunnableEntity can run inside one or several ExclusiveAreas completely or can enter one or several ExclusiveAreas during their execution for one or several times .

- If an AUTOSAR SW-C requests the RTE to look for data consistency for it's internally used data (for a part of it or the complete one) using the ExclusiveArea concept, the SW designer can use the API calls "Rte_Enter()" in 5.6.28 and "Rte_Exit()" in 5.6.29 to specify where he wants to have the protection by RTE applied.
  "Rte_Enter()" defines the begin and "Rte_Exit()" defines the end of the code sequence containing data accesses the RTE has to guarantee data consistency for.

- If the SW designer wants to have the mutual exclusion for complete RunnableEntitys he can specify this by using the *ExclusiveArea* in the role "runsInsideExclusiveArea" in the AUTOSAR SW-C description.

In principle the ExclusiveArea concept can handle the access to single data items as well as the access to several data items realized by a group of instructions. It also doesn't matter if one Runnable is completely running in an ExclusiveArea and another Runnable only temporarily enters the same ExclusiveArea. The RTE has to guarantee data consistency.

[SWS_Rte_03500] ⌈ The RTE has to guarantee data consistency for arbitrary accesses to data items accessed by Runnables marked with the same ExclusiveArea. ⌋*(SRS_Rte_00032, SRS_Rte_00046)*

[SWS_Rte_03515] ⌈ RTE has to provide an API enabling the SW-Cs to access and leave ExclusiveAreas. ⌋*(SRS_Rte_00046)*

If Runnables accessing same ExclusiveArea are assigned to be executing in different task contexts, the RTE can apply suitable mechanisms, e.g. task blocking, to guarantee data consistency for data accesses in the common ExclusiveArea. However, specials attributes can be set that require certain data consistency mechanisms in which case the RTE generator is forced to apply the selected mechanism.

The *Basic Software Scheduler* provides ExclusiveAreas for the *Basic Software Modules*. *Basic Software Modules* have to use the API calls SchM_Enter()" in 6.5.1 and SchM_Exit()" in 6.5.2 to specify where the protection by Basic Software Scheduler has to be applied.

[SWS_Rte_07522] ⌈ The *Basic Software Scheduler* has to guarantee data consistency for arbitrary accesses to data items accessed by BswModuleEntitys marked with the same ExclusiveArea. ⌋*(SRS_Rte_00222, SRS_Rte_00046)*

[SWS_Rte_07523] ⌈ *Basic Software Scheduler* has to provide an API enabling the *Basic Software Module* to access and leave ExclusiveAreas. ⌋*(SRS_Rte_00222, SRS_Rte_00046)*

It is not supported, that a BswModuleEntity which is not a BswSchedulableEntity uses an ExclusiveArea in the role runsInsideExclusiveArea This is not possible, because such BswSchedulableEntity might be called directly by other *Basic Software Modules* and therefore the *Basic Software Scheduler* is not able to enter and exit the ExclusiveArea automatically.

[SWS_Rte_07524] ⌈ The RTE generator shall reject a configuration where a BswModuleEntity which is not a BswSchedulableEntity uses an ExclusiveArea in the role runsInsideExclusiveArea. ⌋*(SRS_Rte_00222, SRS_Rte_00046, SRS_Rte_00018)*

4.2.5.5.1 Assignment of data consistency mechanisms

The data consistency mechanism that has to be applied to an ExclusiveArea might be domain, ECU or even project specific. The decision which mechanism has to be applied by RTE / *Basic Software Scheduler* is taken during ECU integration by setting the ExclusiveArea configuration parameter RteExclusiveAreaImplMechanism. This parameter is an input for RTE generator.

As stated in section 4.2.5.4 there might be more mechanisms to realize ExclusiveAreas as mentioned in this specification. So RTE implementations might provide other mechanisms in plus by a vendor specific solutions. This allows further optimizations.

Actually following values for configuration parameter RteExclusiveAreaImplMechanism must be supported:

- ALL_INTERRUPT_BLOCKING
  This value requests enabling and disabling of all Interrupts and is based on the *Interrupt blocking strategy*.
- OS_INTERRUPT_BLOCKING
  This value requests enabling and disabling of Os Interrupts and is based on the *Interrupt blocking strategy*.
- OS_RESOURCE
  This value requests to apply the *Usage of OS resources* mechanism.
- OS_SPINLOCK
  This value is used to co-ordinate concurrent access by TASKs/ISR2s on different cores to a shared resource.
- NONE
  RTE generator shall not apply any mechanisms for data consistency. Data consistency will be ensured by methods outside of RTE implementation control.
- RTE_PLUGIN
  This value requests to apply the RTE Implementation Plug-In mechanism.

The strategies / mechanisms are described in general in section 4.2.5.4.

[SWS_Rte_03504] ⌈ If the configuration parameter RteExclusiveAreaImplMechanism of an ExclusiveArea is set to value ALL_INTERRUPT_BLOCKING the RTE generator shall use the mechanism of *Interrupt blocking* (blocking all interrupts) to guarantee data consistency if data inconsistency could occur. ⌋*(SRS_Rte_00032)*

[SWS_Rte_05164] ⌈ If the configuration parameter RteExclusiveAreaImplMechanism of an ExclusiveArea is set to value OS_INTERRUPT_BLOCKING the RTE generator shall use the mechanism of *Interrupt blocking* (blocking Os interrupts only) to guarantee data consistency if data inconsistency could occur. ⌋*(SRS_Rte_00032)*

[SWS_Rte_03595] ⌈ If the configuration parameter RteExclusiveAreaImplMechanism of an ExclusiveArea is set to value OS_RESOURCE the RTE generator shall use OS resources to guarantee data consistency if data inconsistency could occur. ⌋ *(SRS_Rte_00032)*

The requirements above have the limitation "if data inconsistency could occur" because it makes no sense to apply a data consistency mechanism if no potential data inconsistency can occur. This can be relevant if e.g. the "Sequential scheduling strategy" (described in section 4.2.5.4) still has solved the item by the ECU integrator defining an appropriate runnable-to-task mapping.

[SWS_Rte_08419] ⌈ If the configuration parameter RteExclusiveAreaImplMechanism of an ExclusiveAreais set to value OS_SPINLOCK the RTE generator shall use OS spinlocks to guarantee data consistency if data inconsistency could occur. ⌋ *(SRS_Rte_00032)*

[SWS_Rte_03999] ⌈ If the configuration parameter RteExclusiveAreaImplMechanism of an ExclusiveArea is set to value NONE then the RTE generator shall create functionally empty implementations for all required APIs. ⌋ *(SRS_Rte_00032)*

Note: The implementation of ExclusiveAreas via RTE Implementation Plug-In mechanism (RteExclusiveAreaImplMechanism set to RTE_PLUGIN) is described in section 7.3.5. Note:
The configuration parameter RteExclusiveAreaImplMechanism can be specified for each SWC instance and therefore the implementation for each API may differ. The description "functionally empty" implies no code to lock/unlock the exclusive area however other code, such as VFB trace, may be present. If all SWC instances result in identical implementations, e.g. empty, then an RTE generator can provide a function-like macro within the RTE API mappings to further optimize the generated API. Such optimization is not possible when implementations differ since the API mappings are generated per-type.

In a SWC code, it is not allowed to use WaitPoints inside an ExclusiveArea: The RTE generator might use OSEK services to implement ExclusiveAreas and waiting for an OS event is not allowed when an OSEK resource has been taken for example. For RunnableEntityEntersExclusiveArea, the RTE generator cannot check if WaitPoints are inside an ExclusiveArea. Therefore, it is the responsibility of the SWC Code writer to ensure that no WaitPoints are used inside an exclusive area. But for RunnableEntitys running inside an ExclusiveArea, the RTE generator is able to do the following check.

[SWS_Rte_07005] ⌈ The RTE generator shall reject a configuration with a WaitPoint applied to a RunnableEntity which is using the ExclusiveArea in the role runsInsideExclusiveArea ⌋ *(SRS_Rte_00032, SRS_Rte_00018)*

4.2.5.6 InterRunnableVariables

AtomicSwComponents (except for NvBlockComponents) can reserve InterRunnable-Variables which can be accessed by the Runnables of this one AtomicSwComponent (also see section 4.3.3.1). Read and write accesses are possible. There is a separate set of those variables per AUTOSAR SW-C instance.

Again the RTE has to guarantee data consistency. Appropriate means will depend on Runnable placement decisions which are taken during ECU configuration.

[SWS_Rte_03516] ⌈ The RTE has to guarantee data consistency for communication between Runnables of one AUTOSAR software-component instance using the same InterRunnableVariable. ⌋*(SRS_Rte_00142, SRS_Rte_00032)*

Next the two kinds of InterRunnableVariables are treated:

1. InterRunnableVariables with **implicit** behavior

   (`implicitInterRunnableVariable`)

2. InterRunnableVariables with **explicit** behavior

   (`explicitInterRunnableVariable`)

4.2.5.6.1 InterRunnableVariables with implicit behavior

In applications with very high SW-C communication needs and much real time constraints (like in powertrain domain) the usage of a copy mechanism to get data consistency might be a good choice because during `RunnableEntity` execution no data consistency overhead in form of concurrent access blocking code and runtime during its execution exists - independent of the number of data item accesses.
Costs are code overhead in the `RunnableEntity` prologue and epilogue which is often be minimal compared to other solutions. Additional RAM need for the copies comes in plus.

When *InterRunnableVariables with implicit behavior* are used the RTE is required to make the data available to the Runnable using the `semantics of a copy` operation but is not necessarily required to use a unique copy for each `RunnableEntity`.

Focus of *InterRunnableVariable with implicit behavior* is to avoid concurrent accesses by redirecting second, third, .. accesses to data item copies.

[SWS_Rte_03517] ⌈ The RTE shall guarantee data consistency for *InterRunnableVariables with implicit behavior* by avoiding concurrent accesses to data items specified by `implicitInterRunnableVariable` using one or more copies and redirecting accesses to the copies.
⌋*(SRS_Rte_00142, SRS_Rte_00032)*

Compared with Sender/Receiver communication

- Like with VariableAccesses in the dataReadAccess and dataWriteAccess roles, the Runnable IN data is stable during Runnable execution, which means that during an Runnable execution several read accesses to an implicitInterRunnableVariable always deliver the same data item value.
- Like with VariableAccesses in the dataReadAccess and dataWriteAccess roles, the Runnable OUT data is forwarded to other Runnables not before Runnable execution has terminated, which means that during an Runnable execution write accesses to implicitInterRunnableVariable are not visible to other Runnables.

This behavior requires that Runnable execution terminates.

[SWS_Rte_03582] ⌈ The value of several read accesses to implicitInterRunnableVariable during a RunnableEntity execution shall only change for write accesses performed within this RunnableEntity to the implicitInterRunnableVariable ⌋*(SRS_Rte_00142)*

[SWS_Rte_03583] ⌈ Several write accesses to implicitInterRunnableVariable during a RunnableEntity execution shall result in only one update of the implicitInterRunnableVariable content visible to other RunnableEntitys with the last written value.
⌋*(SRS_Rte_00142)*

[SWS_Rte_03584] ⌈ The update of implicitInterRunnableVariable done during a RunnableEntity execution shall be made available to other RunnableEntitys after the RunnableEntity execution has terminated.
⌋*(SRS_Rte_00142)*

[SWS_Rte_07022] ⌈ If a RunnableEntity has both read and write access to an implicitInterRunnableVariable the result of the write access shall be immediately visible to subsequent read accesses from within the same runnable entity. ⌋*(SRS_Rte_00142)*

The usage of implicitInterRunnableVariables is permitted for all categories of runnable entities. For runnable entities of category 2, the behavior is guaranteed only if it has a finite execution time. A category 2 runnable that runs forever will not have its data updated.

For API of implicitInterRunnableVariable see sections 5.6.23 and 5.6.24.

For more details how this mechanism could work see "Copy strategy" in section 4.2.5.4.

4.2.5.6.2 InterRunnableVariables with explicit behavior

In many applications saving RAM is more important than saving runtime. Also some application require to have access to the newest data item value without any delay, even several times during execution of a Runnable.

Both requirements can be fulfilled when RTE supports data consistency by blocking second/third/.. concurrent accesses to a signal buffer if data consistency is jeopardized. (Most likely RTE has nothing to do if SW is running on a 16bit machine and making an access to an 16bit value when a 16bit data bus is present.)

Focus of *InterRunnableVariables with explicit behavior* is to block potential concurrent accesses to get data consistency.

The mechanism behind is the same as in the `ExclusiveArea` concept (see section 4.2.5.5). But although ExclusiveAreas can handle single data item accesses too, their API is made to make the RTE to apply data consistency means for a group of instructions accessing several data items as well. So when using an ExclusiveArea to protect accesses to one single common used data item each time two RTE API calls grouped around are needed. This is very inconvenient and might lead to faults if the calls grouped around might be forgotten.
The solution is to support *InterRunnableVariables with explicit behavior*.

[SWS_Rte_03519] ⌈ The RTE shall guarantee data consistency for *InterRunnableVariables with explicit behavior* by blocking concurrent accesses to data items specified by `explicitInterRunnableVariable`.
⌋*(SRS_Rte_00142, SRS_Rte_00032)*

The RTE generator is not free to select on it's own if implicit or explicit behavior shall be applied. Behavior must be known at AUTOSAR SW-C design time because in case of *InterRunnableVariables with implicit behavior* the AUTOSAR SW-C designer might rely on the fact that several read accesses always deliver same data item value.

[SWS_Rte_03580] ⌈ The RTE shall supply different APIs for *InterRunnableVariables with implicit* behavior and *InterRunnableVariables with explicit* behavior.
⌋*(SRS_Rte_00142)*

For API of *InterRunnableVariables with explicit behavior* see sections 5.6.26 and 5.6.27.

4.2.6 Multiple trigger of Runnable Entities and Basic Software Schedulable Entities

Concurrent activation

The AUTOSAR SW-C template specification [2] states that runnable entities (further called "runnables") might be invoked concurrently several times if the Runnables attribute `canBeInvokedConcurrently` is set. It's then in the responsibility of the AUTOSAR SW-C designer that no data might be corrupted when the Runnable is activated several times in parallel.

If a SW-C has multiple instances, they have distinct runnables. Two runnables that use the same `RunnableEntity` description of the same `SwcInternalBehavior` description but are instantiated with two different SW-C instances are treated as two distinct runnables in the following. This kind of concurrency is always allowed between

SW-Cs, even if the runnables have their canBeInvokedConcurrently attribute set to false.

[SWS_Rte_03523] ⌈The RTE shall support concurrent activation of the same instance of a runnable entity if the associative attribute canBeInvokedConcurrently is set to TRUE. This includes concurrent activation in several tasks. If the attribute is not set resp. set to FALSE, concurrent activation of the runnable entity is forbidden. (see requirement [SWS_Rte_05083]) ⌋*(SRS_Rte_00072, SRS_Rte_00133)*

The *Basic Software Module Description Template* [9] specifies the possible concurrent activation of BswModuleEntitys by the attribute isReentrant.

[SWS_Rte_07525] ⌈The *Basic Software Scheduler* shall support concurrent activation of the same instance of a BswSchedulableEntity if the attribute isReentrant of the referenced BswModuleEntry in the role implementedEntry is set to true. This includes concurrent activation in several tasks. If the attribute is set to false concurrent activation of the BswSchedulableEntity is forbidden. (see requirement [SWS_Rte_07588]) ⌋*()*

Concurrent activation of the same instance of an ExecutableEntity results in multiple ExecutableEntity execution-instances. One for each context of activation.

Activation by several RTEEvents and BswEvents

Nevertheless a Runnable whose attribute canBeInvokedConcurrently is NOT set might be still activated by several RTEEvents if activation configuration guarantees that concurrent activation can never occur and the minimumStartInterval condition is kept. This includes activation in different tasks. In this case, the runnable is still considered to have only one ExecutableEntity execution-instances. A standard use case is the activation of same instance of a runnable in different modes.

[SWS_Rte_03520] ⌈The RTE shall support activation of same instance of a runnable entity by multiple RTEEvents. ⌋*(SRS_Rte_00072)*

RTEEvents are triggering runnable activation and may supply 0..several role parameters, see section 5.7.3. Role parameters are not visible in the runnables signature - except in those triggered by an OperationInvokedEvent. With the exception of the RTEEvent OperationInvokedEvent all role parameters can be accessed by user with implicit or explicit Receiver API.

[SWS_Rte_03524] ⌈The RTE shall support activation of same instance of a runnable entity by RTEEvents of different kinds. ⌋*(SRS_Rte_00072)*

The RTE does NOT support a runnable entity triggered by an RTEEvent OperationInvokedEvent to be triggered by any other RTEEvent except for other OperationInvokedEvents of compatible operations. This limitation is stated in appendix in section A.2 ([SWS_Rte_03526]).

The similar configuration as mentioned for the RunnableEntitys might be used for BswSchedulableEntitys. Therefore even a BswSchedulableEntity whose referenced BswModuleEntry in the role implementedEntry has its isReentrant attribute set to false can be activated by several BswEvents.

[SWS_Rte_07526] ⌈ The *Basic Software Scheduler* shall support activation of same instance of a BswSchedulableEntity by multiple BswEvents. ⌋*()*

[SWS_Rte_07527] ⌈ The *Basic Software Scheduler* shall support activation of same instance of a BswSchedulableEntity by BswEvents of different kinds. ⌋*()*

4.2.7 Implementation of Parameter and Data Elements

4.2.7.1 General

A SWC communicates with other SWCs through ports. A port is characterized by a PortInterface and there are several kinds of PortInterfaces. In this section, we focus on the ParameterInterface, the SenderReceiverInterface, and the NvDataInterface. These three kinds of PortInterfaces aggregate some specific interface elements. For example, a ParameterInterface aggregates 0..* ParameterDataPrototypes.

4.2.7.2 Compatibility rules

A receiver port can only be connected to a compatible provider port. The compatibility rules are explained in the AUTOSAR Software Component Template [2]. The compatibility mainly depends on the attribute swImplPolicy attached to the element of the interface. The table 4.7 below gives an overview of compatibility rules.

Provide Port			Require Port					
Port Interface			Prm			S/R		NvD
Interface Element			PDP			VDP		VDP
		swImplPolicy	fixed	const	standard	standard	queued	standard
Prm	PDP	fixed	yes	yes	yes	yes	no	yes
		const	no	yes	yes	yes	no	yes
		standard	no	no	yes	yes	no	yes
S/R	VDP	standard	no	no	no	yes	no	yes
		queued	no	no	no	no	yes	no
NvD	VDP	standard	no	no	no	yes	no	yes

Table 4.7: Overview of compatibility of ParameterDataPrototype and VariableDataPrototypes

Interface Element
PDP : ParameterDataPrototype
VDP : VariableDataPrototype

Port Interface		
Prm	:	ParameterInterface
S/R	:	SenderReceiverInterface
NvD	:	NvDataInterface

Table 4.8: Key to table 4.7

For examples, a Require Port that expects a fixed parameter - i.e produced by a macro #define - can only be connected to a Port that provides a fixed Parameter. This is because this fixed data may be used in a compilation directive like #IF and only macro #define (fixed data) can be compiled in this case. On the other hand, this provided fixed parameter can be connected to almost every require port, except a queued Sender/receiver interface.

The RTE doesn't have to check the compatibility between ports since this task is performed at the VFB level. But it shall provide the right implementation of interface element and API according the attribute swImplPolicy attached to the interface element.

4.2.7.3 Implementation of an interface element

The implementation of an interface element depends on the attribute swImplPolicy. The attribute swCalibrationAccess determines how the interface element can be accessed by e.g. an external calibration tool. The table 4.9 defines the supported combinations of swImplPolicy and swCalibrationAccess attribute setting and gives the corresponding implementation by the RTE.

swImplPolicy	SwCalibrationAccess			
	not Accessible	readOnly	readWrite	Implementation
fixed	yes	not supported	not supported	macro definition or c const declaration dependent from RTE optimization
const	yes	yes	not supported	c const declaration
standard	yes	yes	yes	standard implementation i.e. a variable for VariableDataPrototype in RAM or a calibration parameter in ROM [3]

[3]calibration parameter have to be allocated in RAM if data emulation with SW support is required, see 4.2.8.3.5

queued	yes	not supported	not supported	FIFO Queue
measurement Point	not supported	yes	not supported	Variable

Table 4.9: Data implementation according swImplPolicy

4.2.7.4 Initialization of VariableDataPrototypes

Basically the need for initialization of any VariableDataPrototypes is specified by the Software Component Descriptions defining the VariableDataPrototypes. This information is basically defined by the existence of an initValue, the sectionInitializationPolicy of the related SwAddrMethod. As described in section 8.11 additionally the initialization strategy can be adjusted by the integrator of the RTE to adjust the behavior to the start-up code.

[SWS_Rte_07046] ⌈ Variables implementing VariableDataPrototypes shall be initialized if

- an initValue is defined

  AND

- no SwAddrMethod is defined for VariableDataPrototype.

⌋*(SRS_Rte_00052, SRS_Rte_00068, SRS_Rte_00116)*

[SWS_Rte_03852] ⌈ Variables implementing VariableDataPrototypes shall be initialized if

- an initValue is defined

  AND

- a SwAddrMethod is defined for VariableDataPrototype

  AND

- the RteInitializationStrategy for the sectionInitializationPolicy of the related SwAddrMethod is NOT configured to RTE_INITIALIZATION_STRATEGY_NONE.

⌋*(SRS_Rte_00052, SRS_Rte_00068, SRS_Rte_00116)*

4.2.7.5 Initial value calculation

Basically the Meta Model defines two different flavors of rule based value specifications:

- ApplicationRuleBasedValueSpecification

- NumericalRuleBasedValueSpecification

The ApplicationRuleBasedValueSpecification defines the values in the physical representation whereas the NumericalRuleBasedValueSpecification defines the values in the numerical representation. (See document [2], section *Data Description*) But both are using the RuleBasedValueSpecification to define a set of values based on a rule and arguments for the rule.

Especially in case of large arrays an high amount of initial values are required. But many arrays are initialized with identical values or at least filled up to the end with identical values. For such use case the RuleBasedValueSpecification of category FILL_UNTIL_END can be used to avoid the creation and maintenance of redundant ValueSpecifications.

[SWS_Rte_06764] ⌈ The RTE Generator shall support ApplicationRuleBasedValueSpecifications for DataPrototypes typed by ApplicationArrayDataTypes. ⌋ *(SRS_Rte_00239)*

[SWS_Rte_06765] ⌈ The RTE Generator shall support NumericalRuleBasedValueSpecifications for DataPrototypes typed by ImplementationDataTypes of category ARRAY and for Compound Primitive Data Types which are mapped to ImplementationDataTypes of category ARRAY. ⌋ *(SRS_Rte_00239)*

[SWS_Rte_06733] ⌈ The RTE Generator shall support RuleBasedValueSpecifications with the rule FILL_UNTIL_END. ⌋ *(SRS_Rte_00239)*

[SWS_Rte_08542] ⌈ The RTE Generator shall support RuleBasedValueSpecifications with the rule FILL_UNTIL_MAX_SIZE. ⌋ *(SRS_Rte_00239)*

[SWS_Rte_06734] ⌈ The RTE shall initialize the elements of the array according the values defined by RuleBasedValueSpecification.arguments if a RuleBasedValueSpecification with the rule FILL_UNTIL_END or FILL_UNTIL_MAX_SIZE is applicable.
Thereby the order of arguments corresponds to the order of elements in the array, i.e. the first argument corresponds to the first element of the array, the second argument corresponds to the second element of the array, and so on. ⌋ *(SRS_Rte_00239)*

AUTOSAR defines a standardized behavior of RuleBasedValueSpecifications only for the rules FILL_UNTIL_END and FILL_UNTIL_MAX_SIZE. RTE vendors are free to add additional, non-standardized rules (see [TPS_SWCT_01495]).

[SWS_Rte_06735] ⌈ The RTE Generator shall apply the value of the last RuleBasedValueSpecification argument to any following element of the array until the last element of the array if the rule is set to FILL_UNTIL_END and the number of arguments is smaller than the number of elements of the array to which it is applied. ⌋ *(SRS_Rte_00239)*

[SWS_Rte_08792] ⌈ The RTE Generator shall apply the value of the last RuleBasedValueSpecification argument to so many following elements of the array until first maxSizeToFill elements of the array are filled if the rule is set to

FILL_UNTIL_MAX_SIZE and the number of arguments is smaller than the number of elements of the array to which it is applied. ⌋*(SRS_Rte_00239)*

[SWS_Rte_06736] ⌈ The RTE Generator shall ignore arguments that go beyond the last element of the array if the number of arguments exceeds the number of elements of the array to which it is applied. ⌋*(SRS_Rte_00239)*

4.2.8 Measurement and Calibration

4.2.8.1 General

Calibration is the process of adjusting an ECU SW to fulfill its tasks to control physical processes respectively to fit it to special project needs or environments. To do this two different mechanisms are required and have to be distinguished:

1. Measurement
   Measure what's going on in the ECU e.g. by monitoring communication data (Inter-ECU, Inter-Partition, Intra-partition, Intra-SWC). There are several ways to get the monitor data out of the ECU onto external visualization and interpretation tools.

2. Calibration
   Based on the measurement data the ECU behavior is modified by changing parameters like runtime SW switches, process controlling data of primitive or composite data type, interpolation curves or interpolation fields. In the following for such parameters the term calibration parameter is used.

With AUTOSAR, a calibration parameter is instantiated with a ParameterDataPrototype class that aggregates a SwDataDefProps with properties swCalibrationAccess = readWrite and swImplPolicy = standard.

Nevertheless it is supported, that VariableDataPrototype is instantiated that aggregates a SwDataDefProps with properties swCalibrationAccess = readWrite and swImplPolicy = standard. But in this case the implementation of such VariableDataPrototype is treated identical to swCalibrationAccess = readOnly and the RTE Generator has not to implement further measures (for instance "Data emulation with SW support" 4.2.8.3.5).

It's possible that different SwDataDefProps settings are specified for a VariableDataPrototype and its referenced AutosarDataType. In this case the rules specified in the SWC-T shall be applied. See as well [SWS_Rte_07196].

SwDataDefProps contain more information how measurement values or characteristics are to be interpreted and presented by external calibration tools. This information is needed for the ASAM2 respectively A2L file generation. Afterwards the A2L file is used by ECU-external measurement and calibration tools so that these tools know e.g. how to interpret raw data received from ECU and how to get them.

4.2.8.1.1 Definition of Calibration Parameters

Calibration parameters can be defined in AUTOSAR SW as well as in Basic-SW. In the *AUTOSAR Architecture* there are two possibilities to define calibration parameters. Which one to choose is not in the focus of this RTE specification.

1. RTE provides the calibration parameter access if they are specified via a `ParameterSwComponentType`. A `ParameterSwComponentType` can be defined in order to provide `ParameterDataPrototype`s (via ports) to other Software Components.

2. Calibration parameter access invisible for RTE
   Since multiple instantiation with code sharing is not allowed for Basic-SW and multiple instantiation is not always required for software components it's possible for these software to define own methods how calibration parameters are allocated. Nevertheless these calibration parameters shall be described in the belonging *Basic Software Module Description* respectively *Software Component Description*. In case data emulation with SW-support is used, the whole software and tool chain for calibration and measurement, e.g. Basic-SW (respectively XCP driver) which handles emulation details and data exchange with external calibration tools then has to deal with several emulation methods at once: The one the RTE uses and the other ones each Basic-SW or SWC using local calibration parameters practices.

4.2.8.1.2 Online and offline calibration

The way how measurement and calibration is performed is company, domain and project specific. Nevertheless two different basic situations can be distinguished and are important for understanding:

1. Offline calibration
   Measure when ECU is running, change calibration data when ECU is off.
   Process might look like this:

   (a) Flash the ECU with current program file

   (b) PowerUp ECU in target (actual or emulated) environment

   (c) Measure running ECU behavior - log or monitor via external tooling

   (d) Switch off ECU

   (e) Change calibration parameters and create a new flashable program file (hex-file) e.g. by performing a new SW make run

   (f) Back to (a).

   Do loop as long as a need for calibration parameter change exists or the Flash survives.

2. Online calibration

   Do measurement and calibration in parallel.
   In this case in principle all steps mentioned in "Offline calibration" above have to be performed in parallel. So other mechanisms are introduced avoiding ECU flashing when modifying ECU parameters. ECU works temporarily with changed data and when the calibration process is over the result is an updated set of calibration data. In next step this new data set might be merged into the existing program file or the new data set might be an input for a new SW make run. In both cases the output is a new program file to flash into the ECU.

   Process might look like this:

   (a) Flash the ECU with current program file
   (b) PowerUp ECU in target environment
   (c) Measure running ECU behavior and temporarily modify calibration parameters. Store set of updated calibration parameters (not on the ECU but on the calibration tool computer). Actions in step c) may be done iteratively.
   (d) Switch off ECU
   (e) Create a new flashable program file (hex-file) containing the new calibration parameters

   Procedure over

4.2.8.2 Measurement

4.2.8.2.1 What can be measured

The AUTOSAR SW-C template specification [2] explains to which AUTOSAR prototypes a measurement pattern can be applied.

RTE provides measurement support for

1. communication between Ports
   Measurable are

   - `VariableDataPrototype`s of a `SenderReceiverInterface` used in a `PortPrototype` (of a `SwComponentPrototype`) to capture sender-receiver communication or between `SwComponentPrototype`s
   - `VariableDataPrototype`s of a `NvDataInterface` used in a `PortPrototype` (of a `SwComponentPrototype`) to capture non volatile data communication or between `SwComponentPrototype`s

- ArgumentDataPrototypes of an ClientServerOperation in a ClientServerInterface to capture client-server communication between SwComponentPrototypes

2. communication inside of AUTOSAR SW-Cs
   Measurable are implicitInterRunnableVariable, explicitInterRunnableVariable or arTypedPerInstanceMemory
3. data structures inside a AUTOSAR NvBlockSwComponent
   Measurable are ramBlocks and romBlocks of a NvBlockSwComponent's *NvBlock*
4. Communication inside of AUTOSAR Basic Software Modules
   Measurable are VariableDataPrototypes defined in role of arTypedPerInstanceMemory.

Further on AUTOSAR SW-Cs and *Basic Software Module*s can define measurables which are not instantiated by RTE. These are described by VariableDataPrototypes in the role staticMemory. Hence those kind of measurables are not described in the generated *McSupportData* of the RTE (see 4.2.8.4).

4.2.8.2.2 RTE support for Measurement

The way how measurement data is read out of the ECU is not focus of the RTE specification. But the RTE structure and behavior must be specified in that way that measurement values can be provided by RTE during ECU program execution.

To avoid synchronization effort it shall be possible to read out measurement data asynchronously to RTE code execution. For this the measurement data must be stable. As a consequence this might forbid direct reuse of RAM locations for implementation of several AUTOSAR communications which are independent of each other but occurring sequentially in time (e.g. usage of same RAM cell to store uint8 data sender receiver communication data between Runnables at positions 3 and 7 and later the same RAM cell for the communication between Runnables at positions 9 and 14 of same periodically triggered task). So applying measurable elements might lead to less optimizations in the generated RTE's code and to increased RAM need.

There are circumstances when RTE will store same communication data in different RAM locations, e.g. when realizing implicit sender receiver communication or Inter Runnable Variables with implicit behavior. In these cases there is only the need to have the content of one of these stores made accessible from outside.

Please note: In case the Rte implements Inter partition data communication with IOC the measurement support may become vendor specific since the IOC does not provide standardized support for measurement of IOC channels. But on the other hand the creation of distinct measurement buffers in the Rte in addition to the needed buffers in IOC is also not a worthwhile in any case due to the additional RAM need.

The information that measurement shall be supported by RTE is defined in applied SwDataDefProps:
The value readOnly or readWrite of the property swCalibrationAccess defines that measurement shall be supported, any other value of the property swCalibrationAccess is to be ignored for measurement.

Please note that the definition of [SWS_Rte_03900] and [SWS_Rte_03902] do not have further conditions when the location in memory has to be provided to support the usage of VariableDataPrototype with the swImplPolicy = measurementPoint. In case that the MCD system is permitted to access such a VariableDataPrototype the RTE is not allowed to do optimization which would prevent such measurement even if there is no consuming software component in the input configuration.

The memory locations containing measurement values are initialized according to [SWS_Rte_07046] and [SWS_Rte_03852].

[SWS_Rte_07044] ⌈ The RTE generator shall reject input configurations in which a RunnableEntity defines a read access (VariableAccess in the role readLocalVariable, dataReadAccess, dataReceivePointByValue or dataReceivePointByArgument) to an VariableDataPrototype with a swImplPolicy set to measurementPoint. ⌋*(SRS_Rte_00018)*

For sender-receiver resp. client-server communication same or compatible interfaces are used to specified connected ports. So very often measurement will be demanded two times for same or compatible VariableDataPrototype on provide and require side of a 1:1 communication resp. multiple times in case of 1:N or M:1 communication. In that case providing more than one measurement value for a VariableDataPrototype doesn't make sense and would increase ECU resources need excessively. Instead only one measurement value shall be provided.

Sender-receiver communication

[SWS_Rte_03900] ⌈ If the swCalibrationAccess of a VariableDataPrototype used in an interface of a sender-receiver port of a SwComponentPrototype is set to readOnly or readWrite the RTE generator has to provide one reference to a location in memory where the actual content of the instance specific data of the corresponding VariableDataPrototype of the communication can be accessed. ⌋*(SRS_Rte_00153)*

To prohibit multiple measurement values for same communication:
(Note that affected VariableDataPrototypes might be specified in same or compatible port interfaces.)

[SWS_Rte_03972] ⌈ For 1:1 and 1:N sender-receiver communication the RTE shall provide measurement values taken from sender side if measurement is demanded in provide and require port. ⌋*(SRS_Rte_00153)*

[SWS_Rte_03973] ⌈ For N:1 intra-ECU sender-receiver communication the RTE shall provide measurement values taken from receiver side if measurement is demanded in provide and require ports. ⌋*(SRS_Rte_00153)*

Note:
See further below for support of queued communication.

[SWS_Rte_03974] ⌈ For a `VariableDataPrototype` with measurement demand associated with received data of inter-ECU sender-receiver communication the RTE shall provide only one measurement store reference containing the actual received data even if several receiver ports demand measurement. ⌋*(SRS_Rte_00153)*

[SWS_Rte_07344] ⌈ For a `VariableDataPrototype` with measurement demand associated with received data of inter-Partition sender-receiver communication the RTE shall provide only one measurement store reference per partition containing the actual received data even if several receiver ports demand measurement in the Partition. ⌋*(SRS_Rte_00153)*

Client-Server communication

[SWS_Rte_03901] ⌈ If the `swCalibrationAccess` of an `ArgumentDataPrototype` used in an interface of a client-server port of a `SwComponentPrototype` is set to `readOnly` the RTE generator has to provide one reference to a location in memory where the actual content of the instance specific argument data of the communication can be read. ⌋*(SRS_Rte_00153)*

To prohibit multiple measurement values for same communication:
(Note that affected `ArgumentDataPrototype`s might be specified in same or compatible port interfaces.)

[SWS_Rte_03975] ⌈ For intra-ECU client-server communication the RTE shall provide measurement values taken from client side if measurement of an `ArgumentDataPrototype`s is demanded by provide and require ports. ⌋*(SRS_Rte_00153)*

[SWS_Rte_03976] ⌈ For inter-ECU client-server communication with the client being present on same ECU as the RTE, the RTE shall provide measurement values taken from client side. ⌋*(SRS_Rte_00153)*

[SWS_Rte_03977] ⌈ For inter-ECU client-server communication with the server being present on same ECU as the RTE, the RTE shall provide measurement values taken from server if no client present on same ECU as the server is connected with that server too. ⌋*(SRS_Rte_00153)*

[SWS_Rte_07349] ⌈ For inter-Partition client-server communication with the server being present on the same ECU as the RTE, the RTE shall provide measurement values taken from server if no client present on the same Partition as the server is connected with that server too. ⌋*(SRS_Rte_00153)*

Note:
When a measurement is applied to a client-server call additional copy code might be

produced so that a zero overhead direct server invocation is no longer possible for this call.

Mode Switch Communication

[SWS_Rte_06700] ⌈ If the swCalibrationAccess of a ModeDeclarationGroupPrototype used in an interface of a mode switch port of a SwComponentPrototype is set to readOnly the RTE generator has to provide three references to locations in memory where the *current mode*, the *previous mode* and the *next mode* of the related mode machine instance can be accessed. ⌋*(SRS_Rte_00153)*

The affected ModeDeclarationGroupPrototypes might be used at different ports with the same or compatible port interfaces. [SWS_Rte_06701] prohibits the occurrence of multiple measurement values for the same communication:

[SWS_Rte_06701] ⌈ For 1:1 and 1:N mode switch communication the RTE shall provide measurement values taken from mode manager side if measurement is demanded in provide and require port. ⌋*(SRS_Rte_00153)*

Inter Runnable Variables

[SWS_Rte_03902] ⌈ If the swCalibrationAccess of a VariableDataPrototype in the role implicitInterRunnableVariable or explicitInterRunnableVariable is set to readOnly or readWrite the RTE generator has to provide one reference to a location in memory where the actual content of the *Inter Runnable Variable* can be accessed for a specific instantiation of the AUTOSAR SWC.
⌋*(SRS_Rte_00153)*

PerInstanceMemory

[SWS_Rte_07160] ⌈ If the swCalibrationAccess of a VariableDataPrototype in the role arTypedPerInstanceMemory is set to readOnly or readWrite the RTE generator has to provide one reference to a location in memory where the actual content of the arTypedPerInstanceMemory can be accessed for a specific instantiation of the AUTOSAR SWC.
⌋*(SRS_Rte_00153)*

[SWS_Rte_06206] ⌈ If the swCalibrationAccess of a VariableDataPrototype in the role arTypedPerInstanceMemory is set to readOnly or readWrite the RTE Generator has to provide exactly one reference to a location in memory where the actual content of the arTypedPerInstanceMemory can be accessed for a specific instantiation of the Basic Software Module.
⌋*(SRS_Rte_00153)*

Nv RAM Block

[SWS_Rte_07174] ⌈ If the swCalibrationAccess of a VariableDataPrototype in the role ramBlock of a NvBlockSwComponentType's NvBlockDescriptor is set to readOnly or readWrite the RTE generator has to provide one reference to a location in memory where the actual content of the *Nv RAM Block* can be accessed

for a specific instantiation of the AUTOSAR NvBlockSwComponentType.
⌋(SRS_Rte_00153)

Non Volatile Data communication

[SWS_Rte_07197] ⌈If the swCalibrationAccess of a VariableDataPrototype used in an NvDataInterface of a non volatile data port of a SwComponentPrototype is set to readOnly or readWrite the RTE generator has to provide one reference to a location in memory where the actual content of the instance specific data of the corresponding VariableDataPrototype of the communication can be accessed. ⌋(SRS_Rte_00153)

To prohibit multiple measurement values for same communication:
(Note that affected VariableDataPrototypes might be specified in same or compatible port interfaces.)

[SWS_Rte_07198] ⌈For 1:1 and 1:N non volatile data communication the RTE shall provide measurement values taken from ramBlock if measurement is demanded either in provide port, any require port ([SWS_Rte_07197] or ramBlock ([SWS_Rte_07174]). ⌋(SRS_Rte_00153)

Unconnected ports or compatible interfaces

As stated in section 5.2.7 RTE supports handling of unconnected ports.

Measurement support for unconnected sender-receiver provide ports makes sense since a port might be intentionally added for monitoring purposes only.

Measurement support for unconnected sender-receiver require ports makes sense since the measurement is specified on the type level of the Software Component and therefore independent of the individual usage of the Software Component. In case of unconnected sender-receiver require ports the measurement shall return the initial value.

Support for unconnected client-server provide port does not make sense since the server cannot be called and with this no data can be passed there.

Support for unconnected client-server require port makes sense since the measurement is specified on the type level of the Software Component and therefore independent of the individual usage of the Software Component. In case of unconnected client-server require ports the measurement shall return the actually provided and returned values.

[SWS_Rte_03978] ⌈For sender-receiver communication the RTE generator shall respect measurement demands enclosed in unconnected provide ports. ⌋(SRS_Rte_00139, SRS_Rte_00153)

[SWS_Rte_05101] ⌈For sender-receiver communication the RTE generator shall respect measurement demands enclosed in unconnected require ports and deliver the initial value. ⌋(SRS_Rte_00139, SRS_Rte_00153)

[SWS_Rte_03980] ⌈ For client-server communication the RTE generator shall ignore measurement demands enclosed in unconnected provide ports. ⌋*(SRS_Rte_00139, SRS_Rte_00153)*

[SWS_Rte_05102] ⌈ For client-server communication the RTE generator shall respect measurement demands enclosed in unconnected require ports. The behavior shall be similar as if the require port would be connected and the server does not respond. ⌋ *(SRS_Rte_00139, SRS_Rte_00153)*

[SWS_Rte_05170] ⌈ For client-server communication the RTE generator shall ignore measurement requests for queued client-server communication. ⌋*(SRS_Rte_00139, SRS_Rte_00153)*

In case the measurement of client-server communication is not possible due to requirement [SWS_Rte_05170] the `McSupportData` need to reflect this (see [SWS_Rte_05172]).

In principle the same thoughts as above are applied to unused `VariableDataPrototype`s for sender-receiver communication where ports with compatible but not same interfaces are connected. It's no issue for client-server due to compatibility rules for client-server interfaces since in compatible client-server interfaces all `ClientServerOperation`s have to be present in provide and require port (see AUTOSAR SW-C Template [2]).

[SWS_Rte_03979] ⌈ For sender-receiver communication the RTE generator shall respect measurement demands of those `VariableDataPrototype`s in connected ports when provide and require port interfaces are not the same (but only compatible) even when a `VariableDataPrototype` in the provide port has no assigned `VariableDataPrototype` in the require port.
⌋*(SRS_Rte_00153)*

General measurement disabling switch

To support saving of ECU resources for projects where measurement isn't required at all whereas enclosed AUTOSAR SW-Cs contain SwDataDefProps requiring it, it shall be possible to switch off support for measurement. This shall not influence support for calibration (see 4.2.8.3).

[SWS_Rte_03903] ⌈ The RTE generator shall have the option to switch off support for measurement for generated RTE code. This option shall influence complete RTE code at once. ⌋*(SRS_Rte_00153)*

There also might be projects in which monitoring of ECU internal behavior is required but calibration is not.

[SWS_Rte_03904] ⌈ The enabling of RTE support for measurement shall be independent of the enabling of the RTE support for calibration. ⌋*(SRS_Rte_00153)*

Queued communication

Measurement of queued communication is not supported yet. Reasons are:

- A queue can be empty. What's to measure then?
- Which of the queue entries is the one to take the data from might differ out of user view?
- Only quite inefficient solutions possible because implementation of queues entails storage of information dynamically at different memory locations. So always additional copies are required.

[SWS_Rte_03950] ⌈ RTE generator shall reject configurations where measurement for queued sender-receiver communication is configured. ⌋*(SRS_Rte_00153, SRS_Rte_00018)*

4.2.8.3 Calibration

The RTE and *Basic Software Scheduler* has to support the allocation of calibration parameters and the access to them for SW using them. As seen later on for some calibration methods the RTE and *Basic Software Scheduler* must contain support SW too (see 4.2.8.3.5). But in general the RTE and *Basic Software Scheduler* is not responsible for the exchange of the calibration data values or the transportation of them between the ECU and external calibration tools.

The following sections are mentioning only the RTE but this has to be understood in the context that the support for *Calibration* is a functionality which affects the Basic Software Scheduler part of the RTE as well. In case of the *Basic Software Scheduler Generation Phase* (see 3.4.1) this functionality might even be provided with out any other software component related RTE functionality.

With AUTOSAR, a calibration parameter (which the AUTOSAR SW-C template specification [2] calls `ParameterSwComponentType`) is instantiated with a `ParameterDataPrototype` that aggregates a `SwDataDefProps` with properties `swCalibrationAccess` = `readWrite` and `swImplPolicy` = `standard`. This chapter applies to this kind of `ParameterSwComponentType`s. For other combinations of these properties, consult the section 4.2.7

4.2.8.3.1 Calibration parameters

Calibration parameters can be defined in `ParameterSwComponentType`s, in AUTOSAR SW-Cs, `NvBlockSwComponentType`s and in *Basic Software Modules*.

1. `ParameterSwComponentType`s don't have an internal behavior but contain `ParameterDataPrototype`s and serve to provide calibration parameters used commonly by several AUTOSAR SW-Cs. The use case that one or several of the user SW-Cs are instantiated on different ECUs is supported by instantiation of the `ParameterSwComponentType` on the affected ECUs too.
   Of course several AUTOSAR SW-Cs allocated on one ECU can commonly access the calibration parameters of `ParameterSwComponentType`s too. Also

several instances of an AUTOSAR SW-Cs can share the same calibration parameters of a ParameterSwComponentType.

2. Calibration parameters defined in AUTOSAR SW-Cs can only be used inside the SW-C and are not visible to other SW-Cs. Instance individual and common calibration parameters accessible by all instances of an AUTOSAR SW-C are possible.

3. For NvBlockSwComponentTypes it is supported to provide calibration access to the ParameterDataPrototype defining the romBlock. These values can not be directly accessed by AUTOSAR SW-Cs but are used to serve as default values for the NVRAM Block applied via InitBlockCallbackFunction.

4. Calibration parameters defined in *Basic Software Module*s can only be used inside the defining *Basic Software Module* and are not visible to other *Basic Software Module*s. In contrast to AUTOSAR SW-Cs, *Basic Software Module*s can only define instance specific calibration parameters.

[SWS_Rte_03958] ⌈ Several AUTOSAR SW-Cs (and also several instances of AUTOSAR SW-Cs) shall be able to share same calibration parameters defined in ParameterSwComponentTypes. ⌋*(SRS_Rte_00154, SRS_Rte_00159)*

[SWS_Rte_07186] ⌈ The generated RTE shall initialize the memory objects implementing ParameterDataPrototypes in *p-ports* of ParameterSwComponentTypes according the ValueSpecification of the ParameterProvideComSpec referring the ParameterDataPrototype in the *p-port*,

- if such ParameterProvideComSpec exists and
- if no CalibrationParameterValue refers to the FlatInstanceDescriptor associated to the ParameterDataPrototype

This is also applicable if the swImplPolicy = fixed and if the related ParameterDataPrototype is implemented as preprocessor define which does not immediately allocate a memory object. ⌋*(SRS_Rte_00154, SRS_Rte_00159)*

[SWS_Rte_07029] ⌈ The generated RTE shall initialize the memory objects implementing ParameterDataPrototypes in *p-ports* of ParameterSwComponentTypes according the ValueSpecification in the role implInitValue of the CalibrationParameterValue referring the FlatInstanceDescriptor associated to the ParameterDataPrototype if such CalibrationParameterValue is defined. ⌋*(SRS_Rte_00154)*

Note: the initialization according [SWS_Rte_07029] and [SWS_Rte_07030] precedes the initialization values defined in the context of an component type and used in [SWS_Rte_07185] and [SWS_Rte_07186]. This enables to provide initial values for calibration parameter instances to:

- predefine start values for the calibration process
- utilizes the result of the calibration process

- take calibration parameter values from previous projects

[SWS_Rte_03959] ⌈ If the SwcInternalBehavior aggregates an ParameterDataPrototype in the role perInstanceParameter the RTE shall support the access to instance specific calibration parameters of the AUTOSAR SW-C. ⌋*(SRS_Rte_00154, SRS_Rte_00158)*

[SWS_Rte_05112] ⌈ If the SwcInternalBehavior aggregates an ParameterDataPrototype in the role sharedParameter the RTE shall create a common access to the shared calibration parameter. ⌋*(SRS_Rte_00154, SRS_Rte_00159)*

[SWS_Rte_07096] ⌈ If the BswInternalBehavior aggregates an ParameterDataPrototype in the role perInstanceParameter the *Basic Software Scheduler* shall support the access to instance specific calibration parameters of the *Basic Software Module*. ⌋*(SRS_Rte_00154, SRS_Rte_00158)*

[SWS_Rte_07185] ⌈ The generated RTE and *Basic Software Scheduler* shall initialize the memory objects implementing ParameterDataPrototype in the role perInstanceParameter or sharedParameter

- if it has a ValueSpecification in the role initValue according to this ValueSpecification and
- if no CalibrationParameterValue refer to the FlatInstanceDescriptor associated to the ParameterDataPrototype

This is also applicable if the swImplPolicy = fixed and if the related ParameterDataPrototype is implemented as preprocessor define which does not immediately allocate a memory object. ⌋*(SRS_Rte_00154)*

[SWS_Rte_07030] ⌈ The generated RTE and *Basic Software Scheduler* shall initialize the memory objects implementing ParameterDataPrototypes in the role perInstanceParameter or sharedParameter according the ValueSpecification in the role the implInitValue of the CalibrationParameterValue referring the FlatInstanceDescriptor associated to the ParameterDataPrototype if such CalibrationParameterValue is defined. ⌋*(SRS_Rte_00154)*

It might be project specific or even project phase specific which calibration parameters have to be calibrated and which are assumed to be stable. So it shall be selectable on ParameterSwComponentTypes and AUTOSAR SW-C granularity level for which calibration parameters RTE shall support calibration.

If an r-port contains a ParameterDataPrototype, the following requirements specify its behavior if the port is unconnected.

[SWS_Rte_02749] ⌈ In case of an unconnected parameter r-port, the RTE shall set the values of the ParameterDataPrototypes of the r-port according to the initValue of the r-port's ParameterRequireComSpec referring to the ParameterDataPrototype. ⌋*(SRS_Rte_00139, SRS_Rte_00159)*

If the port is unconnected, RTE expects an init value, see [SWS_Rte_02750].

ParameterDataPrototypes in role romBlock

[SWS_Rte_07033] ⌈ If the swCalibrationAccess of a ParameterDataPrototype in the role romBlock is set to readWrite the RTE generator has to provide one reference to a location in memory where the actual content of the *romBlock* can be accessed. ⌋*(SRS_Rte_00154)*

[SWS_Rte_07034] ⌈ The generated RTE shall initialize any ParameterDataPrototype in the role romBlock

- if it has a ValueSpecification in the role initValue according to this ValueSpecification and
- if no CalibrationParameterValue refer to the FlatInstanceDescriptor associated to the ParameterDataPrototype

⌋*(SRS_Rte_00154)*

[SWS_Rte_07035] ⌈ The generated RTE shall initialize the memory objects implementing ParameterDataPrototypes in the role romBlock according the ValueSpecification in the role the implInitValue of the CalibrationParameterValue referring the FlatInstanceDescriptor associated to the ParameterDataPrototype if such CalibrationParameterValue is defined. ⌋*(SRS_Rte_00154)*

ParameterDataPrototype used as romBlock are instantiated according to [SWS_Rte_07693].

Configuration of calibration support

[SWS_Rte_03905] ⌈ It shall be configurable for each ParameterSwComponentType if RTE calibration support for the enclosed ParameterDataPrototypes is enabled or not. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

[SWS_Rte_03906] ⌈ It shall be configurable for each AUTOSAR SW-C if RTE calibration support for the enclosed ParameterDataPrototypes is enabled or not. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

RTE calibration support means the creation of SW as specified in section 4.2.8.3.5 "Data emulation with SW support".

Require ports on ParameterSwComponentTypes don't make sense. ParameterSwComponentTypes only have to provide calibration parameters to other Component types. So the RTE generator shall reject configurations containing require ports attached to ParameterSwComponentTypes. (see section A.13)

4.2.8.3.1.1 Separation of calibration parameters

Sometimes it is required that one or more calibration parameters out of the mass of calibration parameters of an ParameterSwComponentType respectively an AUTOSAR

SW-C shall be placed in another memory location than the other parameters of the ParameterSwComponentType respectively the AUTOSAR SW-C. This might be due to security reasons (separate normal operation from monitoring calibration data in memory) or the possibility to change calibration data during a diagnosis session (which the calibration parameter located in NVRAM).

[SWS_Rte_03907] ⌈ The RTE generator shall support separation of calibration parameters from ParameterSwComponentTypes, AUTOSAR SW-Cs and *Basic Software Modules* depending on the ParameterDataPrototype property swAddrMethod. ⌋ *(SRS_Rte_00154, SRS_Rte_00158)*

4.2.8.3.2 Support for offline calibration

As described in section 4.2.8.1 when using an offline calibration process measurement is decoupled from providing new calibration parameters to the ECUs SW. During measurement phase information is collected needed to define to which values the calibration parameters are to be set best. Afterwards the new calibration parameter set is brought into the ECU e.g. by using a bootloader.

[SWS_Rte_03971] ⌈ The RTE generator shall have the option to switch off all *data emulation* support for generated RTE code. This option shall influence complete RTE code at once. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

The term *data emulation* is related to mechanisms described in section 4.2.8.3.3.

Out of view of RTE the situation is same as when *data emulation without SW support* (described in section 4.2.8.3.4) is used:
The RTE is only responsible to provide access to the calibration parameters via the RTE API as specified in section 5.6. Exchange of ParameterDataPrototype content is done invisibly for ECU program flow and with this for RTE too.

When no *data emulation support* is required calibration parameter accesses to parameters stored in FLASH could be performed by direct memory read accesses without any indirection for those cases when accesses are coming out of single instantiated AUTOSAR SW-Cs or from *Basic Software Module*s. Nevertheless it's not goal of this specification to require direct accesses since this touches implementation. It might be ECU HW dependent or even be project dependent if other accesses are more efficient or provide other significant advantages or not.

4.2.8.3.3 Support for online calibration: Data emulation

To allow **online calibration** it must be possible to provide alternative calibration parameters invisible for application. The mechanisms behind are described here. We talk of *data emulation*.

In the following several calibration methods are described:

1. Data emulation without SW support and
2. several methods of data emulation with SW-support.

The term **data emulation** is used because the change of calibration parameters is emulated for the ECU SW which uses the calibration data. This change is invisible for the user-SW in the ECU.

RTE is significantly involved when SW support is required and has to create calibration method specific SW. Different calibration methods means different support in Basic SW which typically is ECU integrator specific. So it does not make sense to support DIFFERENT data emulation with SW support methods in ANY one RTE build. But it makes sense that the RTE supports direct access (see section 4.2.8.3.4) for some AUTOSAR SW-Cs resp. `ParameterSwComponentType`s resp. *Basic Software Modules* and one of the data emulation with SW support methods (see section 4.2.8.3.5) for all the other AUTOSAR SW-Cs resp. `ParameterSwComponentType`s resp. *Basic Software Modules* at the same time.

[SWS_Rte_03909] ⌈ The RTE shall support only one of the data emulation with SW support methods at once. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

4.2.8.3.4 Data emulation without SW support (direct access)

For "online calibration" (see section 4.2.8.1) the ECU is provided with additional hardware which consists of control logic and memory to store modified calibration parameters in. During ECU execution the brought in control logic redirects memory accesses to new bought in memory whose content is modified by external tooling without disturbing normal ECU program flow. Some microcontrollers contain features supporting this. A lot of smaller microcontrollers don't. So this methods is highly HW dependent.

To support these cases the RTE doesn't have to provide e.g. a reference table like described in section 4.2.8.3.5. Exchange of `ParameterDataPrototype` content is done invisibly for program flow and for RTE too.

[SWS_Rte_03942] ⌈ The RTE generator shall have the option to switch off *data emulation with SW support* for generated RTE code. This option shall influence complete RTE code at once. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

4.2.8.3.5 Data emulation with SW support

In case "online calibration" (see section 4.2.8.1) is required, quite often data emulation without support by special SW constructs isn't possible. Several methods exist, all have the consequence that additional need of ECU resources like RAM, ROM/FLASH and runtime is required.

Data emulation with SW support is possible in different manners. During calibration process in each of these methods modified calibration data values are kept typically in RAM. Modification is controlled by ECU external tooling and supported by ECU internal SW located in AUTOSAR basic SW or in complex driver.

If calibration process isn't active the accessed calibration data is originated in ROM/FLASH respectively in NVRAM in special circumstances (as seen later on).

Since multiple instantiation is to be supported several instances of the same `ParameterDataPrototype`s have to be allocated. Because the RTE is the only one SW in an AUTOSAR ECU able to handle the different instances the access to these calibration parameters can only be handled by the RTE. So the RTE has to provide additional SW constructs required for data emulation with SW support for calibration.

However the RTE doesn't know which of the ECU functionality shall be calibrated during a calibration session. To allow expensive RAM to be reused to calibrate different ECU functionalities in one or several online calibration sessions (see 4.2.8.1) in case of the single and double pointered methods for data emulation with SW support described below the RTE has only to provide the access to `ParameterDataPrototype`s during runtime but allowing other SW (a BSW module or a complex driver) to redirect the access to alternative calibration parameter values (e.g. located in RAM) invisibly for application.
The RTE is neither the instance to supply the alternative values for `ParameterDataPrototype`s nor in case of the pointered methods for data emulation with SW support to do the redirection to the alternative values.

[SWS_Rte_03910] ⌈ The RTE shall support *data emulation with SW support* for calibration. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

[SWS_Rte_03943] ⌈ The RTE shall support these data emulation methods with SW support:

- Single pointered calibration parameter access
  further called "single pointered method"
- Double pointered calibration parameter access further called "double pointered method"
- Initialized RAM parameters further called "initRAM parameter method"

⌋*(SRS_Rte_00154, SRS_Rte_00156)*

Please note that the support data emulation methods is applicable for calibration parameters provided for software components as well as calibration parameters provided for basic software modules.

ParameterElementGroup

To save RAM/ROM/FLASH resources in single pointered method and double pointered method `ParameterDataPrototype` allocation is done in groups. One entry of the calibration reference table references the begin of a group of `ParameterDataPrototype`s. For better understanding of the following, this group is called

ParameterElementGroup (which is no term out of the AUTOSAR SW-C template specification [2]). One ParameterElementGroup can contain one or several ParameterDataPrototypes.

[SWS_Rte_03911] ⌈ If data emulation with SW support is enabled, the RTE generator shall allocate all ParameterDataPrototypes marked with same property swAddrMethod of one instance of a ParameterSwComponentType consecutively. Together they build a separate ParameterElementGroup. ⌋*(SRS_Rte_00154, SRS_Rte_00156, SRS_Rte_00158)*

[SWS_Rte_03912] ⌈ If data emulation with SW support is enabled, the RTE shall guarantee that all non-shared ParameterDataPrototypes marked with same property swAddrMethod of an AUTOSAR SWC instance are allocated consecutively. Together they build a separate ParameterElementGroup. ⌋*(SRS_Rte_00154, SRS_Rte_00158)*

[SWS_Rte_05194] ⌈ If data emulation with SW support is enabled, the RTE shall guarantee that all shared ParameterDataPrototypes marked with same property swAddrMethod of an AUTOSAR SWC type are allocated consecutively. Together they build a separate ParameterElementGroup. ⌋*(SRS_Rte_00154, SRS_Rte_00158)*

It is not possible to access same calibration parameter inside of a ParameterSwComponentType via several ports. This is a consequence of the need to support the use case that a ParameterSwComponentType shall be able to contain several calibration parameters derived from one ParameterDataPrototype which is contained in one interface applied to several ports of the ParameterSwComponentType. Using only the ParameterDataPrototype names for the names of the elements of a ParameterElementGroup would lead to a name clash since then several elements with same name would have to created. So port prototype and ParameterDataPrototype name are concatenated to specify the ParameterElementGroup member names.
This use case cannot be applied to AUTOSAR SW-C internal calibration parameters since they cannot be accessed via AUTOSAR ports.

[SWS_Rte_03968] ⌈ The names of the elements of a ParameterElementGroup derived from a ParameterSwComponentType shall be <port>_<element> where <port> is the short-name of the provided AUTOSAR port prototype and <element> the short-name of the ParameterDataPrototype within the ParameterInterface categorizing the PPort. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

4.2.8.3.5.1 Single pointered method

There is one calibration reference table in RAM with references to one or several ParameterElementGroups. Accesses to calibration parameters are indirectly performed via this reference table.

Action during calibration procedure e.g. calibration parameter value exchange is not focus of this specification. Nevertheless an example is given for better understanding.

Example how the exchange of calibration parameters could be done for single pointered method:

1. Fill a RAM buffer with the modified calibration parameter values for complete `ParameterElementGroup`
2. Modify the corresponding entry in the calibration reference table so that a redirection to new `ParameterElementGroup` is setup

Now calibration parameter accesses deliver the modified values.

Figure 4.25 illustrates the method.

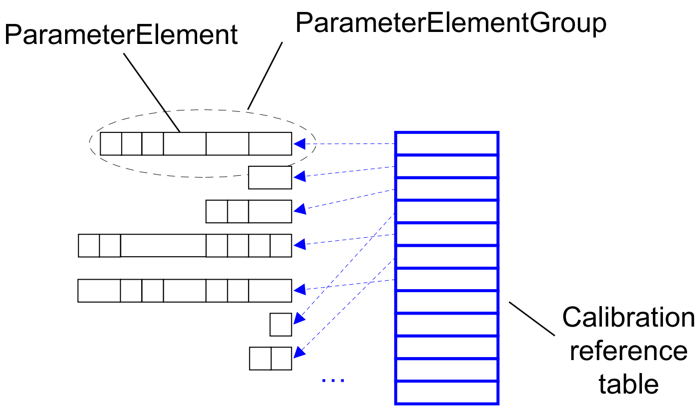


Figure 4.25: ParameterElementGroup in single pointered method context

[SWS_Rte_03913] ⌈ If data emulation with SW support with single pointered method is enabled, the RTE generator shall create a table located in RAM with references to `ParameterElementGroups`. The type of the table is an array of void pointers. ⌋ *(SRS_Rte_00154, SRS_Rte_00156)*

One reason why in this approach the calibration reference table is realized as an array is to make ECU internal reference allocation traceable for external tooling. Another is to allow a Basic-SW respectively a complex driver to emulate other calibration parameters which requires the standardization of the calibration reference table too.

[SWS_Rte_03947] ⌈ If data emulation with SW support with single method is enabled the name (the label) of the calibration reference table shall be `<RteParameterRefTab>`. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

Calibration parameters located in NVRAM are handled same way (also see section 4.2.8.3.6).

[SWS_Rte_03936] ⌈ If data emulation with SW support with single or double pointered method is enabled and calibration parameter respectively a ParameterElementGroups is located in NVRAM the corresponding calibration reference table entry shall reference the PerInstanceMemory working as the NVRAM RAM buffer. ⌋ *(SRS_Rte_00154, SRS_Rte_00156, SRS_Rte_00157)*

4.2.8.3.5.2 Double pointered method

There is one calibration reference table in ROM respectively Flash with references to one or several ParameterElementGroups. Accesses to calibration parameters are performed through a double indirection access. During system startup the base reference is initially filled with a reference to the calibration reference table.

Action during calibration procedure e.g. calibration parameter value exchange is not focus of this specification. Nevertheless an example is given for better understanding.

Example how the exchange of calibration parameters could be done for double pointered method:

1. Copy the calibration reference table into RAM
2. Fill a RAM buffer with modified calibration parameter values for complete ParameterElementGroup
3. Modify the corresponding entry in the RAM copy of the reference table so that a redirection to new ParameterElementGroup is setup
4. Change the content of the base reference so that it references the calibration reference table copy in RAM.

Now calibration parameter accesses deliver the modified values.

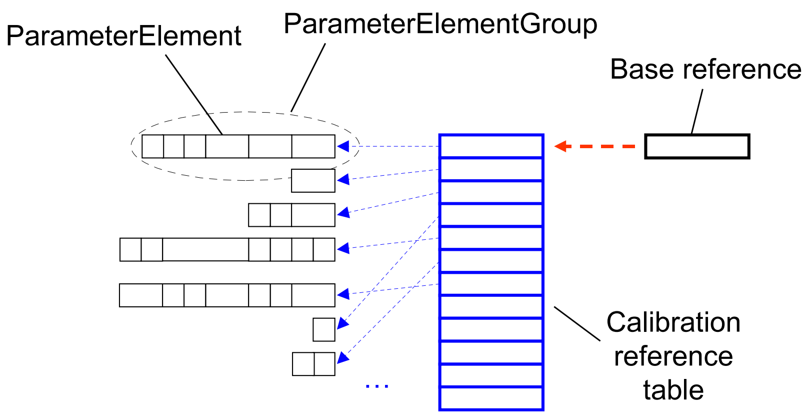


Figure 4.26: ParameterElementGroup in double pointered method context

[SWS_Rte_03914] ⌈ If data emulation with SW support with double pointered method is enabled, the RTE generator shall create a table located in ROM respectively FLASH with references to ParameterElementGroups. The type of the table is an array of void pointers. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

Figure 4.26 illustrates the method.

To allow a Basic-SW respectively a complex driver to emulate other calibration parameters the standardization of the base reference is required.

[SWS_Rte_03948] ⌈ If data emulation with SW support with double method is enabled the name (the label) of the calibration base reference shall be <RteParameterBase>. This label and the base reference type shall be exported and made available to other SW on same ECU.
⌋*(SRS_Rte_00154, SRS_Rte_00156)*

Calibration parameters located in NVRAM are handled same way (also see section 4.2.8.3.6).

For handling of calibration parameters located in NVRAM with single or double pointered method see [SWS_Rte_03936] in section 4.2.8.3.5.1. General information is found in section 4.2.8.3.6).

4.2.8.3.5.3 InitRam parameter method

For each instance of a ParameterDataPrototype the RTE generator creates a calibration parameter in RAM and a corresponding value in ROM/FLASH. During startup of RTE the calibration parameter values of ROM/FLASH are copied into RAM. Accesses to calibration parameters are performed through a direct access to RAM without any indirection.

Action during calibration procedure e.g. calibration parameter value exchange is not focus of this specification. Nevertheless an example is given for better understanding: An implementation simply would have to exchange the content of the RAM cells during runtime.

[SWS_Rte_03915] ⌈ If data emulation with SW support with initRam parameter method is enabled, the RTE generator shall create code guaranteeing that

1. calibration parameters are allocated in ROM/Flash and
2. a copy of them is allocated in RAM made available latest during RTE startup

for those ParameterDataPrototypes for which calibration support is enabled. ⌋ *(SRS_Rte_00154, SRS_Rte_00156)*

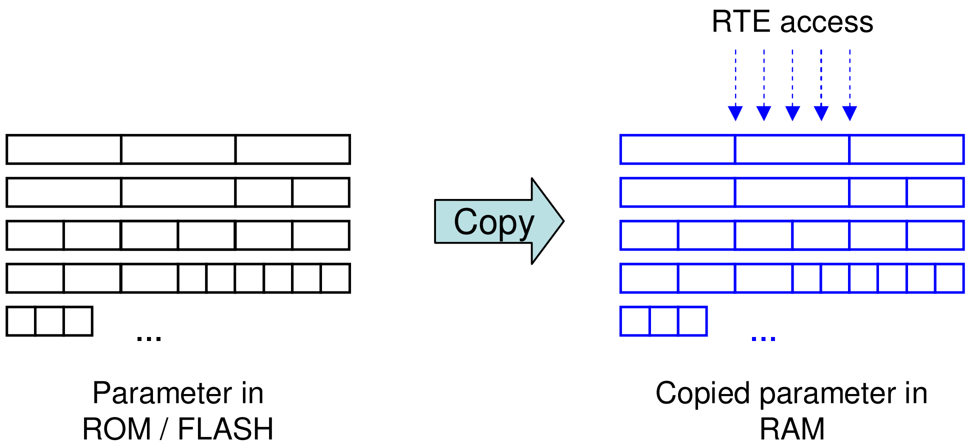


Figure 4.27: initRam Parameter method setup

Figure 4.27 illustrates the method.

A special case is the access of `ParameterDataPrototype`s instantiated in NVRAM (also see section 4.2.8.3.6). In this no extra RAM copy is required because a RAM location containing the calibration parameter value still exists.

[SWS_Rte_03935] ⌈ If data emulation with SW support with initRam parameter method is enabled, the RTE generator shall create direct accesses to the PerInstanceMemory working as RAM buffer for the calibration parameters defined to be in NVRAM. ⌋ *(SRS_Rte_00154, SRS_Rte_00156)*

4.2.8.3.5.4 Arrangement of a ParameterElementGroup for pointered methods

For data emulation with SW support with single or double pointered methods the RTE has to guarantee access to each single member of a `ParameterElementGroup` for source code and object code delivery independent if the member is a primitive or a composite data type. For this the creation of a record type for a `ParameterElementGroup` was chosen.

[SWS_Rte_03916] ⌈ One `ParameterElementGroup` shall be realized as one record type. ⌋ *(SRS_Rte_00154, SRS_Rte_00156)*

The sequence order of `ParameterDataPrototype` in a `ParameterElementGroup` and the order of `ParameterElementGroups` in the reference table will be documented by the RTE Generator by the means of the `McSwEmulationMethodSupport`, see 4.2.8.4.4.

4.2.8.3.5.5 Further definitions for pointered methods

As stated in section 4.2.8.3.1.1, dependent of the value of property `swAddrMethod` calibration parameters shall be separated in different memory locations.

[SWS_Rte_03908] ⌈ If data emulation with SW support with single or double pointered method is enabled the RTE shall create a separate instance specific ParameterElementGroup for all those ParameterDataPrototypes with a common value of the appended property swAddrMethod. Those ParameterDataPrototypes which have no property swAddrMethod appended, shall be grouped together too. ⌋*(SRS_Rte_00154, SRS_Rte_00156, SRS_Rte_00158)*

To allow traceability for external tooling the sequence order of ParameterDataPrototype in a ParameterElementGroup and the order of ParameterElementGroups in the reference table will be documented by the RTE Generator by the means of the McSwEmulationMethodSupport, see 4.2.8.4.4.

4.2.8.3.5.6 Calibration parameter access

Calibration parameters are derived from ParameterDataPrototypes. The RTE has to provide access to each calibration parameter via a separate API call.

API is specified in 5.6.

[SWS_Rte_03922] ⌈ If data emulation with SW support and single or double pointered method is enabled the RTE generator shall export the label of the calibration reference table. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

[SWS_Rte_03960] ⌈ If data emulation with SW support and double pointered method is enabled the RTE generator shall export the label and the type of the calibration base reference. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

[SWS_Rte_03932] ⌈ If data emulation with SW support with single pointered method is enabled the RTE generator shall create API calls using single indirect access via the calibration reference table for those ParameterDataPrototypes which are in a ParameterElementGroup for which calibration is enabled. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

[SWS_Rte_03933] ⌈ If data emulation with SW support with double pointered method is enabled the RTE generator shall create API calls using double indirection access via the calibration base reference and the calibration reference table for those ParameterDataPrototypes which are in a ParameterElementGroup for which calibration is enabled. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

[SWS_Rte_03934] ⌈ If data emulation with SW support with double pointered method is enabled, the calibration base reference shall be located in RAM. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

4.2.8.3.5.7 Calibration parameter allocation

Since only the RTE knows which instances of AUTOSAR SW-Cs, ParameterSwComponentTypes and *Basic Software Module*s are present on the ECU the RTE has to allocate the calibration parameters and reserve memory for them. This approach is also covering multiple instantiated object code integration needs. So memory for instantiated ParameterDataPrototypes is neither provided by ParameterSwComponentTypes nor by AUTOSAR SW-C.

Nevertheless AUTOSAR SW-Cs and *Basic Software Modules* can define calibration parameters which are not instantiated by RTE. These are described by ParameterDataPrototypes in the role constantMemory. Further on the RTE can not implement any software support for data emulation for such calibration parameters. Hence those kind of calibration parameters are not described in the generated *McSupportData* of the RTE (see 4.2.8.4).

[SWS_Rte_03961] ⌈ The RTE shall allocate the memory for calibration parameters. ⌋ *(SRS_Rte_00154, SRS_Rte_00156)*

A ParameterDataPrototype can be defined to be instance specific or can be shared over all instances of an AUTOSAR SW-C or a ParameterSwComponentType. The input for the RTE generator contains the values the RTE shall apply to the calibration parameters.

To support online and offline calibration (see section 4.2.8.1) all parameter values for all instances have to be provided.
Background:

- For online calibration often initially the same default values for calibration parameters can be applied. Variation is then handled later by post link tools. Initial ECU startup is not jeopardized. This allows the usage of a default value e.g. by AUTOSAR SW-C or ParameterSwComponentType supplier for all instances of a ParameterDataPrototype.
- On the other hand applying separate default values for the different instances of a ParameterDataPrototype will be required often for online calibration too, to make a vehicle run initially. This requires additional configuration work e.g. for integrator.
- Offline calibration based on new SW build including new RTE build and compilation process requires all calibration parameter values for all instances to be available for RTE.

Shared ParameterDataPrototypes

[SWS_Rte_03962] ⌈ For accesses to a shared ParameterDataPrototype the RTE API shall deliver the same one value independent of the instance the calibration parameter is assigned to. ⌋ *(SRS_Rte_00154, SRS_Rte_00156)*

[SWS_Rte_03963] ⌈ The calibration parameter of a shared ParameterDataPrototype shall be stored in one memory location only. ⌋ *(SRS_Rte_00154, SRS_Rte_00156)*

Requirements [SWS_Rte_03962] and [SWS_Rte_03963] are to guarantee that only one physical location in memory has to be modified for a change of a shared ParameterDataPrototype. Otherwise this could lead to unforeseeable confusion.
Multiple locations are possible for calibration parameters stored in NVRAM. But there a shared ParameterDataPrototype is allowed to have only one logical data too.

Instance specific **ParameterDataPrototype**s

[SWS_Rte_03964] ⌈ For accesses to an instance specific ParameterDataPrototype the RTE API shall deliver a separate calibration parameter value for each instance of a ParameterDataPrototype. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

[SWS_Rte_03965] ⌈ For an instance specific ParameterDataPrototype the calibration parameter value of each instance of the ParameterDataPrototype shall be stored in a separate memory location. ⌋*(SRS_Rte_00154, SRS_Rte_00156)*

Usage of swAddrMethod

SwDataDefProps contain the optional property *swAddrMethod*. It contains meta information about the memory section in which a measurement data store resp. a calibration parameter shall be allocated in. This abstraction is needed to support the reuse of unmodified AUTOSAR SW-Cs resp. ParameterSwComponentTypes in different projects but allowing allocation of measurement data stores resp. calibration parameters in different sections.
Section usage typically depends on availability of HW resources. In one project the micro controller might have less internal RAM than in another project, requiring that most measurement data have to be placed in external RAM. In another project one addressing method (e.g. indexed addressing) might be more efficient for most of the measurement data - but not for all. Or some calibration parameters are accessed less often than others and could be - depending on project specific FLASH availability - placed in FLASH with slower access speed, others in FLASH with higher access speed.

[SWS_Rte_03981] ⌈ The memory section used to store measurement values in shall be the memory sections associated with the swAddrMethod enclosed in the SwDataDefProps of a measurement definition. ⌋*(SRS_Rte_00153)*

Since it's measurement data obviously this must be in RAM.

[SWS_Rte_03982] ⌈ The memory section used to store calibration parameters in shall be the memory sections associated with the swAddrMethod enclosed in the SwDataDefProps of a calibration parameter definition. ⌋*(SRS_Rte_00153)*

4.2.8.3.6 Calibration parameters in NVRAM

Calibration parameters can be located in NVRAM too. One use case for this is to have the possibility to modify calibration parameters via a diagnosis service without need for special calibration tool.

To allow NVRAM calibration parameters to be accessed, NVRAM with statically allocated RAM buffer in form of PIM memory for the calibration parameters has to be defined or the `ramBlock` of a `NvBlockSwComponentType` defines `readWrite` access for the MCD system. Please see as well [SWS_Rte_07174] and [SWS_Rte_07160].

Note:

As the NVRAM Manager might not be able to access the `PerInstanceMemory` across core boundaries in a multi core environment, the support of Calibration parameters in NVRAM for multi core controllers is limited. See also note in 4.2.9.1.

4.2.8.3.7 Multiple calibration parameters instances

In complex systems the situation occur that calibration parameter values may depend on the configuration of the vehicle due to functional side effects. The difficulty is that those dependencies are typically detected after design of the software components and shall not change the software component design. In addition the overall ECU SW has to support all vehicle variants and therefore the detection and selection of the concrete vehicle variant needs to be done post build.

[SWS_Rte_06815] ⌈ The RTE Generator shall provide one separate memory location per `FlatInstanceDescriptor` pointing to the identical `ParameterDataPrototype` instance in the root software composition. ⌋*(SRS_Rte_00154, SRS_Rte_00191)*

Thereby the `FlatInstanceDescriptor` needs to have different `postBuildVariantConditions` as described in [constr_3114]. As a consequence at most one location in memory location created according [SWS_Rte_06815] can be active in a specific post build variant. This value needs to be accessed by the according RTE APIs `Rte_CData` and `Rte_Prm` accessing parameters.

[SWS_Rte_06816] ⌈ For accesses to a `ParameterDataPrototype` the RTE API shall deliver the value of the memory location which belongs to the currently selected post build variant. ⌋*(SRS_Rte_00154, SRS_Rte_00156, SRS_Rte_00191)*

In order to ensure the functionality of `Rte_CData` and `Rte_Prm` depending on post build variability it needs to be ensured, that exactly one `FlatInstanceDescriptor` is selected in a specific post build variant when the RTE generator creates an RTE Post Build Data Set, see section 3.6.

The binding of the post build variability is done at the call of `SchM_Init` according the passed post build data set as described in sections section 4.7.2 and section 5.3.10

Please note that the requirements [SWS_Rte_07029] and [SWS_Rte_07030] also apply in this scenario and therefore the different memory locations due to multiple FlatInstanceDescriptors can get different initial values.

The following example shall illustrate the usage of post build variant FlatInstanceDescriptors in combination with multiple instantiation. The raw ARXML is listed in the section F.5.

In the given configuration a ParameterSwComponentType 'PSWC' is defined with on PPortPrototype 'EP' typed by the ParameterInterface 'EP'. The root software composition defines two SwComponentPrototypes 'SWC_PA' and 'SWC_PB'.

The ApplicationSwComponentType 'ASWC' defines RPortPrototype 'EP', a perInstanceParameter 'PIP' and a sharedParameter 'SP' The root software composition defines two SwComponentPrototypes 'SWC_A' and 'SWC_B' and therefore two component instances for the component type ASWC exist. PPortPrototype 'EP' of 'SWC_PA' is connected to RPortPrototype 'EP' of 'SWC_A', PPortPrototype 'EP' of 'SWC_PB' is connected to RPortPrototype 'EP' of 'SWC_B'. (not shown in the figure 4.28)

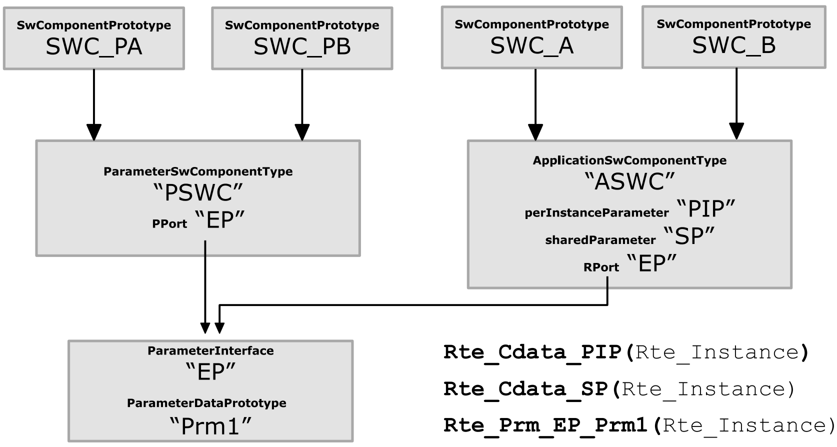


Figure 4.28: Example of component model

When the feature of multiple FlatInstanceDescriptors per ParameterDataPrototype is NOT applied the following locations in memory and access by Rte APIs would result:

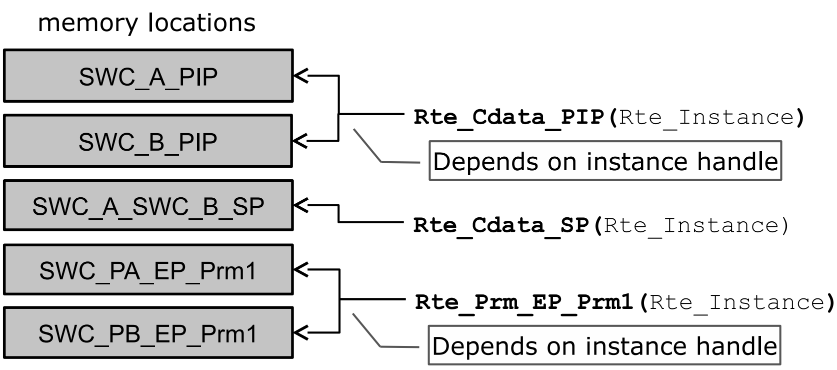


Figure 4.29: Resulting memory location of component model

Please note that the resulting names of the memory locations are not standardized but the applied pattern shall illustrate to which information in the input model they belong to. Assuming now following configuration in the Flat Map:

'SWC_A_PIP_Z0' {depends on PostBuildVariantCriterion 'Z'= 0}

'SWC_A_PIP_Z1' {depends on PostBuildVariantCriterion 'Z' = 1}

'SWC_B_PIP'

'SWC_A_SWC_B_SP_Z0' {depends on PostBuildVariantCriterion 'Z'= 0}

'SWC_A_SWC_B_SP_Z1' {depends on PostBuildVariantCriterion 'Z'= 1}

'SWC_PA_EP_Prm1_Z0' {depends on PostBuildVariantCriterion 'Z'= 0}

'SWC_PA_EP_Prm1_Z1' {depends on PostBuildVariantCriterion 'Z'= 1}

'SWC_PB_EP_Prm1'

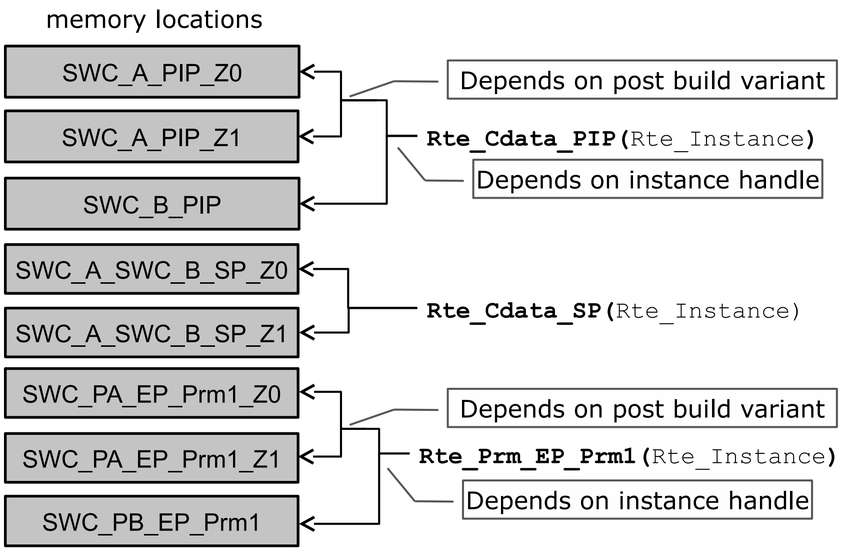


Figure 4.30: Resulting memory location of component model

There are different possibility to implement this mechanism. Nevertheless there are cross dependencies to the requirements concerning 'Data emulation with SW support' in section 4.2.8.3.5.

One possibility is to create an array of parameter values which contains one array element for each different Post Build Variant. The used index for this parameter value array in the relate RTE API is determined by the chosen variant in the post build configuration of the RTE and indexes the active array element. With this approach its easier to combine multiple calibration data instances with the 'Data emulation with SW support' feature since the number of ParameterElementGroups are not changed.

An other approach is to create one base pointer per identical combination of postBuildVariantConditions applied to calibration parameters. The related calibration parameters are grouped into a structure and for each combination of postBuildVariantConditions one instance of the structure is created. The base pointer is initialized according chosen variant in the post build configuration of RTE and points to the active structure instance.

4.2.8.4 Generation of *McSupportData*

The RTE Generator supports the definition, allocation and access to measurement and calibration data for Software Components as well as for Basic Software. The specific support of measurement and calibration tools however is neither in the focus of the RTE Generator nor AUTOSAR. This would require the generation of an "A2L"-file (like specified in [20]) which is the standard in this domain – but out of the focus of AUTOSAR.

The RTE Generator however shall support an intermediate exchange format called McSupportData which is building the bridge between the ECU software and the final "A2L"-file needed by the measurement and calibration tools. The details about the McSupportData format and the involved methodology are described in the Basic Software Module Description Template document [9].

In this section the requirements on the RTE Generator are collected which elements shall be provided in the McSupportData element.

4.2.8.4.1 Export of the *McSupportData*

Figure 4.31 shows the structure of the McSupportData element. The McSupportData element and its sub-content is part of the Implementation element. In case of the RTE this is the BswImplementation element which is generated / updated by the RTE Generator in the Generation Phase (see [SWS_Rte_05086] in chapter 3.4.2).

[SWS_Rte_05118] ⌈ The RTE Generator in Generation Phase shall create the McSupportData element as part of the BswImplementation description of the generated RTE. ⌋*(SRS_Rte_00189)*

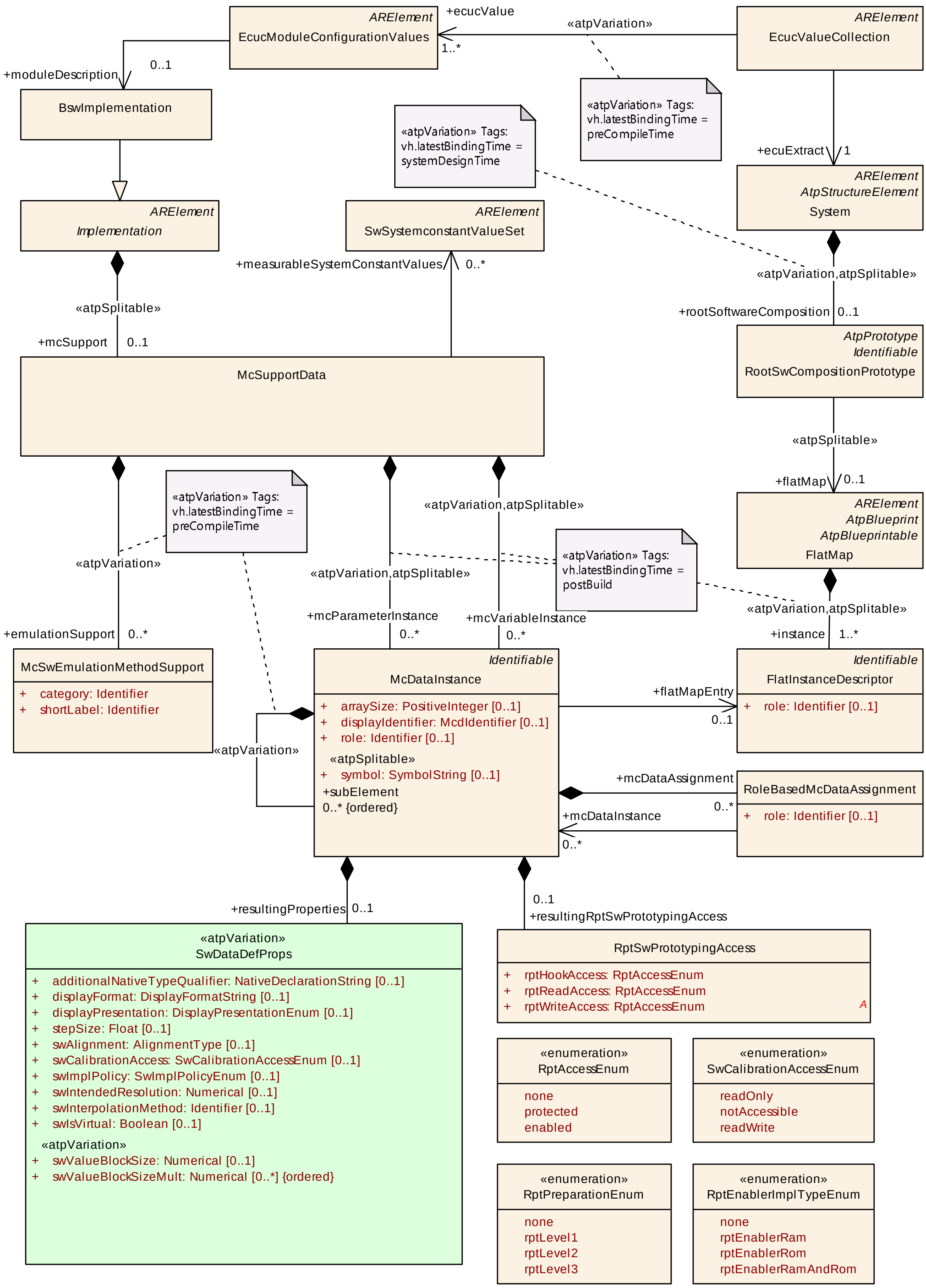


Figure 4.31: Overview of the `McSupportData` element

The individual measurable and calibratable data is described using the element McDataInstance. This is aggregated from McSupportData in the role mcVariableInstance (for measurement) or mcParameterInstance (for calibration).

Usage of the *FlatMap*

The FlatMap is part of the *Ecu Extract of System Description* and contains a collection of FlatInstanceDescriptor elements. The details of the FlatMap are described in the *Specification of the System Template* [8].

In particular the FlatMap may be request several parameter instances for the identical ParameterDataPrototype as described in section 4.2.8.3.7.

Common attributes of McDataInstance

The element McDataInstance specifies one element of the McSupportData. The following requirement specify common attributes which shall to be filled in a harmonized way.

[SWS_Rte_05130] ⌈ The RTE Generator shall use the shortName of the FlatInstanceDescriptor as the shortName of the McDataInstance. ⌋ *(SRS_Rte_00189)*

[SWS_Rte_03998] ⌈ The RTE Generator shall use the AliasNameAssignment.shortLabel referencing the according FlatInstanceDescriptor as the displayIdentifier of the McDataInstance. ⌋*(SRS_Rte_00189)*

[SWS_Rte_05131] ⌈ If the input element (e.g. ApplicationDataType or ImplementationDataType) has a category specified the category value shall be copied to the McDataInstance element. ⌋*(SRS_Rte_00189)*

[SWS_Rte_05132] ⌈ If the input element (e.g. ApplicationDataType or ImplementationDataType) specifies an array, the attribute arraySize of McDataInstance shall be set to the size of the array. ⌋*(SRS_Rte_00189)*

[SWS_Rte_05133] ⌈ If the input element (e.g. ApplicationDataType or ImplementationDataType) specifies a record, the McDataInstance shall aggregate the record element's parts as subElements of type McDataInstance. ⌋ *(SRS_Rte_00189)*

[SWS_Rte_05119] ⌈ The McSupportData element and its sub-structure shall be self-contained in the sense that there is no need to deliver the whole upstream descriptions of the ECU (including the ECU Extract, Software Component descriptions, Basic Software Module descriptions, ECU Configuration Values descriptions, Flat Map, etc.) in order to later generate the final "A2L"-file. This means that the RTE Generator has to copy the required information from the upstream descriptions into the McSupportData element. ⌋*(SRS_Rte_00189)*

[SWS_Rte_05129] ⌈ The RTE Generator in Generation Phase shall export the effective SwDataDefProps (including all of the referenced and aggregated sub-elements like e.g. CompuMethod or SwRecordLayout) in the role resultingProperties for each McDataInstance after resolving the precedence rules defined in the SW-Component Template [2] chapter *Properties of Data Definitions*. Thereby the ImplementationDataType properties compuMethod and dataConstraint are not taken in consideration for effective SwDataDefProps of the McDataInstance due to their refinement nature of **C** and **AI**. ⌋*(SRS_Rte_00189)*

[SWS_Rte_05135] ⌈ If a ParameterDataPrototype is associated with a ParameterAccess the corresponding SwDataDefProps and their sub-structure shall be exported. ⌋*(SRS_Rte_00189)*

For each flatMapEntry referencing to measurable or calibratible data prototype or measureable ModeDeclarationGroupPrototype the McDataInstance shall be generated in the McSupportData. Thereby the effected SwDataDefProps shall be taken from the data prototype according the precedence rules defined in the SWCT.

[SWS_Rte_08313] ⌈ The RTE Generator shall create McDataInstance element(s) in the McSupportData for each measurable or calibratible DataPrototype / ModeDeclarationGroupPrototype referenced by a FlatInstanceDescriptor. ⌋*(SRS_Rte_00189)*

Explanation: In case of connected ports it may occur that the DataPrototype in the DataInterface of the PPortPrototype and the DataPrototype in the DataInterface of the RPortPrototype are referenced by FlatInstanceDescriptors. In this case its intended to get two McDataInstance in order to access the value by MCD system with two different names and may be with two different scaling (typically offset and resolution).

In case of composite data FlatInstanceDescriptors may point to one or several ApplicationCompositeElementDataPrototypes in order to define an individual name for each record or array element. Thereby it is even possible that a FlatInstanceDescriptor exists for the "whole" DataPrototype typed by an ApplicationCompositeDataType and additional FlatInstanceDescriptors exist for the ApplicationCompositeElementDataPrototypes of such DataPrototype.

In this case a McDataInstance as child of McSupportData exists due to the FlatInstanceDescriptors for the "whole" DataPrototype and additional McDataInstances as child of McSupportData exists for each FlatInstanceDescriptor pointing to a ApplicationCompositeElementDataPrototypes in the "whole" DataPrototypes type.

[SWS_Rte_08314] ⌈ If the input element is typed by an ApplicationDataType the subElements structure of the McDataInstance is determined by the ApplicationDataType. This means

- in case of ApplicationRecordDataType the number and shortName of the subElement is determined by the ApplicationRecordElement if [SWS_Rte_05133] and [SWS_Rte_08316] is applied,

- in case of ApplicationArrayDataType the number of the subElements is determined by the ApplicationArrayElement if [SWS_Rte_08315] is applied,
- in case of a ApplicationPrimitiveDataType, inclusive compound primitives, no subElements are applicable.

⌋*(SRS_Rte_00189)*

[SWS_Rte_08315] ⌈ If the input element (e.g. ApplicationDataType or ImplementationDataType) specifies an array, the McDataInstance shall aggregate subElementss for each array element. The McDataInstance.subElements.symbol shall express the array index in the C-notation. (e.g. [0], [4]). ⌋*(SRS_Rte_00189)*

[SWS_Rte_08316] ⌈ If the input element (e.g. ApplicationDataType or ImplementationDataType) specifies a record and no FlatInstanceDescriptor is defined for the record element, the McDataInstance.subElement shortName shall be set copied either from the related ApplicationRecordElement. Or from the ImplementationDataTypeElement if no ApplicationDataType is typing the DataPrototype. The McDataInstance.subElement.symbol is set to the related ImplementationDataTypeElement.shortName ⌋*(SRS_Rte_00189)*

General handling of the symbol attribute: The concatenation of all symbol strings starting from the root element over the hierarchy of McDataInstances shall represent the full combined symbol in the programming language for all hierarchy levels in the McDataInstance tree. When the concatenation is applied the subElements of McDataInstances of category STRUCTURE are separated by a dot.

[SWS_Rte_08317] ⌈ The RTE Generator shall document the Rte internal grouping of measurement and calibration data in composite data datatypes in each symbol attribute of the McDataInstances representing the data which is grouped.

This means the RTE Generator has to document the insertion of structures for Rte internal purpose in the symbol attribute of the related McDataInstance. For instance if the Rte groups a set of measurable inside a Rte internal structure (here called RteInternalBuffer) the McDataInstance.symbol of the first measurable child element carries the information about the internal structure element. e.g. McDataInstance.shortName: "MyMeasurable" McDataInstance.symbol: "RteInternalBuffer.measurable1" ⌋*(SRS_Rte_00189)*

4.2.8.4.2 Export of Measurement information

Sender-Receiver communication

[SWS_Rte_05120] ⌈ If the swCalibrationAccess of a VariableDataPrototype used in an interface of a sender-receiver port of a SwComponentPrototype is set to readOnly or readWrite and RteMeasurementSupport is set to *true* the RTE Generator shall create a McDataInstance element with

- symbol set to the C-symbol name used for the allocation (see also [SWS_Rte_03900])
- flatMapEntry referencing to the corresponding FlatInstanceDescriptor element of the VariableDataPrototype

⌋*(SRS_Rte_00153, SRS_Rte_00189)*

Client-Server communication

[SWS_Rte_05121] ⌈ If the swCalibrationAccess of an ArgumentDataPrototype used in an interface of a client-server port of a SwComponentPrototype is set to readOnly and RteMeasurementSupport is set to *true* the RTE Generator shall create a McDataInstance element with

- symbol set to the C-symbol name used for the allocation (see also [SWS_Rte_03901])
- flatMapEntry referencing to the corresponding FlatInstanceDescriptor element of the ArgumentDataPrototype

⌋*(SRS_Rte_00153, SRS_Rte_00189)*

[SWS_Rte_05172] ⌈ If the measurement of client-server communication is ignored due to requirement [SWS_Rte_05170] the corresponding McDataInstance in the McSupportData shall have a resultingProperties swCalibrationAccess set to notAccessible. ⌋*(SRS_Rte_00153)*

Mode Switch Communication

[SWS_Rte_06702] ⌈ If the swCalibrationAccess of a ModeDeclarationGroupPrototype used in an interface of a mode switch port of a SwComponentPrototype is set to readOnly and RteMeasurementSupport is set to *true* the RTE Generator shall create three McDataInstance elements with

- symbol set to the C-symbol name used for the allocation (see also [SWS_Rte_06700])
- flatMapEntry referencing to the corresponding FlatInstanceDescriptor element of the ModeDeclarationGroupPrototype

Thereby the McDataInstance element corresponding to the

- *current mode* has to reference the FlatInstanceDescriptor which role attribute is set to CURRENT_MODE,
- *previous mode* has to reference the FlatInstanceDescriptor which role attribute is set to PREVIOUS_MODE and
- *next mode* has to reference the FlatInstanceDescriptor which role attribute is set to NEXT_MODE

⌋*(SRS_Rte_00153, SRS_Rte_00189)*

Please note that the resultingProperties of the McDataInstance elements corresponding to the ModeDeclarationGroupPrototype may get associated with a CompuMethod if a CompuMethod is defined at the FlatInstanceDescriptor due to [SWS_Rte_05129]. Those CompuMethod may specify a literal display of the measured modes.

InterRunnableVariable

[SWS_Rte_05122] ⌈ If the swCalibrationAccess of a VariableDataPrototype in the role implicitInterRunnableVariable or explicitInterRunnableVariable is set to readOnly or readWrite and RteMeasurementSupport is set to *true* the RTE Generator shall create a McDataInstance element with

- symbol set to the C-symbol name used for the allocation (see also [SWS_Rte_03902])
- flatMapEntry referencing to the corresponding FlatInstanceDescriptor element of the VariableDataPrototype

⌋*(SRS_Rte_00153, SRS_Rte_00189)*

PerInstanceMemory

[SWS_Rte_05123] ⌈ If the swCalibrationAccess of a VariableDataPrototype in the role arTypedPerInstanceMemory is set to readOnly or readWrite and RteMeasurementSupport is set to *true* the RTE Generator shall create a McDataInstance element with

- symbol set to the C-symbol name used for the allocation (see also [SWS_Rte_07160])
- flatMapEntry referencing to the corresponding FlatInstanceDescriptor element of the VariableDataPrototype

⌋*(SRS_Rte_00153, SRS_Rte_00189)*

Nv RAM Block

[SWS_Rte_05124] ⌈ If the swCalibrationAccess of a VariableDataPrototype in the role ramBlock of a NvBlockSwComponentType's NvBlockDescriptor is set to readOnly or readWrite and RteMeasurementSupport is set to *true* the RTE Generator shall create a McDataInstance element with

- symbol set to the C-symbol name used for the allocation (see also [SWS_Rte_07174])
- flatMapEntry referencing to the corresponding FlatInstanceDescriptor element of the NvBlockSwComponentType

⌋*(SRS_Rte_00153, SRS_Rte_00189)*

Non Volatile Data communication

[SWS_Rte_05125] ⌈ If the swCalibrationAccess of a VariableDataPrototype used in an NvDataInterface of a non volatile data port of a SwComponentPrototype is set to readOnly or readWrite and RteMeasurementSupport is set to *true* the RTE Generator shall create a McDataInstance element with

- symbol set to the C-symbol name used for the allocation (see also [SWS_Rte_07197])
- flatMapEntry referencing to the corresponding FlatInstanceDescriptor element of the VariableDataPrototype

⌋*(SRS_Rte_00153, SRS_Rte_00189)*

4.2.8.4.3 Export Calibration information

Calibration can be either actively supported by the RTE using the pre-defined calibration mechanisms of section 4.2.8.3.5 or calibration can be transparent to the RTE. In both cases the location and attributes of the calibratable data has to be provided by the RTE Generator in the Generation Phase in order to support the setup of the measurement and calibration tools.

ParameterDataPrototypes of ParameterSwComponentType

[SWS_Rte_05126] ⌈ For each FlatInstanceDescriptor referencing a ParameterDataPrototype instance in a PortPrototype of a ParameterSwComponentType with the swCalibrationAccess set to readOnly or readWrite an entry in the McSupportData with the role mcParameterInstance shall be created with the following attributes:

- symbol set to the C-symbol name used for the allocation
- flatMapEntry referencing to the corresponding FlatInstanceDescriptor element of the ParameterDataPrototype

⌋*(SRS_Rte_00189)*

Shared ParameterDataPrototypes

[SWS_Rte_05127] ⌈ For each FlatInstanceDescriptor referencing a ParameterDataPrototype instance of a AtomicSwComponentType's SwcInternalBehavior aggregated in the role sharedParameter with the swCalibrationAccess set to readOnly or readWrite an entry in the McSupportData with the role mcParameterInstance shall be created with the following attributes:

- symbol set to the C-symbol name used for the allocation
- flatMapEntry referencing to the corresponding FlatInstanceDescriptor element of the ParameterDataPrototype

⌋*(SRS_Rte_00189)*

Instance specific ParameterDataPrototypes

[SWS_Rte_05128] ⌈ For each FlatInstanceDescriptor referencing a ParameterDataPrototype instance of a AtomicSwComponentType's SwcInternalBehavior aggregated in the role perInstanceParameter with the swCalibrationAccess set to readOnly or readWrite an entry in the McSupportData with the role mcParameterInstance shall be created with the following attributes:

- symbol set to the C-symbol name used for the allocation
- flatMapEntry referencing to the corresponding FlatInstanceDescriptor element of the ParameterDataPrototype

⌋*(SRS_Rte_00189)*

[SWS_Rte_07097] ⌈ For each ParameterDataPrototype of a BswModuleDescription's BswInternalBehavior aggregated in the role perInstanceParameter with the swCalibrationAccess set to readOnly or readWrite an entry in the McSupportData with the role mcParameterInstance shall be created with the following attributes:

- symbol set to the C-symbol name used for the allocation
- flatMapEntry referencing to the corresponding FlatInstanceDescriptor element of the ParameterDataPrototype

⌋*(SRS_Rte_00189)*

Default values for RAM Block

[SWS_Rte_05136] ⌈ If the swCalibrationAccess of a ParameterDataPrototype in the role romBlock is set to readOnly or readWrite an entry in the McSupportData with the role mcParameterInstance shall be created with the following attributes:

- symbol set to the C-symbol name used for the allocation in [SWS_Rte_07033]
- flatMapEntry referencing to the corresponding FlatInstanceDescriptor element of the ParameterDataPrototype

⌋*(SRS_Rte_00153, SRS_Rte_00189)*

4.2.8.4.4 Export of the Calibration Method

The RTE does provide several Software Emulation Methods which can be selected in the Ecu Configuration of the RTE (see section 8.2).

Which Software Emulation Method has been used for a particular RTE Generation shall be documented in the McSupportData in order to allow measurement and calibration tools to support the RTE's Software Emulation Methods. Additionally it is also possible for an RTE Vendor to add custom Software Emulation Methods which needs to be documented as well. The structure of the McSwEmulationMethodSupport is shown in figure 4.32.

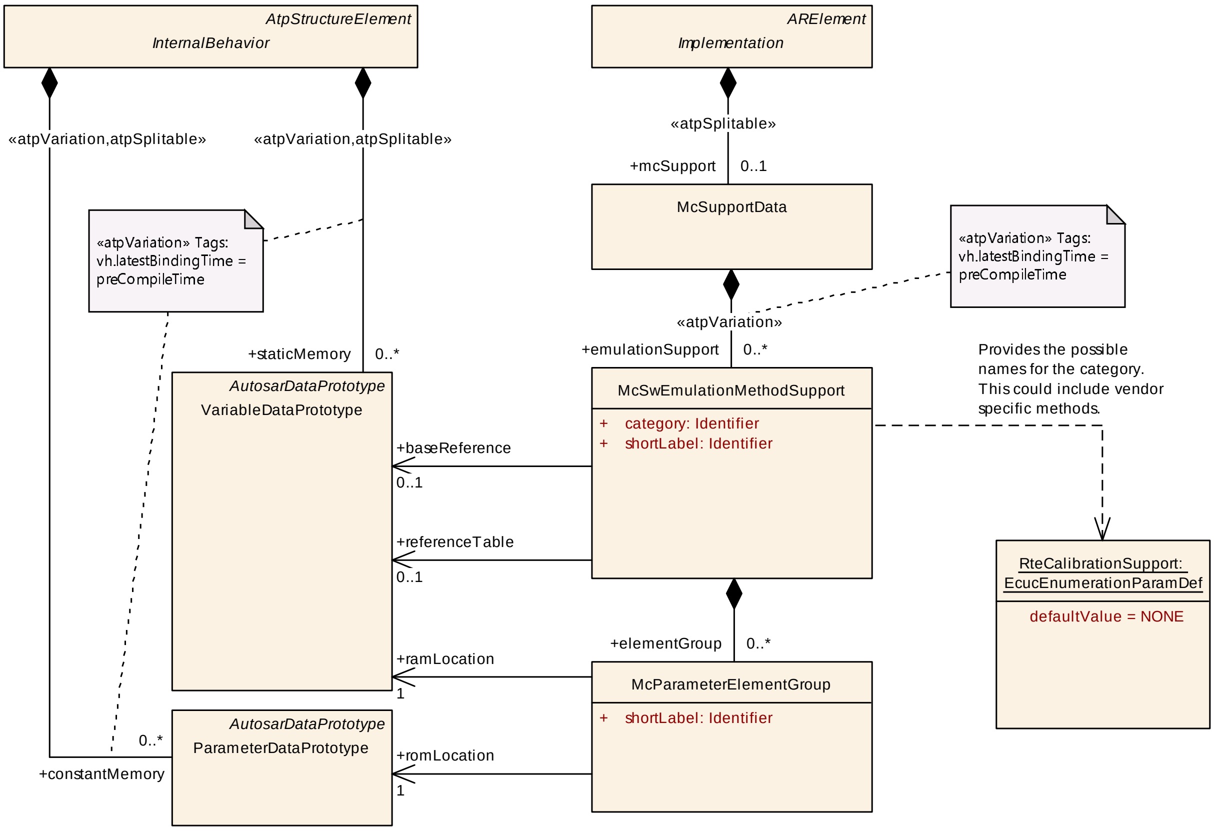


Figure 4.32: Structure of the McSwEmulationMethodSupport element

[SWS_Rte_05137] ⌈ The RTE Generator in Generation Phase shall create the McSwEmulationMethodSupport element as part of the McSupportData description of the generated RTE. ⌋*(SRS_Rte_00189)*

[SWS_Rte_05138] ⌈ The RTE Generator in Generation Phase shall set the value of the category attribute of McSwEmulationMethodSupport element according to the implemented Software Emulation Method based on the Ecu configuration parameter RteCalibrationSupport:

- NONE
- SINGLE_POINTERED
- DOUBLE_POINTERED
- INITIALIZED_RAM
- *custom category name*: vendor specific Software Emulation Method

⌋*(SRS_Rte_00189)*

The description of the generated structures is using the existing mechanisms already available in the Basic Software Module Description Template [9].

Description of ParameterElementGroup

For the description of the ParameterElementGroup an ImplementationDataType representing a structure of the group is created ([SWS_Rte_05139]).

[SWS_Rte_05139] ⌈ For each generated ParameterElementGroup an ImplementationDataType shall be created. The contained ParameterDataPrototypes are aggregated with the role subElement as ImplementationDataTypeElement. ⌋ *(SRS_Rte_00189)*

In the example figure 4.33 the ImplementationDataTypes are called RteMcSupportGroupType1 and RteMcSupportGroupType2.

McSupport description of the InitRam parameter method

For the description of the InitRam parameter method the specific ParameterElementGroups allocated in ram and rom are specified ([SWS_Rte_05140] and [SWS_Rte_05141]). Then the collection and correspondence of these groups is specified (in [SWS_Rte_05142]).

[SWS_Rte_05140] ⌈ If the RTE Generator is configured to support the (INITIALIZED_RAM) method the RTE Generator in generation phase shall generate for each ParameterElementGroup a ParameterDataPrototype with the role constantMemory in the InternalBehavior of the RTE's Basic Software Module Description. The ParameterDataPrototype shall have a reference to the corresponding ImplementationDataType from [SWS_Rte_05139] with the role type. ⌋ *(SRS_Rte_00189)*

[SWS_Rte_05141] ⌈ If the RTE Generator is configured to support the (INITIALIZED_RAM) method the RTE Generator in generation phase shall generate for each ParameterElementGroup a VariableDataPrototype with the role staticMemory in the InternalBehavior of the RTE's Basic Software Module Description. The VariableDataPrototype shall have a reference to the corresponding ImplementationDataType from [SWS_Rte_05139] with the role type. ⌋ *(SRS_Rte_00189)*

[SWS_Rte_05142] ⌈ If the RTE Generator is configured to support the (INITIALIZED_RAM) method the RTE Generator in generation phase shall generate for each ParameterElementGroup a McParameterElementGroup with the role elementGroup in the McSwEmulationMethodSupport [SWS_Rte_05137] element.

- The McParameterElementGroup shall have a reference to the corresponding ParameterDataPrototype from [SWS_Rte_05140] with the role romLocation.
- The McParameterElementGroup shall have a reference to the corresponding VariableDataPrototype from [SWS_Rte_05141] with the role ramLocation.

⌋ *(SRS_Rte_00189)*

McSupport description of the Single pointered method

For the description of the Single pointered method the specific ParameterElementGroups allocated in rom are specified ([SWS_Rte_05143]). Then an array data type is specified which contains as many number of elements (void pointers) as there are ParameterElementGroups ([SWS_Rte_05144]). Then the instance of this array is specified in ram ([SWS_Rte_05152]) and referenced from the McSwEmulationMethodSupport ([SWS_Rte_05153]). The actual values for each array element are specified as references to the ParameterElementGroup prototypes ([SWS_Rte_05154]).

[SWS_Rte_05143] ⌈ If the RTE Generator is configured to support the (SINGLE_POINTERED) method the RTE Generator in generation phase shall generate for each ParameterElementGroup a ParameterDataPrototype with the role constantMemory in the InternalBehavior of the RTE's Basic Software Module Description. The ParameterDataPrototype shall have a reference to the corresponding ImplementationDataType from [SWS_Rte_05139] with the role type. ⌋ *(SRS_Rte_00189)*

[SWS_Rte_05144] ⌈ If the RTE Generator is configured to support the (SINGLE_POINTERED) method the RTE Generator in generation phase shall generate an ImplementationDataType with one ImplementationDataTypeElement in the role subElement.

- The ImplementationDataTypeElement shall have the attribute arraySize set to the number of ParameterElementGroups from [SWS_Rte_05139].
- The ImplementationDataTypeElement shall have a SwDataDefProps element with a reference to an ImplementationDataType representing a *void pointer*, in the role implementationDataType.

⌋ *(SRS_Rte_00189)*

[SWS_Rte_05152] ⌈ If the RTE Generator is configured to support the (SINGLE_POINTERED) method the RTE Generator in generation phase shall generate a VariableDataPrototype with the role staticMemory in the InternalBehavior of the RTE's Basic Software Module Description. The VariableDataPrototype shall have a reference to the ImplementationDataType from [SWS_Rte_05144] with the role type. ⌋ *(SRS_Rte_00189)*

[SWS_Rte_05153] ⌈ If the RTE Generator is configured to support the (SINGLE_POINTERED) method the RTE Generator in generation phase shall generate a reference from the McSwEmulationMethodSupport [SWS_Rte_05137] element to the VariableDataPrototype [SWS_Rte_05152] in the role referenceTable. ⌋ *(SRS_Rte_00189)*

[SWS_Rte_05154] ⌈ If the RTE Generator is configured to support the (SINGLE_POINTERED) method the RTE Generator in generation phase shall generate an ArrayValueSpecification as the initValue of the array [SWS_Rte_05152] and for each ParameterElementGroup a ReferenceValueSpecification element in the ArrayValueSpecification defining the references to the individual ParameterElementGroup prototypes [SWS_Rte_05143]. ⌋*(SRS_Rte_00189)*

McSupport description of the Double pointered method

The description of the Double pointered method is quite similar to the Single pointered method, but the allocation to ram and rom is different and it allocates the additional pointer parameter. The specific ParameterElementGroups allocated in rom are specified ([SWS_Rte_05155]). Then an array data type is specified which contains as many number of elements (void pointers) as there are ParameterElementGroups ([SWS_Rte_05156]). Then the instance of this array is specified in rom ([SWS_Rte_05157]) and referenced from the McSwEmulationMethodSupport ([SWS_Rte_05158]). The actual values for each array element are specified as references to the ParameterElementGroup prototypes ([SWS_Rte_05159]). Then the type of the base pointer is then created ([SWS_Rte_05160]) and an instance is allocated in ram ([SWS_Rte_05161]). The reference is initialized to the array in rom ([SWS_Rte_05162]).

[SWS_Rte_05155] ⌈ If the RTE Generator is configured to support the (DOUBLE_POINTERED) method the RTE Generator in generation phase shall generate for each ParameterElementGroup a ParameterDataPrototype with the role constantMemory in the InternalBehavior of the RTE's Basic Software Module Description. The ParameterDataPrototype shall have a reference to the corresponding ImplementationDataType from [SWS_Rte_05139] with the role type. ⌋ *(SRS_Rte_00189)*

In the example figure 4.33 the ParameterDataPrototypes are called RteMcSupportParamGroup1 and RteMcSupportParamGroup1.

[SWS_Rte_05156] ⌈ If the RTE Generator is configured to support the (DOUBLE_POINTERED) method the RTE Generator in generation phase shall generate an ImplementationDataType with one ImplementationDataTypeElement in the role subElement.

- The ImplementationDataTypeElement shall be of category ARRAY with the attribute arraySize set to the number of ParameterElementGroups from [SWS_Rte_05139].
- The ImplementationDataTypeElement shall have a SwDataDefProps element with a reference to an ImplementationDataType representing a *void pointer*, in the role implementationDataType.

⌋*(SRS_Rte_00189)*

In the example figure 4.33 the ImplementationDataType is called RteMcSupportPointerTableType.

[SWS_Rte_05157] ⌈ If the RTE Generator is configured to support the (DOUBLE_POINTERED) method the RTE Generator in generation phase shall generate a ParameterDataPrototype with the role constantMemory in the InternalBehavior of the RTE's Basic Software Module Description. The ParameterDataPrototype shall have a reference to the ImplementationDataType from [SWS_Rte_05156] with the role type. ⌋*(SRS_Rte_00189)*

In the example figure 4.33 the ParameterDataPrototype is called RteMcSupportPointerTable.

[SWS_Rte_05158] ⌈ If the RTE Generator is configured to support the (DOUBLE_POINTERED) method the RTE Generator in generation phase shall generate a reference from the McSwEmulationMethodSupport [SWS_Rte_05137] element to the ParameterDataPrototype [SWS_Rte_05157] in the role referenceTable. ⌋*(SRS_Rte_00189)*

[SWS_Rte_05159] ⌈ If the RTE Generator is configured to support the (DOUBLE_POINTERED) method the RTE Generator in generation phase shall generate an ArrayValueSpecification as the initValue of the array [SWS_Rte_05157] and for each ParameterElementGroup a ReferenceValueSpecification element in the ArrayValueSpecification defining the references to the individual ParameterElementGroup prototypes [SWS_Rte_05155]. ⌋*(SRS_Rte_00189)*

In the example figure 4.33 the ArrayValueSpecification is called RteMcSupportPointerTableInit. The ReferenceValueSpecifications are called RteMcSupportParamGroup1Ref and RteMcSupportParamGroup2Ref.

[SWS_Rte_05160] ⌈ If the RTE Generator is configured to support the (DOUBLE_POINTERED) method the RTE Generator in generation phase shall generate an ImplementationDataType with one ImplementationDataTypeElement being a reference to the array type from [SWS_Rte_05156]. ⌋*(SRS_Rte_00189)*

In the example figure 4.33 the ImplementationDataType is called RteMcSupportBasePointerType.

[SWS_Rte_05161] ⌈ If the RTE Generator is configured to support the (DOUBLE_POINTERED) method the RTE Generator in generation phase shall generate a VariableDataPrototype with the role staticMemory in the InternalBehavior of the RTE's Basic Software Module Description. The VariableDataPrototype shall have a reference to the ImplementationDataType from [SWS_Rte_05160] with the role type. ⌋*(SRS_Rte_00189)*

In the example figure 4.33 the VariableDataPrototype is called RteMcSupportBasePointer.

[SWS_Rte_05162] ⌈ If the RTE Generator is configured to support the (DOUBLE_POINTERED) method the RTE Generator in generation phase shall generate a ReferenceValueSpecification to the array from [SWS_Rte_05157] as the initValue of the reference [SWS_Rte_05161]. ⌋*(SRS_Rte_00189)*

In the example figure 4.33 the ReferenceValueSpecification is called RteMcSupportBasePointerInit.

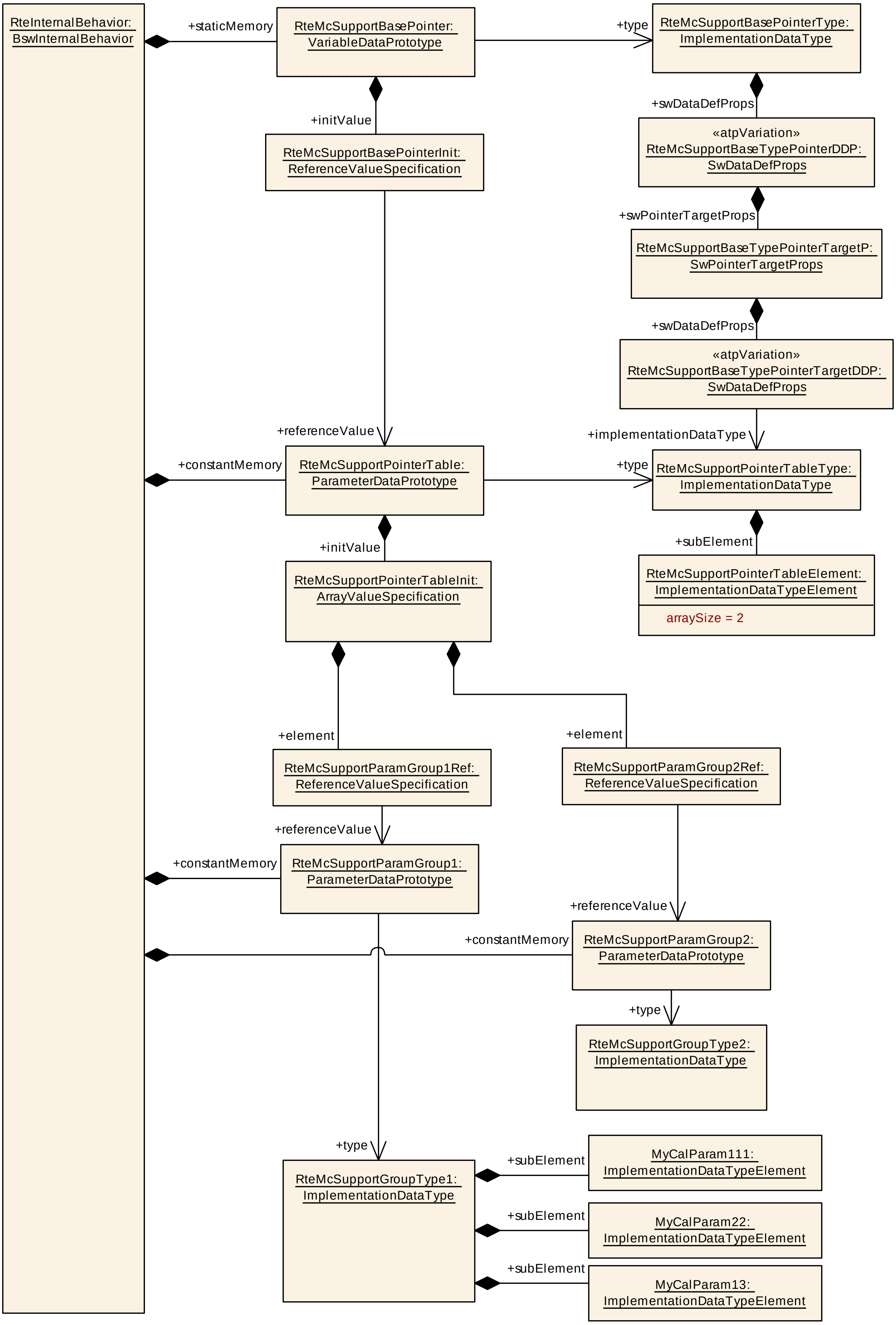


Figure 4.33: Example of the structure for Double Pointered Method

4.2.8.4.5 Export of Variant Handling

The Rte Generator shall provide information on values of system constants. The values are part of the input information and need to be collected and copied into a dedicated artifact to be delivered with the McSupportData.

[SWS_Rte_05168] ⌈ The Rte Generator in generation phase shall create an elements of type SwSystemconstantValueSet and create copies of all system constant values found in the input information of type SwSystemconstValue where the referenced SwSystemconst element has the swCalibrationAccess set to readOnly. ⌋*(SRS_Rte_00153, SRS_Rte_00191)*

In case the SwSystemconstValue is subject to variability and the variability can be resolved during Rte generation phase

[SWS_Rte_05176] ⌈ If a SwSystemconst with swCalibrationAccess set to readOnly has an assigned SwSystemconstValue which is subject to variability with the latest binding time SystemDesignTime or CodeGenerationTime the related SwSystemconstValue copy in the SwSystemconstantValueSet according to [SWS_Rte_05168] shall contain the resolved value. ⌋*(SRS_Rte_00153, SRS_Rte_00191)*

[SWS_Rte_05174] ⌈ If a SwSystemconst with swCalibrationAccess set to readOnly has an assigned SwSystemconstValue which is subject to variability with the latest binding time PreCompileTime the related SwSystemconstValue copy in the SwSystemconstantValueSet according to [SWS_Rte_05168] shall have an AttributeValueVariationPoint. The *PreBuild* conditions of the AttributeValueVariationPoint shall correspond to the *PreBuild* conditions of the input SwSystemconstValue's conditions. ⌋*(SRS_Rte_00153, SRS_Rte_00191)*

[SWS_Rte_05169] ⌈ The Rte Generator in generation phase shall create a reference from the McSupportData element ([SWS_Rte_05118]) to the SwSystemconstantValueSet element ([SWS_Rte_05168]). ⌋*(SRS_Rte_00153, SRS_Rte_00191)*

In case the RTE Generator implements variability on an element which is accessible by a MCD system the related existence condition has to be documented in the McSupportData structure as well.

[SWS_Rte_05175] ⌈ If an element in the McSupportData is related to an element in the input configuration which is subject to variability with the latest binding time PreCompileTime or *PostBuild* the RTE Generator shall add a VariationPoint for such element. The *PreBuild* and *PostBuild* conditions of the VariationPoint shall correspond to the *PreBuild* and *PostBuild* conditions of the input element's conditions. ⌋*(SRS_Rte_00153, SRS_Rte_00191)*

4.2.9 Access to NVRAM data

4.2.9.1 General

There are different methods available for AUTOSAR SW-Cs to access data stored in NVRAM.

- **"Calibration data"** – Calibrations can be stored in NVRAM, but are not modified during a "normal" execution of the ECU. Calibrations are usually directly read from their memory location, but can also be read from a RAM buffer when the access time needs to be optimized (e.g. for interpolation tables). They are described in section 4.2.8.
- **"Access to NVRAM blocks"** – This method uses PerInstanceMemory as a RAM Block for the NVRAM blocks. While this method is efficient, its use is restricted.

  The NVRAM Manager [21] is a BSW module which provides services for SW-C to access NVRAM Blocks during runtime. The NVM block data is not accessed directly, but through a RAM Block, which can be a PerInstanceMemory instantiated by the RTE, or a SW-C internal buffer. When this method is used, the RTE does not provide any data consistency mechanisms (i.e. different runnables from the SW-C and the NVM can access the RAM Block concurrently without being protected by the RTE).

  Note:

  This mechanism permits efficient usage of NVRAM data, but requires the SW-C designer to take care that accesses to the PerInstanceMemory from different task contexts don't cause data inconsistencies. The "Access to NVRAM blocks" should not be used in multi core environments. In AUTOSAR release 4.0, it can not be expected that the NVRAM Manager can access the PerInstanceMemory of another core. The presence of a shared memory section is not required by AUTOSAR. Only in the case of arTypedPerInstanceMemory, a SwDataDefProps item is available to assign the PerInstanceMemory to a shared memory section.
- **"Access to NVRAM data with a NvBlockSwComponentType"** – The data is accessed through a NvDataInterface connected to a NvBlockSwComponentTypes. This access is modeled at the VFB level, and, when necessary, protected by the RTE against concurrent accesses. It will be described further in this section.

Please note that the terms NVRAM Block, NV Block, RAM Block, ROM Block and RAM mirror used in this document are defined in the specification of the NVRAM Manager [21].

4.2.9.2 Usage of the NvBlockSwComponentType

The code of NvBlock SwComponentPrototypes is implemented by the RTE Generator. NvBlockSwComponentTypes provide a port interface for the access and management of data stored in NVRAM.

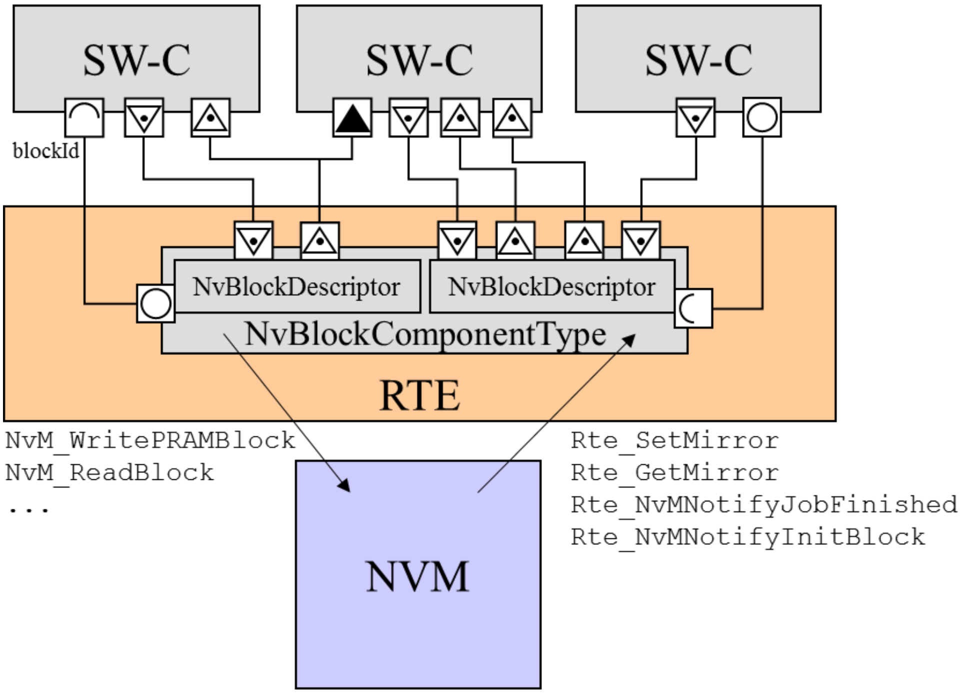


Figure 4.34: Connection to the NvBlockSwComponentType

Figure 4.34 illustrates the usage of a NvBlockSwComponentType. Depending on the use-case SW-Cs can be connected to a NvBlockSwComponentType in different ways. For example by Ports typed by SenderReceiverInterfaces / NvDataInterfaces only or by Ports typed by SenderReceiverInterfaces / NvDataInterfaces and ClientServerInterfaces. Ports typed by SenderReceiverInterfaces / NvDataInterfaces are used to provide access to NV data and Ports typed by ClientServerInterfaces are used for the management of NV data. Managing NV data by SW-Cs is useful in order to copy data of the RAM Block to NV block vice versa at certain points in time (SW-Cs are clients). Additionally SW-Cs can get notifications from NVM (SW-Cs are servers).

In the following sections the requirements for the usage of NvBlockSwComponentType will be given.

[SWS_Rte_07301] ⌈ Several AUTOSAR SW-Cs (and also several instances of a AUTOSAR SW-C) shall be able to read the same VariableDataPrototypes of a NvBlockSwComponentType. ⌋*(SRS_Rte_00176)*

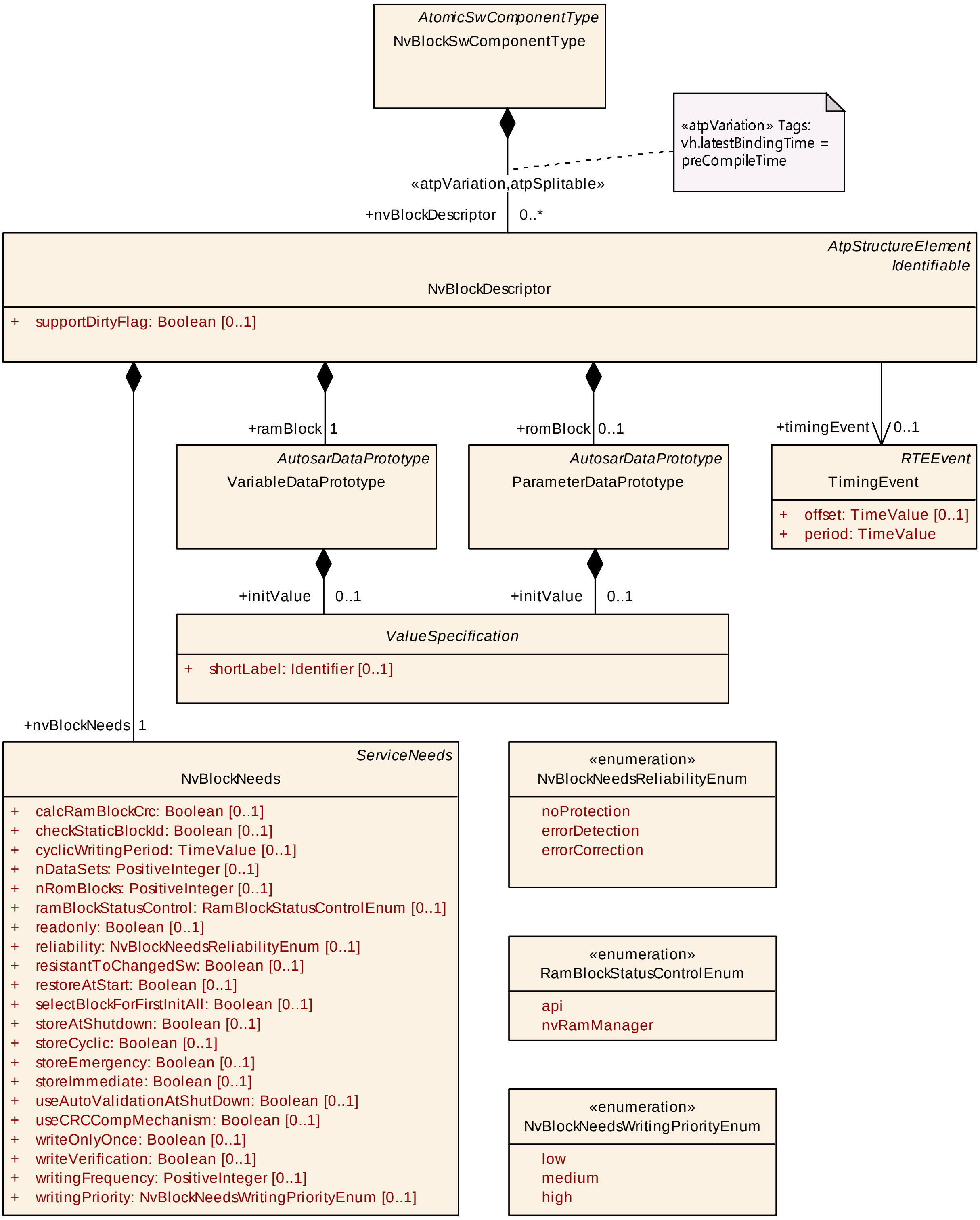


Figure 4.35: NvBlockSwComponentType and NvBlockDescriptor

A NvBlockSwComponentType contains multiple NvBlockDescriptors. Each of these NvBlockDescriptor is associated to exactly one NVRAM Block.

A NvBlockDescriptor contains a VariableDataPrototype which acts as a RAM Block for the NVRAM Block, and optionally a ParameterDataPrototype to act as the default ROM value for the NVRAM Block.

[SWS_Rte_07353] ⌈ The RTE Generator shall reject configurations where a NvBlockDescriptor of a NvBlockSwComponentType contains a romBlock whose data type is not compatible with the type of the ramBlock. ⌋*(SRS_Rte_00177, SRS_Rte_00018)*

[SWS_Rte_07303] ⌈ The RTE shall allocate memory for the ramBlock VariableDataPrototype of the NvBlockDescriptor instances. ⌋*(SRS_Rte_00177)*

[SWS_Rte_07632] ⌈ The variables allocated for the ramBlocks shall be initialized if the general initialization conditions in [SWS_Rte_07046] are fulfilled. The initialization as to be applied during Rte_Start and Rte_RestartPartition depending from the configured RteInitializationStrategy. ⌋*(SRS_Rte_00177)*

Note: When blocks are configured to be read by NvM_ReadAll, the initialization may erase the value read by the NVM. These blocks should not have an initValue.

[SWS_Rte_07355] ⌈ For each NvBlockDescriptor with a romBlock ParameterDataPrototype, the RTE shall allocate a constant block of default values. ⌋*(SRS_Rte_00177)*

[SWS_Rte_07633] ⌈ The constants allocated for the romBlocks shall be initialized to the value of the initValue, if they have an initValue. ⌋*(SRS_Rte_00177)*

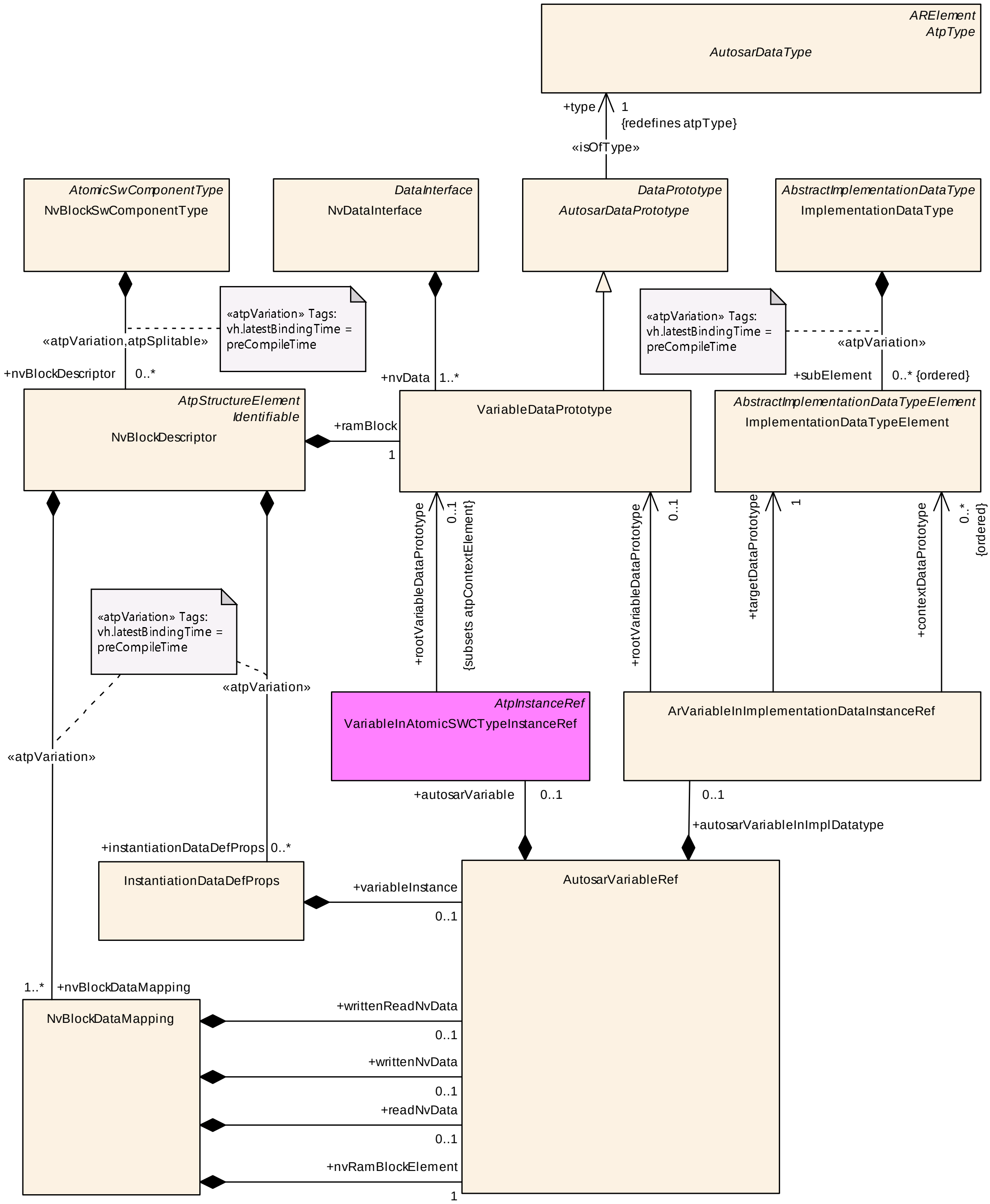


Figure 4.36: `NvBlockDataMapping`

For each element stored in the `NVRAM Block` of a `NvBlockDescriptor`, there should be one `NvBlockDataMapping` to associate the `VariableDataPrototypes` of the ports used for read and write access and the `VariableDataPrototype` defining the location of the element in the `ramBlock`. Thereby the `ImplementationDataTypes` of the `VariableDataPrototypes` have to compatible.

[SWS_Rte_03866] ⌈ The RTE Generator shall reject any configuration that violates [constr_1395], [constr_1403] and [constr_1404]. ⌋*(SRS_Rte_00018)*

[SWS_Rte_07621] ⌈ The RTE Generator shall reject configurations where [constr_2013] or [constr_1285] is violated. ⌋*(SRS_Rte_00018)*

Note: This is required to ensure that the default values in romBlock are structurally matching data in the ramBlock and therefore can be copied to the ramBlock in case that the callback Rte_NvMNotifyInitBlock of the related NvBlock is called.

[SWS_Rte_07343] ⌈ The RTE Generator shall reject configurations where a VariableDataPrototype instance in the role ramBlock is accessed by SW-C instances of different partitions. ⌋*(SRS_Rte_00177, SRS_Rte_00018)*

The rational for [SWS_Rte_07343] is to allow the implementation of cleanup activities in case of termination or restart of a partition. These cleanup activities may require to invalidate the RAM Block or reload data from the NVRAM device, which would impact other partitions if a the ramBlock is accessed by SW-Cs of different partitions.

A NvBlockSwComponentType can be used to reduce the quantity of NVRAM Blocks needed on an ECU:

- the same block can be used to store different flags or other small data elements;
- the same data element can be used by different SW-Cs or different instances of a SW-C.

It also permits to simplify processes and algorithms when it must be guaranteed that two SW-Cs of an ECU use the same NVRAM data.

Note: this feature can increase the RAM usage of the ECU because it forces the NVRAM Manager to instantiate an additional RAM buffer, called RAM mirror. However, when the same data elements have to be shared between SW-Cs, it reduces the number of RAM Blocks needed to be instantiated by the RTE, and can reduce the overall RAM usage of the ECU.

[SWS_Rte_07356] ⌈ The RTE Generator shall reject configurations where a VariableDataPrototype referenced by a NvDataInterface has a queued swImplPolicy. ⌋*(SRS_Rte_00018)*

[SWS_Rte_CONSTR_09011] NvMBlockDescriptor related to a RAM Block of a NvBlockSwComponentType shall use NvmBlockUseSyncMechanism ⌈ The NVRAM Block associated to the NvBlockDescriptors of a NvBlockSwComponentType shall be configured with the NvMBlockUseSyncMechanism feature enabled, and the NvMWriteRamBlockToNvCallback and NvMReadRamBlockFromNvCallback parameters set to the Rte_GetMirror and Rte_SetMirror API of the NvBlockDescriptor. ⌋*()*

An NvBlockSwComponentType may have unconnected p-ports or r-ports (see [SWS_Rte_01329]).

[SWS_Rte_07669] ⌈ An NvBlockSwComponentType with an unconnected r-port shall behave as if no updated data were received for VariableDataPrototypes this unconnected r-port. ⌋*(SRS_Rte_00139)*

4.2.9.3 Interface of the NvBlockSwComponentType

4.2.9.3.1 Access to the NVRAM data

The NvBlockSwComponentType provides PPortPrototypes and RPortPrototypes with an NvDataInterface data Sender-Receiver semantic to read the value of the NVRAM data or write the new value.

Like the SenderReceiverInterfaces, each of these NvDataInterfaces can provide access to multiple VariableDataPrototypes.

The same Rte_Read, Rte_IRead, Rte_DRead, Rte_Write, Rte_IWrite, Rte_IWriteRef APIs are used to access these VariableDataPrototypes as for SenderReceiverInterfaces.

Due to the usage of the implicit APIs Rte_IRead and Rte_IWriteRef multiple buffering can be avoided, i.e. the RunnableEntitys of application SW-Cs or ExecutableEntitys of BSW modules (e.g. DCM) can directly access the VariableDataPrototypes on the RAM Block. To guarantee this behavior one of the following preconditions must apply:

- VariableDataPrototypes on a RAM Block are only accessed by dataReadAccess
- VariableDataPrototypes on a RAM Block are accessed by dataReadAccess and dataWriteAccess and there is no mutual preemption between the write accesses or between the write and read accesses, including no preemption by Rte_SetMirror and Rte_GetMirror.
- No PortInterfaceMappings are applied which requiring data conversions

See also chapter 4.3.1.5.1 about ConsistencyNeeds.

[SWS_Rte_07667] ⌈ The RTE Generator shall reject configurations where an r-port typed with an NvDataInterface is not connected and no NvRequireComSpec with an initValue are provided for each VariableDataPrototype of this NvDataInterface. This requirement does not apply if the r-port belongs to a NvBlockSwComponentType. ⌋*(SRS_Rte_00018, SRS_Rte_00139)*

[SWS_Rte_07667] is required to avoid unconnected r-port without a defined initValue. Please note that for NvBlockSwComponent unconnected r-ports without init values are not a fault because the init values are defined in the NvBlockDescriptors ramBlock (see as well [SWS_Rte_07632], [SWS_Rte_07669])

[SWS_Rte_07668] ⌈ The RTE shall initialize the VariableDataPrototypes of an r-port according to the initValue of the r-port's NvRequireComSpec referring to the VariableDataPrototype. ⌋*(SRS_Rte_00139, SRS_Rte_00108, SRS_Rte_00068)*

In order to write updated NV data of NVRAM Blocks to NV memory with a certain timing schema the RTE provides a functionality called "dirty flag mechanism". This mechanism interacts directly with the NvM module when write APIs of the RTE are invoked by an AtomicSwComponentType using a PortPrototype typed by an NvDataInterface. The behavior of the dirty flag mechanism depends on the writing strategy of the related NvBlockDescriptors.

[SWS_Rte_08080] ⌈ If an AtomicSwComponentType using a PortPrototype with an NvDataInterface invokes the explicit API Rte_Write and the attributes NvBlockDescriptor.supportDirtyFlag and NvBlockNeeds.storeAtShutdown are set to true, the RTE shall mark the associated RAM Block(s) as CHANGED by calling the NvM_SetRamBlockStatus function of the NvM module with the BlockChanged parameter set to true. The NvM_SetRamBlockStatus function shall be called by the RTE after the data accessed by the Rte_Write function is written back to the RAM Block(s). ⌋*(SRS_Rte_00177, SRS_Rte_00245)*

[SWS_Rte_08081] ⌈ If an AtomicSwComponentType using a PortPrototype with an NvDataInterface invokes the implicit APIs Rte_IWrite / Rte_IWriteRef and the attributes NvBlockDescriptor.supportDirtyFlag and NvBlockNeeds.storeAtShutdown are set to true, the RTE shall mark the associated RAM Block(s) as CHANGED by calling the NvM_SetRamBlockStatus function of the NvM module with the BlockChanged parameter set to true. The function NvM_SetRamBlockStatus shall be called by the RTE after the data accessed by the Rte_IWrite / Rte_IWriteRef functions is written back from the preemption area buffer to the RAM Block(s) (for further details see chapter 4.3.1.5.1). ⌋*(SRS_Rte_00177, SRS_Rte_00245)*

[SWS_Rte_08082] ⌈ If an AtomicSwComponentType using a PortPrototype with an NvDataInterface invokes the explicit API Rte_Write and the attributes NvBlockDescriptor.supportDirtyFlag and NvBlockNeeds.storeCyclic are set to true, the RTE shall write the associated RAM Block(s) to NV memory by calling the NvM_WritePRAMBlock function of the NvM module in the next cycle of a periodic activity after the data accessed by the Rte_Write function is written back to the RAM Block(s). The periodic activity shall be implemented in the context of an NvBlockDescriptor's RunnableEntity (see requirements [SWS_Rte_08086], [SWS_Rte_08087], [SWS_Rte_08088], [SWS_Rte_08089], [SWS_Rte_08090]) according to the cycle period defined in the attribute NvBlockDescriptor.timingEvent.period. ⌋*(SRS_Rte_00177, SRS_Rte_00245)*

[SWS_Rte_08083] ⌈ If an AtomicSwComponentType using a PortPrototype with an NvDataInterface invokes the implicit APIs Rte_IWrite / Rte_IWriteRef and the attributes NvBlockDescriptor.supportDirtyFlag and NvBlockNeeds.storeCyclic are set to true, the RTE shall write the associated RAM Block(s) to NV memory by calling the NvM_WritePRAMBlock function of the NvM module in the cycle of a periodic activity after the data accessed by the Rte_IWrite / Rte_IWriteRef functions is written back from the preemption area buffer to the RAM Block(s) (for further details see chapter 4.3.1.5.1). The periodic activity shall be implemented in the context of an NvBlockDescriptor's RunnableEntity (see requirements [SWS_Rte_08086], [SWS_Rte_08087], [SWS_Rte_08088], [SWS_Rte_08089], [SWS_Rte_08090]) according to the cycle period defined in the attribute NvBlockDescriptor.timingEvent.period. ⌋*(SRS_Rte_00177, SRS_Rte_00245)*

[SWS_Rte_08084] ⌈ If an AtomicSwComponentType using a PortPrototype with an NvDataInterface invokes the explicit API Rte_Write and the attributes NvBlockDescriptor.supportDirtyFlag and NvBlockNeeds.storeImmediate are set to true, the RTE shall write the associated RAM Block(s) to NV memory by calling the NvM_WritePRAMBlock function of the NvM module. The NvM_WritePRAMBlock function shall be called in the context of an NvBlockDescriptor's RunnableEntity (see requirements [SWS_Rte_08086], [SWS_Rte_08087], [SWS_Rte_08088], [SWS_Rte_08089], [SWS_Rte_08090]) after the data accessed by the Rte_Write function is written back to the RAM Block(s). ⌋ *(SRS_Rte_00177, SRS_Rte_00245)*

[SWS_Rte_08085] ⌈ If an AtomicSwComponentType using a PortPrototype with an NvDataInterface invokes the implicit APIs Rte_IWrite / Rte_IWriteRef and the attributes NvBlockDescriptor.supportDirtyFlag and NvBlockNeeds.storeImmediate are set to true, the RTE shall write the associated RAM Block(s) to NV memory by calling the NvM_WritePRAMBlock function of the NvM module. The function NvM_WritePRAMBlock shall be called in the context of an NvBlockDescriptor's RunnableEntity (see requirements [SWS_Rte_08086], [SWS_Rte_08087], [SWS_Rte_08088], [SWS_Rte_08089], [SWS_Rte_08090]) after the data accessed by the Rte_IWrite / Rte_IWriteRef functions is written back from the preemption area buffer to the RAM Block(s) (for further details see chapter 4.3.1.5.1). ⌋*(SRS_Rte_00177, SRS_Rte_00245)*

Note: Notifications received from the NVM module (e.g. NvMNotifyJobFinished) will not be forwarded to the SW-Cs by the dirty flag mechanism. The standardized NvM Client-Server interfaces can be used (see chapter 4.2.9.3.2) if a SW-C needs to be informed regarding the NvM job result.

4.2.9.3.2 NVM interfaces

The NvBlockSwComponentType can also have ports used for NV data management and typed by Client-Server interfaces derived from the NVRAM Manager [21] standardized ones. Note that these ports shall always have a PortInterface with the attribute isService set to FALSE. The definition of blueprints for these interfaces can be found in document MOD_GeneralBlueprints [22] in the ARPackage AUTOSAR/NvBlockSoftwareComponentType/ClientServerInterfaces_Blueprint.

The standardized NvM Client-Server interfaces are composed as follows:

- NvMService

  This interface is used to send commands to the NVM. The NvBlockSwComponentType provides a server port intended to be used by the SW-C users of this NvBlockSwComponentType.

- NvMNotifyJobFinished

  This interface is used by the NVM to notify the end of job. The NvBlockSwComponentType provides a server port intended to be used by the NVM, and client ports intended to be connected to the SW-C users of this NvBlockSwComponentType.

- NvMNotifyInitBlock

  This interface is used by the NVM to request users to provide the default values in the RAM Block. The NvBlockSwComponentType provides a server port intended to be used by the NVM, and client ports intended to be connected to the SW-C users of this NvBlockSwComponentType.

- NvMAdmin

  This interface is used to order some administrative operations to the NVM. The NvBlockSwComponentType provides a server port intended to be used by the SW-C users of this NvBlockSwComponentType.

For the implementation of NvBlockSwComponentTypes that have NvM service ports the RTE has to call the API of NvM. In order to access NvM API the NvM.h file has to be included.

[SWS_Rte_08063] ⌈The RTE shall include the NvM.h file, if it has to access NvM API. ⌋*(SRS_Rte_00177)*

Note: no restrictions have been added to the NVM interfaces. However, some operations of the NVM might require cooperation between the different users of the NvBlockSwComponentType. For example, a ReadBlock operation will overwrite the RAM Block, which might affect multiple SW-Cs.

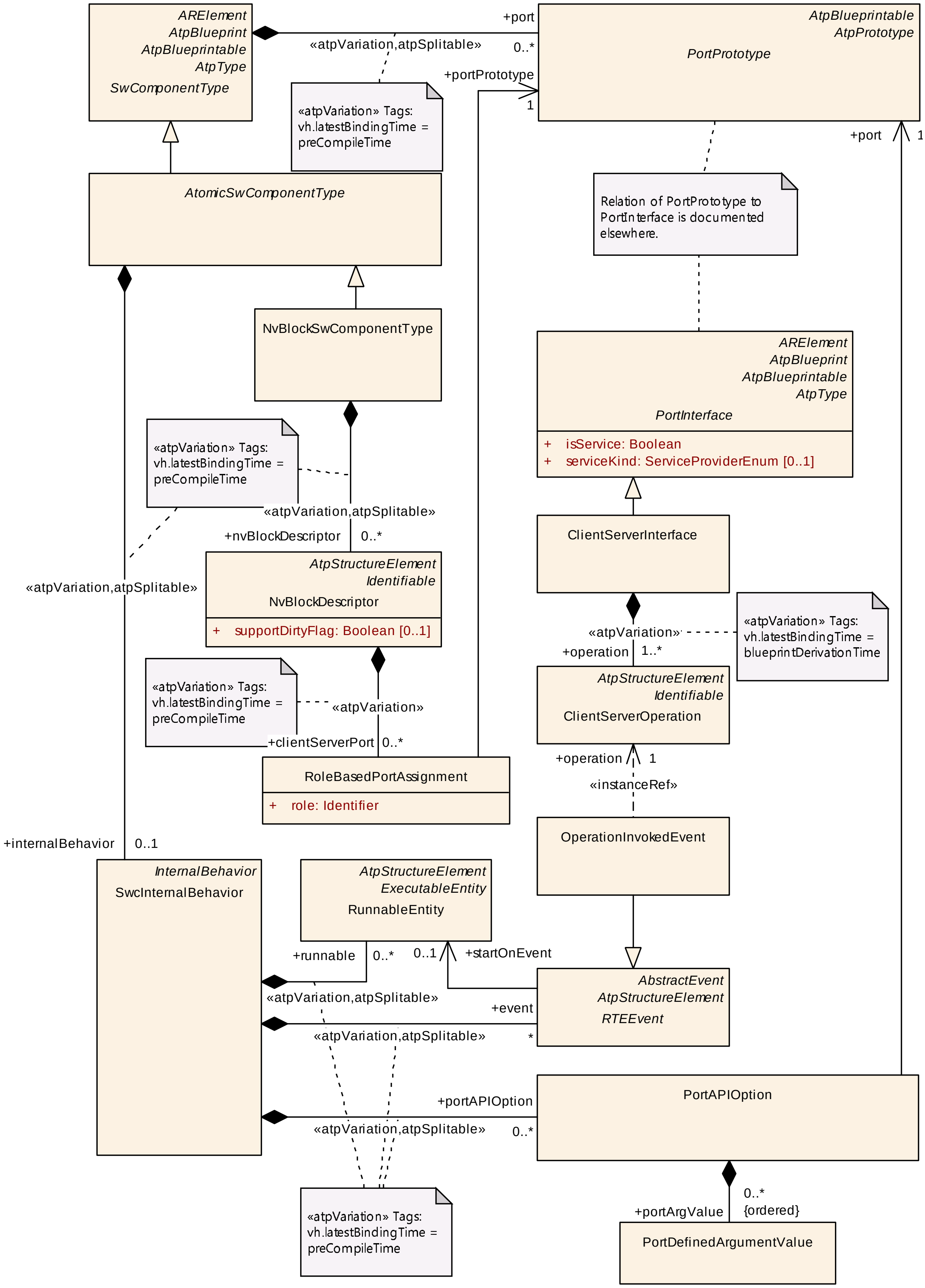


Figure 4.37: `SwcInternalBehavior` of `NvBlockSwComponentTypes`

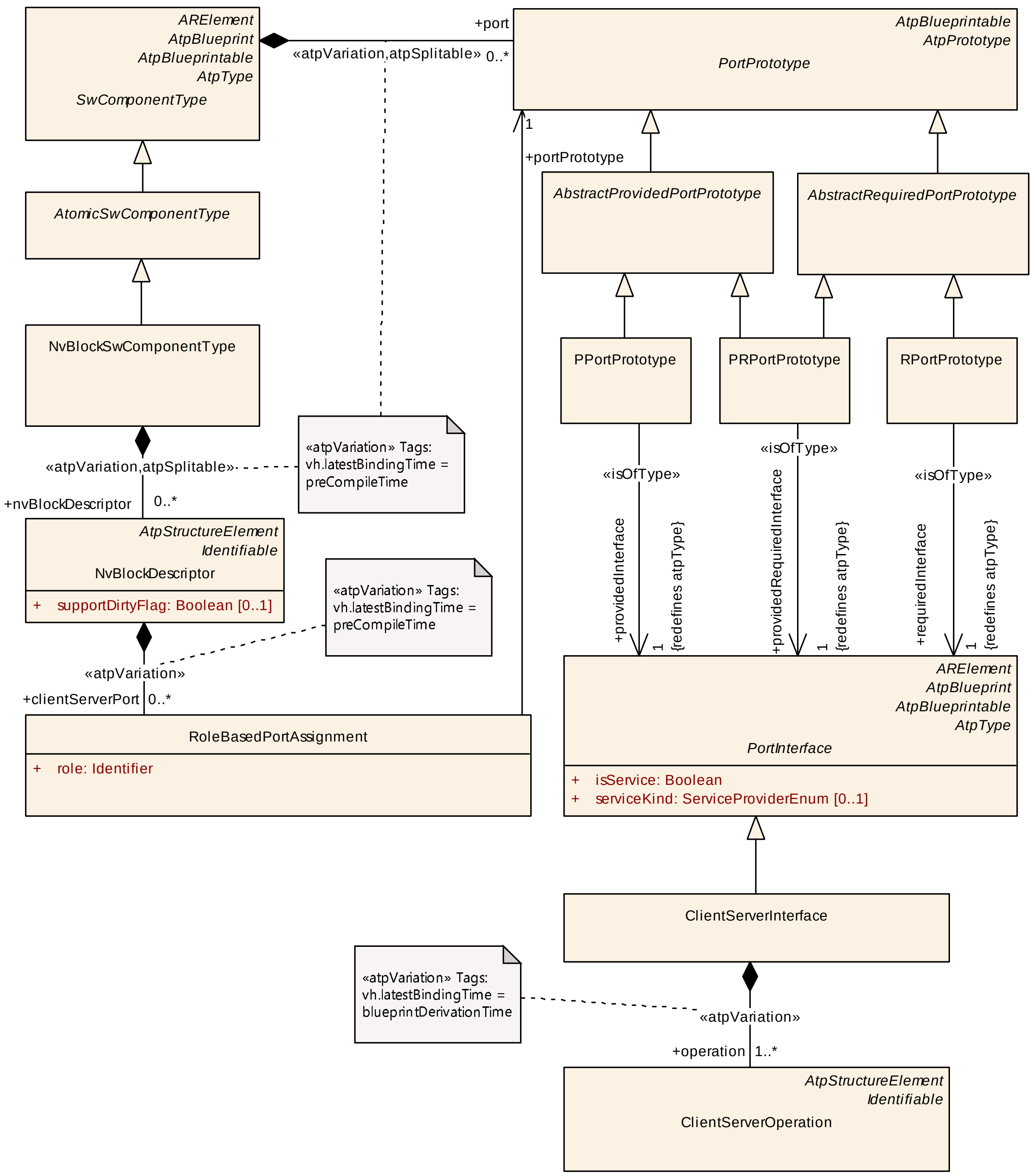


Figure 4.38: NVM notifications

The requests received from the SW-C side are forwarded by the `NvBlockSwComponentType`'s runnables to the NVM module, using the NVM C API indicated by the `RoleBasedPortAssignment`. See figure 4.37.

Notifications received from the NVM are forwarded to all the SW-C connected to the notification interfaces of the `NvBlockSwComponentType` with a `RoleBasedPortAssignment` of the corresponding type. See figure 4.38.

[SWS_Rte_07398] ⌈ The RTE Generator shall implement runnables for each connected server port of a NvBlockSwComponentType. ⌋*(SRS_Rte_00177)*

[SWS_Rte_07399] ⌈ The NvBlockSwComponentType's runnables used as servers connected to the SW-C shall forward the request to the NVM by calling the associated NVM API. ⌋*(SRS_Rte_00177)*

[SWS_Rte_04535] ⌈ The return values of NvM APIs NvM_WriteBlock and NvM_SetRAMBlockStatus (See requirements [SWS_Rte_08080], [SWS_Rte_08081], [SWS_Rte_08082], [SWS_Rte_08083], [SWS_Rte_08084], [SWS_Rte_08085]) called by the RTE shall be ignored. ⌋*(SRS_Rte_00177)*

[SWS_Rte_08064] ⌈ The symbol attribute of RunnableEntitys triggered by an OperationInvokedEvent of NvBlockSwComponentTypes shall be used by the RTE generator to identify the to be called NvM API function (see [constr_1234] in software component template [2]). ⌋*(SRS_Rte_00177)*

The NvBlockSwComponentType may define PortDefinedArgumentValues to provide the BlockId value in case the NvBlockSwComponentType defines server ports for the call of NvM services. Till R4.2 this was the only possibility to provide the BlockId value. But these values are not mandatory any longer and are superseded by the configuration of RteNvRamAllocation, see [SWS_Rte_06211] and [SWS_Rte_06212].

[SWS_Rte_06211] ⌈ The RTE generator shall determine the appropriate BlockId value for the invocation of NvM API functions from the parameter of the NvMBlockDescriptor which is mapped via RteNvRamAllocation.RteNvmBlockRef to the according NvBlockDescriptor. ⌋*(SRS_Rte_00177)*

Please note: Thereby the relationship of an invocation to a specific NvBlockDescriptor can be determined by following ways:

- NvBlockDescriptor.timingEvent for the cyclic invocation
- NvBlockDescriptor.clientServerPort where attribute role has the value NvMService or NvMAdmin. In this case all OperationInvokedEvents referencing an operation in such a PPortPrototype are belonging to the NvBlockDescriptor.
- VariableDataPrototype instances in AbstractProvidedPortPrototype mapped to the NvBlockDescriptor.ramBlock via an NvBlockDataMapping. In this case all DataReceivedEvents referencing those VariableDataPrototype instances are belonging to the NvBlockDescriptor.
- NvBlockDescriptor.modeSwitchEventTriggeredActivity for the mode switch based invocation.

[SWS_Rte_06212] ⌈ The RTE generator shall ignore the given PortAPIOption with PortDefinedArgumentValue applied to a PPortPrototype of a NvBlockSwComponentType when the BlockId value is determined according [SWS_Rte_06211]. ⌋*(SRS_Rte_00177)*

Besides forwarding requests from the SW-C side to the NVM module via NvM service ports, the NvBlockSwComponentType also supports the dirty flag mechanism mentioned in chapter 4.2.9.3.1. In order to realize the behavior of the dirty flag mechanism the RTE implements RunnableEntitys for each NvBlockDescriptor that can be triggered by RTEEvents. Depending on the writing strategy different kind of RTEEvents will be used for triggering the RunnableEntitys.

The configuration of the NvBlockSwComponentType (i.e. defining RTEEvents for triggering the RunnableEntitys for the NvBlockDescriptors and mapping of RTEEvents to tasks) is usually not in the responsibility of the SW-C developer. For this reason the SW-C developer can provide the required writing strategy in the SwcServiceDependency.serviceNeeds by using the attributes storeAtShutdown, storeCyclic, cyclicWritingPeriod, storeEmergency and storeImmediate (for more details see Software Component Template [2]).

[SWS_Rte_08086] ⌈ The RTE generator shall implement RunnableEntitys for each NvBlockDescriptor of an NvBlockSwComponentType with the attribute supportDirtyFlag set to true. ⌋ *(SRS_Rte_00177, SRS_Rte_00245)*

[SWS_Rte_08087] ⌈ The RunnableEntity of an NvBlockDescriptor shall be activated by a TimingEvent if the attribute NvBlockNeeds.storeCyclic is set to true. ⌋ *(SRS_Rte_00177, SRS_Rte_00245)*

[SWS_Rte_08088] ⌈ The RunnableEntity of an NvBlockDescriptor shall be activated by a DataReceivedEvent if the attribute NvBlockNeeds.storeAtShutdown or NvBlockNeeds.storeImmediate is set to true. ⌋ *(SRS_Rte_00177, SRS_Rte_00245)*

[SWS_Rte_08111] ⌈ The RunnableEntity of an NvBlockDescriptor shall be activated by a SwcModeSwitchEvent when the attribute NvBlockDescriptor.modeSwitchEventTriggeredActivity exists. ⌋ *(SRS_Rte_00177, SRS_Rte_00245)*

[SWS_Rte_08089] ⌈ For NvBlockDescriptors which need to combine several writing strategies, i.e. several NvBlockNeeds attributes referring to a writing strategy are set to true, the RunnableEntity of the NvBlockDescriptor shall be activated by one TimingEvent or DataReceivedEvent per writing strategy according to the requirements [SWS_Rte_08087] and [SWS_Rte_08088]. ⌋ *(SRS_Rte_00177, SRS_Rte_00245)*

[SWS_Rte_08090] ⌈ If no RteEventToTaskMapping is defined for DataReceivedEvents or SwcModeSwitchEvents which are responsible for activating RunnableEntitys of NvBlockDescriptors (see [SWS_Rte_08087] and [SWS_Rte_08088]), the according activities shall be processed in the RTE code issuing the DataReceivedEvents or SwcModeSwitchEvents. For explicit communication this shall be done in the related Rte_Write function and for implicit communication in the task bodies where the preemption buffers are handled. For SwcModeSwitchEvents using asynchronous mode switch procedure, this shall be done in the related Rte_Switch function.

Note: For SwcModeSwitchEvents a direct-call requires an asynchronous mode switch.

⌋(*SRS_Rte_00177, SRS_Rte_00245*)

4.2.9.4 Data Consistency

A VariableDataPrototype contained in a NvBlockSwComponentType is accessed when SW-Cs read the value or write a new value. It is also accessed by the NVM when read or write requests are processed by the NVM for the associated block.

The NVM does not access directly the VariableDataPrototypes, but shall use the Rte_GetMirror, and Rte_SetMirror APIs specified in section 5.9.3

The RTE has to ensure the data consistency of the VariableDataPrototypes, with any of the data consistency mechanisms defined in section 4.2.5. Depending on the user's input, an efficient scheduling with the use of implicit APIs should permit a low resources (OS resources, RAM, and code) implementation.

4.3 Communication Paradigms

AUTOSAR supports two basic communication paradigms: Client-Server and Sender-Receiver. AUTOSAR software-components communicate through well defined ports and the behavior is statically defined by attributes. Some attributes are defined on the modeling level and others are closely related to the network topology and must be defined on the implementation level.

The RTE provides the implementation of these communication paradigms. For inter-ECU communication the RTE uses the functionalities provided by COM. For inter-Partition communication (within the same ECU) the RTE may use functionalities provided by the IOC module. For intra-Partition the RTE provides the functionality on its own.

Both communication paradigms can be used together with data transformation which is described in chapter 4.10.

With Sender-Receiver communication there are two main principles: Data Distribution and Event Distribution. When data is distributed, the last received value is of interest (last-is-best semantics). When events are distributed the whole history of received events is of interest, hence they must be queued on receiver side. Therefore the software implementation policy can be queued or non queued. This is stated in the swImplPolicy attribute of the SwDataDefProps, which can have the value queued (corresponding to event distribution with a queue) or standard (corresponding to last-is-best data distribution). If a data element has event semantics, the swImplPolicy is set to queued. The other possible values of this attribute correspond to data semantics.

[SWS_Rte_07192] ⌈ The RTE generator shall reject the configuration when an `r-port` is connected to an `r-port` or a `p-port` is connected to a `p-port` with an `AssemblySwConnector`⌋*(SRS_Rte_00018)*

For example, a require port (`r-port`) of a component typed by an AUTOSAR sender-receiver interface can read data elements of this interface. A provide port (`p-port`) of a component typed by an AUTOSAR sender-receiver interface can write data elements of this interface.

[SWS_Rte_07006] ⌈ The RTE generator shall reject the configuration violating the [constr_1032], so when an `r-port` is connected to a `p-port` or a `p-port` is connected to an `r-port` with a `DelegationSwConnector`. ⌋*(SRS_Rte_00018)*

[SWS_Rte_08767] ⌈ In case of functionality depending on attributes of `ComSpecs` the RTE Generator shall consider only the `ComSpecs` defined in the context of `AtomicSwComponentType`s or `ParameterSwComponentType`s. ⌋*(SRS_Rte_00018)*

4.3.1 Sender-Receiver

4.3.1.1 Introduction

Sender-receiver communication involves the transmission and reception of signals consisting of atomic data elements that are sent by one component and received by one or more components. A sender-receiver interface can contain multiple data elements. Sender-receiver communication is one-way - any reply sent by the receiver is sent as a separate sender-receiver communication.

A require port (r-port) of a component typed by an AUTOSAR sender-receiver interface can read data elements of this interface. A provide port (p-port) of a component typed by an AUTOSAR sender-receiver interface can write data elements of this interface.

4.3.1.2 Receive Modes

The RTE supports multiple receive modes for passing data to receivers. The four possible receive modes are:

- **"Implicit data read access"** – when the receiver's runnable executes it shall have access to a "copy" of the data that remains unchanged during the execution of the runnable.

  [SWS_Rte_06000] ⌈ For data elements specified with implicit data read access, the RTE shall make the receive data available to the runnable through the `semantics of a copy`. ⌋*(SRS_Rte_00128, SRS_Rte_00019)*

  [SWS_Rte_06001] ⌈ For data elements specified with implicit data read access the receive data shall not change during execution of the runnable. ⌋*(SRS_Rte_00128)*

When “implicit data read access” is used the RTE is required to make the data available as a “copy”. It is not necessarily required to use a unique copy for each runnable. Thus the RTE may use a unique copy of the data for each runnable entity or may, if several runnables (even from different components) need the same data, share the same copy between runnables. Runnable entities can only share a copy of the same data when the scheduling structure can make sure the contents of the data is protected from modification by any other party.

[SWS_Rte_06004] ⌈ The RTE shall read the data elements specified with implicit data read access before the associated runnable entity is invoked. ⌋ *(SRS_Rte_00128)*

Composite data types shall be handled in the same way as primitive data types, i.e. RTE shall make a “copy” available for the `RunnableEntity`.

[SWS_Rte_06003] ⌈ The “implicit data read access” receive mode shall be valid for all categories of runnable entity (i.e. 1A, 1B and 2). ⌋ *(SRS_Rte_00134)*

- **“Explicit data read access”** – the RTE generator creates a non-blocking API call to enable a receiver to poll (and read) data. This receive mode is an “explicit” mode since an explicit API call is invoked by the receiver.

  The explicit “data read access” receive mode is only valid for category 1B or 2 runnable entities [SRS_Rte_00134].

- **“wake up of wait point”** – the RTE generator creates a blocking API call that the receiver invokes to read data.

  [SWS_Rte_06002] ⌈ The “wake up of wait point” receive mode shall support a time-out to prevent infinite blocking if no data is available. ⌋ *(SRS_Rte_00109, SRS_Rte_00069)*

  The “wake up of wait point” receive mode is inherently only valid for a category 2 runnable entity.

  A category 2 runnable entity is required since the implementation may need to suspend execution of the caller if no data is available.

- **“activation of runnable entity”** – the receiving runnable entity is invoked automatically by the RTE whenever new data is available. To access the new data, the runnable entity either has to use “implicit data read access” or “explicit data read access”, i.e. invoke an `Rte_IRead`, `Rte_Read`, `Rte_DRead` or `Rte_Receive` call, depending on the input configuration. This receive mode differs from “implicit data read access” since the receiver is invoked by the RTE in response to a `DataReceivedEvent`.

  [SWS_Rte_06007] ⌈ The “activation of runnable entity” receive mode shall be valid for category 1A, 1B and 2 runnable entities. ⌋ *(SRS_Rte_00134)*

The validity of receive modes in conjunction with different categories of runnable entity is summarized in Table 4.10.

Receive Mode	Cat 1A	Cat 1B	Cat 2
Implicit Data Read Access	Yes	Yes	Yes
Explicit Data Read Access	No	Yes	Yes
Wake up of wait point	No	No	Yes
Activation of runnable entity	Yes	Yes	Yes

Table 4.10: Receive mode validity

The category of a runnable entity is not an inherent property but is instead determined by the features of the runnable. Thus the presence of explicit API calls makes the runnable at least category 1B and the presence of a WaitPoint forces the runnable to be category 2.

4.3.1.2.1 Applicability

The different receive modes are not just used for receivers in sender-receiver communication. The same semantics are also applied in the following situations:

- **Success feedback** – The mechanism used to return transmission acknowledgments to a component. See Section 5.2.6.9.
- **Asynchronous client-server result** – The mechanism used to return the result of an asynchronous client-server call to a component. See Section 5.7.5.4.

4.3.1.2.2 Representation in the Software Component Template

The following list serves as a reference for how the RTE Generator determines the Receive Mode from its input [SRS_Rte_00109]. Note that references to "the VariableDataPrototype" within this sub-section will implicitly mean "the VariableDataPrototype for which the API is being generated".

- **"wake up of wait point"** – A VariableAccess in the dataReceivePointByValue or dataReceivePointByArgument role references a VariableDataPrototype and a WaitPoint references a DataReceivedEvent which in turn references the same VariableDataPrototype.
- **"activation of runnable entity"** – a *DataReceivedEvent* references the VariableDataPrototype and a runnable entity to start when the data is received.
- **"explicit data read access"** – A VariableAccess in the dataReceivePointByValue or dataReceivePointByArgument role references the VariableDataPrototype.
- **"implicit data read access"** – A VariableAccess in the dataReadAccess role references the VariableDataPrototype.

It is possible to combine certain access methods; for example 'activation of runnable entity' can be combined with 'explicit' or 'implicit' data read access (indeed, one of these pairings is necessary to cause API generation to actually *read* the datum) but it is an input error if 'activation of runnable entity' and 'wakeup of wait point' are combined (i.e. a `WaitPoint` references a `DataReceivedEvent` that references a runnable entity). It is also possible to specify both implicit and explicit data read access simultaneously.

For details of the semantics of "implicit data read access" and "explicit data read access" see Section 4.3.1.5.

4.3.1.3 Multiple Data Elements

A sender-receiver interface can contain one or more data elements. The transmission and reception of elements is independent – each data element, e.g. AUTOSAR signal, can be considered to form a separate logical data channel between the "provide" port and a "require" port.

[SWS_Rte_06008] ⌈ Each data element in a sender-receiver interface shall be sent separately. ⌋*(SRS_Rte_00089)*

Example 4.5

Consider an interface that has two data elements, `speed` and `freq` and that a component template defines a provide port that is typed by the interface. The RTE generator will then create two API calls; one to transmit `speed` and another to transmit `freq`.

Where it is important that multiple data elements are sent simultaneously they should be combined into a composite data structure (Section 4.3.1.11.1). The sender then creates an instance of the data structure which is filled with the required data before the RTE is invoked to transmit the data.

4.3.1.3.1 Initial Values

[SWS_Rte_06009] ⌈ For each data element in an interface specified with `data semantics`, the RTE shall support the `initValue` attribute. ⌋*(SRS_Rte_00108)*

The `initValue` attribute is used to ensure that AUTOSAR software-components always access valid data even if no value has yet been received. This information is required for inter-ECU, inter-Partition, and intra-Partition communication. For inter-ECU communication initial values can be handled by COM but for intra-ECU communication RTE has to guarantee that `initValue` is handled.

In general, the specification of an `initValue` is mandatory for each data element prototype with `data semantics`, see [SWS_Rte_07642]. If all senders and receivers are located in the same partition, this restriction is relaxed, see [SWS_Rte_04501].

[SWS_Rte_06010] ⌈ The RTE shall use any specified initial value to prevent the receiver performing calculations based on invalid (i.e. uninitialized) values when the `swImplPolicy` is not `queued` and if the general initialization conditions in [SWS_Rte_07046] are fulfilled. ⌋*(SRS_Rte_00107)*

The above requirement ensures that RTE API calls return the initialized value until a "real" value has been received, possibly via the communication service. The requirement does *not* apply when "event" semantics are used since the implied state change when the event data is received will mean that the receiver will not start to process invalid data and would therefore never see the initialized value.

[SWS_Rte_04500] ⌈ An initial value cannot be specified when the implementation policy is set to 'queued' attribute is specified as true. ⌋*(SRS_Rte_00107)*

For senders, an initial value is not used directly by the RTE (since an AUTOSAR SW-C must supply a value using `Rte_Send`) however it may be needed to configure the communication service - for example, an un-initialised signal can be transmitted if multiple signals are mapped to a single frame and the communication service transmits the whole frame when any contained signal is sent by the application. Note that it is not the responsibility of the RTE generator to configure the communication service.

It is permitted for an initial value to be specified for either the sender or receiver. In this case the same value is used for both sides of the communication.

[SWS_Rte_04501] ⌈ If in context of one partition a sender specifies an initial value and the receiver does not (or *vice versa*) the same initial value is used for both sides of the communication. ⌋*(SRS_Rte_00108)*

It is also permitted for both sender and receiver to specify an initial value. In this case it is defined that the receiver's initial value is used by the RTE generator for both sides of the communication.

[SWS_Rte_04502] ⌈ If in context of one partition both receiver and sender specify an initial value the specification for the *receiver* takes priority. ⌋*(SRS_Rte_00108)*

4.3.1.4 Multiple Receivers and Senders

Sender-receiver communication is not restricted to communication connections between a single sender and a single receiver. Instead, sender receiver communication connection can have multiple senders ('n:1' communication) or multiple receivers ('1:m' communication) with the restrictions that multiple senders are not allowed for `mode switch notifications`, see metamodel restriction [SWS_Rte_02670].

The RTE does not impose any co-ordination on senders – the behavior of senders is independent of the behavior of other senders. For example, consider two senders `A` and `B` that both transmit data to the same receiver (i.e. 'n:1' communication). Transmissions by either sender can be made at any time and there is no requirement that the senders co-ordinate their transmission. However, while the RTE does not impose any co-ordination on the senders it does ensure that simultaneous transmissions do not conflict.

In the same way that the RTE does not impose any co-ordination on senders there is no co-ordination imposed on receivers. For example, consider two receivers `P` and `Q` that both receive the same data transmitted by a single sender (i.e. '1:m' communication). The RTE does not guarantee that multiple receivers see the data simultaneously even when all receivers are on the same ECU.

4.3.1.5 Implicit and Explicit Data Reception and Transmission

[SWS_Rte_06011] ⌈ The RTE shall support 'explicit' and 'implicit' data reception and transmission. ⌋*(SRS_Rte_00019, SRS_Rte_00098, SRS_Rte_00129, SRS_Rte_00128, SRS_Rte_00141)*

Implicit data access transmission means that a runnable does not actively initiate the reception or transmission of data. Instead, the required data is received automatically when the runnable starts and is made available for other runnables at the earliest when it terminates.

Explicit data reception and transmission means that a runnable employs an explicit API call to send or receive certain data elements. Depending on the category of the runnable and on the configuration of the according ports, these API calls can be either blocking or non-blocking.

4.3.1.5.1 Implicit

Implicit Read

For the implicit reading of data, `VariableAccess`es aggregated with a `dataReadAccess` role [SRS_Rte_00128], the data is made available when the runnable starts using the `semantics of a copy` operation and the RTE ensures that the 'copy' will not be modified until the runnable terminates.

If data transformation shall be executed for this data element, the data transformation takes place after reception of the data from the Com stack and before start of the runnable execution. (See [SWS_Rte_08570], [SWS_Rte_08108])

When a runnable *R* is started, the RTE reads all `VariableDataPrototype`s referenced by a `VariableAccess` in the `dataReadAccess` role, if the data elements may be changed by other runnables a copy is created that will be available to runnable *R*. The runnable *R* can read the data element by using the RTE APIs for implicit read (see the API description in Section 5.6.18). That way, the data is guaranteed not to change (e.g. by write operations of other runnables) during the entire lifetime of *R*. If several runnables (even from different components) need the data, they can share the *same* buffer. This is only applicable when the scheduling structure can make sure the contents of the data is protected from modification by any other party.

Note that this concept implies that the runnable does in fact terminate. Therefore, while implicit read is allowed for category 1A and 1B runnable entities as well as category 2 only the former are guaranteed to have a finite execution time. A category 2 runnable that runs forever will not see any updated data.

VariableAccess in the dataReadAccess role is only allowed for VariableDataPrototypes with their swImplPolicy different from 'queued' ([constr_2020]).

Implicit Write

Implicit writing, VariableAccesses aggregated with a dataWriteAccess role [SRS_Rte_00129], is the opposite concept. VariableDataPrototypes referenced by a VariableAccess in the dataWriteAccess role are sent by the RTE after the runnable terminates. The runnable can write the data element by using the RTE APIs for implicit write (see the API description in Sect. 5.6.19 and 5.6.20). The sending is independent from the position in the execution flow in which the Rte_IWrite is performed inside the Runnable. When performing several write accesses during runnable execution to the same data element, only the last one will be recognized. Here we have a last-is-best semantics.

If data transformation shall be executed for this data element, the data transformation takes place after termination of the runnable and before sending the data to the Com stack. (See [SWS_Rte_08571], [SWS_Rte_08109])

[SWS_Rte_08418] ⌈ The content of a preemption area specific buffer which is used exclusively for an implicit write access to a VariableDataPrototype shall be initialized by the generated RTE with a copy of the global buffer between the beginning of the task and the execution of the first RunnableEntity with access to this VariableDataPrototype in the task. ⌋ *(SRS_Rte_00129)*

Note:
[SWS_Rte_08418] ensures that no undefined values are written back to a preemption area specific buffer at runnable termination if a VariableDataPrototype is referenced by a VariableAccess in the dataWriteAccess role and no RTE API for implicit write of this VariableDataPrototype is called during an execution of the Runnable. For the first entry to the preemption area the "global buffer" will contain the initValue of the VariableDataPrototype (if no initValue is configured then the value will depend on the initialization strategy of the startup code). For second and subsequent entries the "global buffer" will contain the previously written value (if any).

[SWS_Rte_03570] ⌈ For VariableAccesses in the dataWriteAccess role the RTE shall make the sent data available to others (other runnables, other AUTOSAR SWCs, Basic SW, ..) with the semantics of a copy. ⌋ *(SRS_Rte_00129)*

[SWS_Rte_03571] ⌈ For VariableAccesses in the dataWriteAccess role the RTE shall make the sent data available to others (other runnables, other AUTOSAR SWCs, Basic SW, ..) at the earliest when the runnable has terminated. ⌋ *(SRS_Rte_00129)*

[SWS_Rte_03572] ⌈ For VariableAccesses in the dataWriteAccess role several accesses to the same VariableDataPrototype performed inside a runnable during one runnable execution shall lead to only one transmission of the VariableDataPrototype. ⌋*(SRS_Rte_00129)*

[SWS_Rte_03573] ⌈ If several VariableAccesses in the dataWriteAccess role referencing the same VariableDataPrototype are performed inside a runnable during the runnable execution, the RTE shall use the last value written. (last-is-best semantics) ⌋*(SRS_Rte_00129)*

A VariableAccess in the dataWriteAccess role is only sensible for runnable entities that are guaranteed to terminate, i.e. category 1A and 1B. If it is used for a category 2 runnable which does not terminate then no data write-back will occur.

[SWS_Rte_03574] ⌈ VariableAccess in the dataWriteAccess role shall be valid for all categories of runnable entity. ⌋*(SRS_Rte_00129, SRS_Rte_00134)*

To get common behavior in RTEs from different suppliers further requirements defining the semantic of implicit communication exist:

Please note that the behavior of Implicit Communication can be adjusted with ECU Configuration. For further information see section 8.7.

Implicit Communication Behavior in case of incoherent implicit data access

[SWS_Rte_03954] ⌈ The RTE generator shall use exactly one buffer to contain data copies of the same VariableDataPrototype per preemption area for the implementation of the copy semantic of incoherent implicit data access. ⌋*(SRS_Rte_00128, SRS_Rte_00129, SRS_Rte_00134)*

Requirement [SWS_Rte_03954] means that all runnable entities mapped to tasks of a preemption area with an incoherent implicit read access or incoherent implicit write access access the same buffers.

[SWS_Rte_03598] ⌈ For implicit communication, the RTE shall provide a single shared read/write buffer when no runnable entity mapped to tasks of the preemption area has VariableAccess in both incoherent implicit read access and incoherent implicit write access referencing the same VariableDataPrototype. ⌋*(SRS_Rte_00128, SRS_Rte_00129)*

If either the sender or the receiver uses a data element with status and the other uses a data element without status, a data element with status can be implemented and casted in the component data structure when a pointer to a data element without status is needed.

[SWS_Rte_03955] ⌈ For implicit communication, in case that dedicated RPortPrototype and PPortPrototype are used, separate read and write buffers shall be used when at least one RunnableEntity mapped to tasks of the preemption area has implicit read access and implicit write access referencing the same VariableDataPrototype. ⌋*(SRS_Rte_00128, SRS_Rte_00129)*

In the case that a RunnableEntity defines dataWriteAccess and dataReadAccess to the same VariableDataPrototype in the context of a PRPortPrototype [SWS_Rte_03955] does not apply. In such configuration the writing RunnableEntity immediately sees its own updates of the data values even before the RunnableEntity has terminated.

[SWS_Rte_08408] ⌈ If a RunnableEntity has both dataWriteAccess and dataReadAccess to a VariableDataPrototype in the context of a PRPortPrototype the result of the write access shall be immediately visible to subsequent read accesses from within the same RunnableEntity. ⌋*(SRS_Rte_00128, SRS_Rte_00129)*

Please note that the content of the write buffers are copied into the read buffer of the preemption area after the RunnableEntity with the write access terminates (see [SWS_Rte_07041]). Therefore the write buffer might be implemented as temporary buffer.

[SWS_Rte_03599] ⌈ For implicit communication with incoherent implicit data access all readers within a preemption area shall access the same buffer. ⌋*(SRS_Rte_00128)*

[SWS_Rte_03953] ⌈ For implicit communication with incoherent implicit data access all writers within a preemption area shall access the same buffer. ⌋*(SRS_Rte_00129)*

The content of a shared buffer (see [SWS_Rte_03598]) is not guaranteed to stay constant during the whole task since a writer will change the shared copy and hence readers mapped in the task after the writer will access the updated copy. When buffers are shared, written data is visible to other RunnableEntitys within the same execution of the task. However since no runnable within the task will both read and write the same buffer ([SWS_Rte_03598] and [SWS_Rte_03955]) consistency *within a runnable* is ensured.

When separate buffers used for implicit communication (see [SWS_Rte_03955]) any data written by a runnable is not visible (to either other RunnableEntitys or to the writing runnable) until the data is written back after the runnable has terminated.

Implicit Communication Behavior in case of coherent implicit data access

[SWS_Rte_07062] ⌈ The RTE generator shall use exactly one buffer to contain data copies of the same VariableDataPrototype per coherency group for the implementation of the copy semantic of coherent implicit data access. ⌋*(SRS_Rte_00128, SRS_Rte_00129, SRS_Rte_00134)*

Requirement [SWS_Rte_07062] means that all runnable entities with coherent implicit data accesses access the same buffers. Please note that it is only supported to group implicit read accesses or implicit write accesses of RunnableEntitys executed in the same OS Task. Therefore a coherent implicit data access results in a task local buffer as it was specified in previous

AUTOSAR releases. With this means a backward compatible bahavior of the RTE can be ensured.

Please note that [SWS_Rte_03955] applies as well for coherent implicit data access. [SWS_Rte_07062] includes already that a single shared read/write buffer shall be used when no runnable entity has coherent implicit read access and coherent implicit write access belonging to the same coherency group.

Implicit Communication buffer handling

The preemption area specific buffer should not be updated or made available more often than required. The following requirements detail how to obtain that for read and write access.

[SWS_Rte_03956] ⌈ The content of a preemption area specific buffer used for an incoherent implicit read access to a data element shall be filled with actual data by a copy action between the beginning of the task and the execution of the first RunnableEntity with access to this data element in the task. ⌋ *(SRS_Rte_00128)*

[SWS_Rte_07020] ⌈ If the RteImmediateBufferUpdate = TRUE is configured for an incoherent implicit read access to a data element the content of a preemption area specific buffer used for that VariableAccess shall be filled with actual data by a copy action immediately before the RunnableEntity with the related implicit read access to the data element starts. ⌋ *(SRS_Rte_00128)*

[SWS_Rte_07041] ⌈ The content of a separate write buffer (see [SWS_Rte_03955]) modified by an incoherent implicit write access of a RunnableEntity shall be made available to RunnableEntitys using an implicit read access allocated in the **same** preemption area immediately after the execution of the RunnableEntity with the related implicit write access to the data element. ⌋ *(SRS_Rte_00129)*

[SWS_Rte_03957] ⌈ The content of a preemption area specific buffer modified by a incoherent implicit write access in one task shall be made available to RunnableEntitys using an implicit read access allocated in **other** preemption areas at latest after the execution of the last RunnableEntity mapped to the task. ⌋ *(SRS_Rte_00129)*

[SWS_Rte_07021] ⌈ If the RteImmediateBufferUpdate = TRUE is configured for an incoherent implicit write access the content of a preemption area specific buffer shall be made available to RunnableEntitys using an implicit read access allocated in **other** preemption areas immediately after the execution of the RunnableEntity with the related implicit write access to the data element. ⌋ *(SRS_Rte_00129)*

Note:
It's the semantic of implicit communication that a VariableAccess in the dataWriteAccess role is interpreted as writing the whole dataElement.

Explicit Schedule Points defined by RteOsSchedulePoints are placed between RunnableEntitys after the data written with implicit write access by the

RunnableEntity are propagated to other RunnableEntitys and before the preemption area specific buffer used for a implicit read access of the successor RunnableEntity are filled with actual data by a copy action according [SWS_Rte_07020]. This ensures that the data produced by one RunnableEntity is propagated before RunnableEntitys assigned to other Os Tasks are activated due to Task scheduling caused by the explicit Schedule Point. See as well [SWS_Rte_07042] and [SWS_Rte_07043].

The requirements regarding buffer handling for implicit communication do not apply in case of filters. Buffer handling of RTE for filters is specified in chapter 4.3.1.9 (requirements: [SWS_Rte_08077], [SWS_Rte_08078] and [SWS_Rte_08079]).

Implicit Communication buffer handling for coherent implicit data access

[SWS_Rte_07063] ⌈ The content of a coherency group specific buffer used for an coherent implicit read access to one or more data elements shall be filled with actual data by a copy action between the beginning of the task and the execution of the first RunnableEntity in the task with a coherent implicit read access belonging to the coherency group. ⌋ *(SRS_Rte_00128)*

[SWS_Rte_07064] ⌈ If the RteImmediateBufferUpdate = TRUE is configured for coherent implicit read accesses the content of a coherency group specific buffer used for these VariableAccesses shall be filled with actual data by a copy action immediately before the first RunnableEntity in the task with a coherent implicit read access belonging to the coherency group starts. ⌋ *(SRS_Rte_00128)*

[SWS_Rte_07065] ⌈ The content of a separate write buffer (see [SWS_Rte_03955]) modified by a coherent implicit write access of a RunnableEntity shall be made available to RunnableEntitys using a coherent implicit read access belonging to the same coherency group immediately after the execution of the RunnableEntity with the related coherent implicit write access. ⌋ *(SRS_Rte_00129)*

[SWS_Rte_07066] ⌈ The content of a coherency group specific buffer modified by coherent implicit write accesses in one task shall be made available to other RunnableEntitys at earliest after the execution of the last RunnableEntity with a coherent implicit write access belonging to this coherency group. ⌋ *(SRS_Rte_00129)*

[SWS_Rte_07067] ⌈ The content of a coherency group specific buffer modified by coherent implicit write accesses in one task shall be made available to other RunnableEntitys at latest after the execution of the last RunnableEntity mapped to the task. ⌋ *(SRS_Rte_00129)*

[SWS_Rte_07068] ⌈ If the RteImmediateBufferUpdate = TRUE is configured for a coherent implicit write accesses the content of a coherency group specific buffer modified by coherent implicit write accesses in one task shall be made available to other readers not belonging to this coherency group immediately after the execution of the last RunnableEntity with a coherent implicit write access belonging to this coherency group ⌋*(SRS_Rte_00129)*

Handling of ConsistencyNeeds

ConsistencyNeeds are not directly processed by the RTE Generator but providing an important information for the correct configuration of the RTE and OS with respect to preemption, RteEventToTaskMapping and RteImplicitCommunication. Therefore following constraints apply:

[SWS_Rte_CONSTR_09001] Whole DataPrototypeGroup in role dpgRequiresCoherency shall be propagated coherently ⌈

All RunnableEntitys in a RunnableEntityGroup with dataWriteAccess to data belonging to the same DataPrototypeGroup in the role dpgRequiresCoherency shall

- Be mapped to the same OS Task

  AND shall

- A) either be scheduled in a way that these RunnableEntitys can not be interrupted by RunnableEntitys with dataReadAccess to (more than one) data belonging to the DataPrototypeGroup.
- B) or the RteImplicitCommunication shall be configured to ensure a coherent propagation (RteCoherentAccess == true) for reading RunnableEntitys [4].

⌋*()*

Please note that the interruption of RunnableEntitys and between RunnableEntitys depends from many factors like the configuration of the OS and the configuration of the RTE (e.g. RteOsSchedulePoint).

[SWS_Rte_CONSTR_09002] The whole DataPrototypeGroup shall be read stable for the whole RunnableEntityGroup in the role regRequiresStability ⌈.

All RunnableEntitys with dataReadAccess to data belonging to the same DataPrototypeGroup and which are belonging to the same RunnableEntityGroup in the role regRequiresStability shall

- either be configured in a way that the chain of RunnableEntitys with dataReadAccess to the data of the DataPrototypeGroup can not be interrupted by any of the RunnableEntity(s) with dataWriteAccess to data of the DataPrototypeGroup

[4] RunnableEntitys with have as well dataWriteAccess to data belonging to the DataPrototypeGroup are excluded because inside the calculation chain the latest data values are visible

- or the RteImplicitCommunication shall be configured to ensure stable data values (RteCoherentAccess == true) for reading RunnableEntitys belonging to the RunnableEntityGroup.

⌋()

Examples

Following examples shall illustrate how ConsistencyNeeds can be implemented with either scheduling or coherency groups.

Example 4.6

Common definition of PortInterfaces

In order to simplify the examples all PortInterfaces are of type SenderReceiverInterface and contain exactly one VariableDataPrototype with identical shortName. For example SenderReceiverInterface "A" contains VariableDataPrototype "A"

Additionally the shortName of the SenderReceiverInterface is identical to the shortName of the PortPrototype. For example PPortPrototype "A" is typed by SenderReceiverInterface "A".

Example 4.7

Stability need for received data

Setup of SWCs

ApplicationSwComponentType "ASWC_A" with the PPortPrototypes: "A","B"

and the RunnableEntity "ASWC_A_RUN1" which in turn has following dataWriteAccesses

- "DWP_ASWC_A_RUN1_A_A" referencing VariableDataPrototype "A" in PPortPrototype "A"
- "DWP_ASWC_A_RUN1_B_B" referencing VariableDataPrototype "B" in PPortPrototype "B"

ApplicationSwComponentType "ASWC_B" with the RPortPrototypes: "A","B"

and the RunnableEntity "ASWC_B_RUN1" which in turn has dataReadAccesses

- "DRP_ASWC_B_RUN1_A_A" referencing VariableDataPrototype "A" in RPortPrototype "A"
- "DRP_ASWC_B_RUN1_B_B" referencing VariableDataPrototype "B" in RPortPrototype "B"

ApplicationSwComponentType "ASWC_C" with the RPortPrototypes: "A","B" and the RunnableEntity "ASWC_C_RUN1" which in turn has dataReadAccesses

- "DRP_ASWC_C_RUN1_A_A" referencing VariableDataPrototype "A" in RPortPrototype "A"
- "DRP_ASWC_C_RUN1_B_B" referencing VariableDataPrototype "B" in RPortPrototype "B"

The ConsistencyNeeds "CN_BC" defines a RunnableEntityGroup in the role regRequiresStability with the members "ASWC_B_RUN1", "ASWC_C_RUN1" In addition the ConsistencyNeeds "CN_BC" defines a DataPrototypeGroup in the role dpgDoesNotRequireCoherency to the VariableDataPrototypes ASWC_B.A.A.A, ASWC_C.A.A.A, ASWC_B.B.B.B and ASWC_C.B.B.B The complete example is listed as ARXML in Appendix F.2.

Assuming now a configuration:

ASWC_A_RUN1 is mapped to OsTask T10MS

ASWC_B_RUN1 is mapped to OsTask T100MS

ASWC_C_RUN1 is mapped to OsTask T100MS

where T10MS can **NOT** interrupt T100MS during the execution of ASWC_B_RUN1 and ASWC_C_RUN1. This configuration fulfills [SWS_Rte_CONSTR_09002] with respect to "CN_BC" due the scheduling conditions. Since the producer of "A" and "B" can **NOT** interrupt the RunnableEntitys with the dataReadAccesses it is guaranteed that the value for all accesses of ASWC_B_RUN1 and ASWC_C_RUN1 to the same data is identical (and therefore stable) during one execution of OsTask T100MS.

Assuming now a configuration:

ASWC_A_RUN1 is mapped to OsTask T10MS

ASWC_B_RUN1 is mapped to OsTask T100MS + RteOsSchedulePoint == UNCONDITIONAL

ASWC_C_RUN1 is mapped to OsTask T100MS

where T10MS can interrupt T100MS after the execution of ASWC_B_RUN1. Without further means this configuration would violate [SWS_Rte_CONSTR_09002] due the scheduling conditions. Since the producer of "A" and "B" can interrupt the RunnableEntitys with the dataReadAccesse it is not guaranteed that the value for all accesses of ASWC_B_RUN1 and ASWC_C_RUN1 to the same data is kept stable during one execution of OsTask T100MS.

With the additional configuration RteImplicitCommunication "CN_BC_A":

- RteVariableReadAccessRef referencing "DRP_ASWC_B_RUN1_A_A"

- RteVariableReadAccessRef referencing "DRP_ASWC_C_RUN1_A_A"
- RteCoherentAccess = true

and

RteImplicitCommunication "CN_BC_B":

- RteVariableReadAccessRef referencing "DRP_ASWC_B_RUN1_B_B"
- RteVariableReadAccessRef referencing "DRP_ASWC_C_RUN1_B_B"
- RteCoherentAccess = true

"ASWC_B_RUN1_A_A" and "ASWC_C_RUN1_A_A" as well as "ASWC_B_RUN1_B_B" and "ASWC_C_RUN1_B_B" are in the same coherency group. Therefore the read data values for "A" and "B" are from the same age in one execution of OsTask T100MS for ASWC_B_RUN1 and ASWC_C_RUN1.

Please note, since it is not requested that data "A" and "B" are communicated coherently the setup of RteImplicitCommunication for "A" and "B" can be handled independently from each other. In particular if there a further RunnableEntitys with dataReadAccesses to "A" or "B" mapped to the OsTask T100MS the buffers for "A" and "B" can be loaded at different points in the execution sequence. Further on it is not requested that "A" and "B" is produced in the same recurrence as it is show in this example.

Example 4.8

Coherency need and stability need for received data

Setup of SWCs

ApplicationSwComponentType "ASWC_H" with the PPortPrototype: "X"

and the RunnableEntity "ASWC_H_RUN1" which in turn has following dataWriteAccesses

- "DWP_ASWC_H_RUN1_X_X" referencing VariableDataPrototype "X" in PPortPrototype "X"

ApplicationSwComponentType "ASWC_I" with the RPortPrototype: "Y"

and the RunnableEntity "ASWC_I_RUN1" which in turn has following dataWriteAccesses

- "DWP_ASWC_I_RUN1_Y_Y" referencing VariableDataPrototype "Y" in RPortPrototype "Y"

ApplicationSwComponentType "ASWC_J" with the RPortPrototypes: "X","Y" and the RunnableEntity "ASWC_J_RUN1" which in turn has following dataReadAccesses

- "DRP_ASWC_J_RUN1_X_X" referencing VariableDataPrototype "X" in RPortPrototype "X"
- "DRP_ASWC_J_RUN1_Y_Y" referencing VariableDataPrototype "Y" in RPortPrototype "Y"

ApplicationSwComponentType "ASWC_K" with the RPortPrototype: "X"

and the RunnableEntity "ASWC_K_RUN1" which in turn has following dataReadAccesses

- "DRP_ASWC_K_RUN1_X_X" referencing VariableDataPrototype "X" in RPortPrototype "X"

The ConsistencyNeeds "CN_J" defines a RunnableEntityGroup in the role regDoesNotRequireStability with the member "ASWC_I_RUN1" In addition the ConsistencyNeeds "CN_J" defines a DataPrototypeGroup in the role dpgRequiresCoherency to the VariableDataPrototypes ASWC_J.X.X.X, ASWC_K.Y.Y.Y

The ConsistencyNeeds "CN_JK" defines a RunnableEntityGroup in the role regRequiresStability with the member "ASWC_I_RUN1", "ASWC_J_RUN1" In addition the ConsistencyNeeds "CN_JK" defines a DataPrototypeGroup in the role dpgDoesNotRequireCoherency to the VariableDataPrototypes ASWC_J.X.X.X, ASWC_K.X.X.X

Assuming now a configuration:

ASWC_H_RUN1 is mapped to OsTask T100MS + RteOsSchedulePoint == UNCONDITIONAL

ASWC_I_RUN1 is mapped to OsTask T100MS

ASWC_J_RUN1 is mapped to OsTask T10MS

ASWC_K_RUN1 is mapped to OsTask T10MS

where T10MS can interrupt T100MS Without further means this configuration would violate [SWS_Rte_CONSTR_09001] with respect to "CN_J" due to the scheduling conditions. Since the consumer of "X" and "Y" can interrupt the RunnableEntitys witch are producing "X" and "Y"it is not guaranteed that the value for all accesses of ASWC_J_RUN1 and ASWC_K_RUN1 returning data of the same age during one execution of OsTask T10MS. The ConsistencyNeeds "CN_JK" is already fulfilled since the consumers "ASWC_J_RUN1" and "ASWC_K_RUN1" can't be interrupted by the producing RunnableEntity ASWC_H_RUN1

With the additional configuration RteImplicitCommunication "CN_J":

- RteVariableWriteAccessRef referencing "DWP_ASWC_H_RUN1_X_X"
- RteVariableReadAccessRef referencing "DWP_ASWC_I_RUN1_Y_Y"
- RteCoherentAccess = true

the write accesses to "X" and "Y" are in the same coherency group. Due to this "CN_J" is fulfilled since the propagation of "X" and "Y" is delayed until the termination of ASWC_I_RUN1.

4.3.1.5.2 Explicit

The behavior of explicit reception depends on the category of the runnable and on the configuration of the according ports.

An explicit API call can be either non-blocking or blocking. If the call is non-blocking (i.e. there is a VariableAccess in the dataReceivePointByValue or dataReceivePointByArgument role referencing the VariableDataPrototype for which the API is being generated, but no WaitPoint referencing a DataReceivedEvent which references the VariableDataPrototype for which the API is being generated), the API call immediately returns the next value to be read and, if the communication is queued (event reception), it removes the data from the receiver-side queue, see Section 4.3.1.10

[SWS_Rte_06012] ⌈ A non-blocking RTE API "read" call shall indicate if no data is available. ⌋*(SRS_Rte_00109)*

In contrast, a blocking call (i.e. the VariableDataPrototype, referenced by a VariableAccess in the role dataReceivePointByArgument, and for which the API is being generated, is referenced by a DataReceivedEvent which is itself referenced by a WaitPoint) will suspend execution of the caller until new data arrives (or a timeout occurs) at the according port. When new data is received, the RTE resumes the execution of the waiting runnable. ([SRS_Rte_00092])

To prevent infinite waiting, a blocking RTE API call can have a timeout applied. The RTE monitors the timeout and if it expires without data being received returns a particular error status.

[SWS_Rte_06013] ⌈ A blocking RTE API "read" call shall indicate the expiry of a timeout. ⌋*(SRS_Rte_00069)*

The "timeout expired" indication also indicates that no data was received before the timeout expired.

Blocking reception of data ("wake up of wait point" receive mode as described in Section 4.3.1.2) is only applicable for category 2 runnables whereas non-blocking reception ("explicit data read access" receive mode) can be employed by runnables of category 2 or 1B. Neither blocking nor non-blocking explicit reception is applicable for category

1A runnable because they must not invoke functions with unknown execution time (see table 4.10).

[SWS_Rte_06016] ⌈ The RTE API call for explicit sending (VariableAccessin the dataSendPoint role, [SRS_Rte_00098]) shall be non-blocking. ⌋*(SRS_Rte_00098)*

Using this API call, the runnable can explicitly send new values of the VariableDataPrototype.

Explicit writing is valid for runnables of category 1b and 2 only. Explicit writing is not allowed for a category 1A runnable since these require API calls with constant execution time (i.e. macros).

Although the API call for explicit sending is non-blocking, it is possible for a category 2 runnable to block waiting for a notification whether the (explicit) send operation was successful. This is specified by the AcknowledgementRequest attribute and occurs by a separate API call Rte_Feedback. If the feedback method is 'wake_up_of_wait_point', the runnable will block and be resumed by the RTE either when a positive or negative acknowledgment arrives or when the timeout associated with the WaitPoint expires.

4.3.1.5.3 Concepts of data access

Tables 4.11 and 4.12 summarize the characteristics of implicit versus explicit data reception and transmission.

Implicit Read	Explicit Read
Receiving of data element values is performed only once when runnable starts	Runnable decides when and how often a data element value is received
Values of data elements do not change while runnable is running.	Runnable can always decide to receive the latest value
Several API calls to the same signal always yield the same data element value	Several API calls to the same signal may yield different data element values
Runnable must terminate (all categories)	Runnable is of cat. 1B or 2

Table 4.11: Implicit vs. explicit read

Implicit Write	Explicit Write
Sending of data element values is only done once after runnable returns	Runnable can decide when sending of data element values is done via the API call
Several usages of the API call inside the runnable cause only one data element transmission	Several usages of the API call inside the runnable cause several transmissions of the data element content. (Depending on the behavior of COM, the number of API calls and the number of transmissions are not necessarily equal.)
Runnable must terminate (all categories)	Runnable is cat. 1B or 2

Table 4.12: Implicit vs. explicit write

4.3.1.6 Transmission Acknowledgement

When `TransmissionAcknowledgementRequest` is specified, the RTE will inform the sending component if the data has been sent correctly or not. Note that a positive transmission acknowledgement gives no guaranty that the data is actually sent on a physical bus nor that it has been received correctly by the corresponding receiver AUTOSAR software-component. Instead the transmission acknowledgement just confirms that the data was accepted for transmission and subsequent transmissions will not override the sent data.

[SWS_Rte_05504] ⌈ The RTE shall support the use of `TransmissionAcknowledgementRequest` independently for each data item of an AUTOSAR software-component's AUTOSAR interface. ⌋*(SRS_Rte_00122)*

[SWS_Rte_08076] ⌈ The RTE generator shall reject configurations violating [constr_3074] in System Template [8]. ⌋*(SRS_Rte_00122, SRS_Rte_00018)*

[SWS_Rte_07927] ⌈ The RTE generator shall reject configurations violating [constr_1256] in Software Component Template [2]. ⌋*(SRS_Rte_00122, SRS_Rte_00018)*

The result of the feedback can be collected using "wake up of wait point", "explicit data read access", "implicit data read access" or "activation of runnable entity".

The `TransmissionAcknowledgementRequest` allows to specify a time-out.

[SWS_Rte_03754] ⌈ If `TransmissionAcknowledgementRequest` is specified, the RTE shall ensure that time-out monitoring is performed, regardless of the receive mode of the acknowledgment. ⌋*(SRS_Rte_00069, SRS_Rte_00122)*

For inter-ECU communication, AUTOSAR COM provides the necessary functionality, for intra-ECU communication, the RTE has to implement the time-out monitoring.

If a WaitPoint is specified to collect the acknowledgment, two time-out values have to be specified, one for the TransmissionAcknowledgementRequest and one for the WaitPoint.

[SWS_Rte_03755] ⌈ The RTE generator shall reject the configuration, violating the [constr_2033]. ⌋*(SRS_Rte_00018)* The DataSendCompletedEvent associated with the VariableAccess in the dataSendPoint role for a VariableDataPrototype shall indicate that the transmission was successful or that the transmission was not successful. The status information about the success of the transmission shall be available as the return value of the generated RTE API call.

[SWS_Rte_03756] ⌈ For each transmission of a VariableDataPrototype only one acknowledgment shall be passed to the sending component by the RTE. The acknowledgment indicates either that the transmission was successful or that the transmission was not successful. ⌋*(SRS_Rte_00122)*

[SWS_Rte_03757] ⌈ The status information about the success or failure of the transmission shall be available as the return value of the RTE API call to retrieve the acknowledgment. ⌋*(SRS_Rte_00122)*

[SWS_Rte_03604] ⌈ The status information about the success or failure of the transmission shall be buffered with last-is-best semantics. When a data item is sent, the status information is reset. ⌋*(SRS_Rte_00122)*

[SWS_Rte_03604] implies that once the DataSendCompletedEvent has occurred, repeated API calls to retrieve the acknowledgment shall always return the same result until the next data item is sent.

[SWS_Rte_03758] ⌈ If the time-out value of the TransmissionAcknowledgementRequest is 0, no time-out monitoring shall be performed. ⌋*(SRS_Rte_00069, SRS_Rte_00122)*

4.3.1.7 Communication Time-out

When sender-receiver communication is performed using some physical network there is a chance this communication may fail and the receiver does not get an update of data (in time or at all). To allow the receiver of a data element to react appropriately to such a condition the SW-C template allows the specification of a time-out which the infrastructure shall monitor and indicate to the interested software components.

A data element is the actual information exchanged in case of sender-receiver communication. In the COM specification this is represented by a ComSignal. In the SW-C template a data element is represented by the instance of a VariableDataPrototype.

When present, the aliveTimeout attribute[5] enables the monitoring of the timely reception of the data element with data semantics transmitted over the network.

[5]This attribute is called “LIVELIHOOD” in the VFB specification

[SWS_Rte_08061] ⌈ If the `aliveTimeout` attribute is present the RTE shall provide the RTE COM Rx time-out callback (`Rte_COMCbkRxTOut_<sg> or Rte_COMCbkRxTOut_<sn>`). ⌋*(SRS_Rte_00147)*

The monitoring functionality is provided by the COM module, the RTE transports the event of reception time-outs to software components as "data element outdated". The software components can either subscribe to that event (activation of runnable entity) or get that situation passed by the implicit and explicit status information (using API calls).

[SWS_Rte_08062] ⌈ If COM indicates a reception time-out (via RTE COM Rx time-out callback) the RTE shall raise an event of reception time-out to software components as "data element outdated". ⌋*(SRS_Rte_00147)*

[SWS_Rte_05021] ⌈ The RTE shall have time-out monitoring disabled for communications local to the partition, independently of the presence of `aliveTimeout`. ⌋*(SRS_Rte_00147)*

In such case, The RTE does not raise events of reception time-out to software components.

Therefore the Software Component shall not rely in its functionality on the time-out notification, because for local communication the notification will never occur. Time-out notification is intended as pure error reporting.

[SWS_Rte_02710] ⌈ If `aliveTimeout` is present, and the communication is between different partitions of the same ECU, time-out monitoring is disabled. Instead, a time-out notification of the receiver will occur immediately, when the partition of the sender is stopped and the last correctly received value shall be provided to the software components. ⌋*(SRS_Rte_00147)*

Therefore the Software Component shall not rely in its functionality on the time-out notification, because for local communication the notification will never occur. Time-out notification is intended as pure error reporting.

[SWS_Rte_03759] ⌈ If the `aliveTimeout` attribute is 0, no time-out monitoring shall be performed. ⌋*(SRS_Rte_00069, SRS_Rte_00147)*

[SWS_Rte_08004] ⌈ If a signal is received, even if the signal is marked as invalid, the time-out for the same signal shall be restarted. ⌋*(SRS_Rte_00078, SRS_Rte_00147)*

Note: time-out detection may already be implemented by COM. Nevertheless this is the expected behavior towards the software components.

The time-out support (called "deadline monitoring" in COM) provided by COM has some restrictions which have to be respected when using this mechanism. Since the COM module is configured based on the System Description the restrictions mainly arise from the `data element` to I-PDU mapping. This already has to be considered when developing the System Description and the RTE Generator can only provide warnings when inconsistencies are detected. Therefore the RTE Generator needs to have access to the configuration information of COM.

In case time-out is enabled on a data element with update bit, there shall be a separate time-out monitoring for each data element with an update bit [SWS_Com_00292].

There shall be an I-PDU based time-out for data elements without an update bit [SWS_Com_00290]. For all data elements without update bits within the same I-PDU, the smallest configured time-out of the associated data elements is chosen as time-out for the I-PDU [SWS_Com_00291]. The notification from COM to RTE is performed per data element.

In case one data element coming from COM needs to be distributed to several AUTOSAR software-components the AUTOSAR Software Component Template allows to configure different aliveTimeout values at each Port. In this case the RTE has to ensure that the time-out notifications for each port will occur according to the configured aliveTimeout value in the NonqueuedReceiverComSpec.

[SWS_Rte_08103] ⌈ The RTE shall pass time-out notifications to the SW-Cs according to the configured aliveTimeout values in the NonqueuedReceiverComSpec. Depending on the configuration of the COM module following rules shall apply:

- ComSignal.ComTimeout/ComSignalGroup.ComTimeout configured to 0: No time-out notifications shall occur.
- ComSignal.ComTimeout/ComSignalGroup.ComTimeout not configured to 0 (ComSignals/ComSignalGroups with update bits): Time-out notifications shall occur according to the greatest multiple of the ComSignal.ComTimeout/ComSignalGroup.ComTimeout value of the associated ComSignal/ComSignalGroup lower than or equal to the aliveTimeout value in the NonqueuedReceiverComSpec.
- I-PDU based time-out not equal to 0 (ComSignals/ComSignalGroups without update bits): Time-out notifications shall occur according to the greatest multiple of the I-PDU based time-out value lower than or equal to the aliveTimeout value in the NonqueuedReceiverComSpec.

⌋*(SRS_Rte_00147)*

Following example illustrates how the value of the ComTimeout parameter of a ComSignal is derived and the time-out monitoring in RTE is performed in case one data element coming from COM needs to be distributed to several SW-Cs.

Consider 3 SW-Cs receiving same data element with different aliveTimeout values specified in the NonqueuedReceiverComSpec:

- SW-C1: aliveTimeout = 500ms
- SW-C2: aliveTimeout = 0ms (or not specified)
- SW-C3: aliveTimeout = 1200ms

The derived ComTimeout value of the ComSignal the data element is mapped to will be in this case 500ms. I.e. the smallest aliveTimeout value of the associated

SW-Cs (This value must be bigger or equal to the main function cycle of the COM module).

The RTE will pass time-out notifications to the 3 SW-Cs in case of a reception time-out indicated by COM as follows:

- SW-C1: directly
- SW-C2: no time-out notification
- SW-C3: after 500ms (i.e. the RTE has to count internally further 500ms before notifying SW-C3)

[SWS_Rte_08104] ⌈ The RTE shall implement a replacement strategy according to the `handleTimeoutType` attribute defined by the `NonqueuedReceiverComSpec` in each receiving SWC:

- `handleTimeoutType` configured to `none`: SWC observes the latest received value.
- `handleTimeoutType` configured to `replace`: SWC observes the `NonqueuedReceiverComSpec`'s `initValue`.

⌋*(SRS_Rte_00147)*

Note: In the case of receiving SWCs with different `handleTimeoutType` values it's expected that the related `ComSignal`/`ComSignalGroup` has attribute `ComSignal`.`ComRxDataTimeoutAction`/`ComSignalGroup`.`ComRxDataTimeoutAction` equal to `NONE` to ensure that the RTE always has access to the last received value.

4.3.1.8 Data Element Invalidation

The Software Component template allows to specify whether a `data element`, defined in an AUTOSAR Interface, can be invalidated by the sender. The communication infrastructure shall provide means to set a data element to invalid and also indicate an invalid data element to the receiving software components. This functionality is called "data element invalidation". For an overview see figure 4.45.

[SWS_Rte_05024] ⌈ If the `handleInvalid` attribute of the `InvalidationPolicy` (when present) is set to `keep`, `replace` or `externalReplacement` the invalidation support for this `dataElement` is enabled on sender side. The actual value used to represent the invalid data element shall be specified in the Data Semantics part of the data element definition defined in `invalidValue`[6]. ⌋*(SRS_Rte_00078)*

For data element invalidation, it is intended that the `Rte_Invalidate()` API is used by the software component. Nevertheless, passing the invalid value as a parameter of the `Rte_Write()` API may intentionally occur. In this case, the `handleInvalid`

[6]When `InvalidationPolicy` is set to `keep`, `replace` or `externalReplacement` but there is no `invalidValue` specified it is considered as an invalid configuration.

is only allowed to be set to the value dontInvalidate in order to avoid undesired behaviour and additional effort in the RTE implementation (see [TPS_SWCT_01646] and [constr_1390]).

[SWS_Rte_05032] ⌈On receiver side the handleInvalid attribute of the associated InvalidationPolicy specifies how to handle the reception of the invalid value. ⌋*(SRS_Rte_00078)*

Data element invalidation is only supported for data elements with a swImplPolicy different from 'queued'. Configurations violating this constraint are rejected by the RTE generator, see [SWS_Rte_06727].

[SWS_Rte_06727] ⌈The RTE generator shall reject configurations which are violating [constr_1219]. ⌋*(SRS_Rte_00078)*

The API to set a dataElement to invalid shall be provided to the RunnableEntitys on data element level.

In case an invalidated data element is received a software component can be notified using the activation of runnable entity. If an invalidated data element is read by the SW-C the invalid status shall be indicated in the status code of the API.

[SWS_Rte_08005] ⌈If the initValue of an unqueued data element equals the invalidValue and handleInvalid is set to keep and the handleNeverReceived is set to FALSE, the RTE APIs Rte_Read() and Rte_IStatus() shall return RTE_E_INVALID until first reception of data element. In this case the APIs Rte_Read() and Rte_IRead() shall provide the invalidValue. ⌋*(SRS_Rte_00078, SRS_Rte_00184)*

[SWS_Rte_08008] ⌈If the initValue of an unqueued data element equals the invalidValue and handleInvalid is set to keep and the handleNeverReceived is not defined, the RTE APIs Rte_Read() and Rte_IStatus() shall return RTE_E_INVALID until first reception of data element. In this case the APIs Rte_Read() and Rte_IRead() shall provide the invalidValue. ⌋*(SRS_Rte_00078, SRS_Rte_00184)*

[SWS_Rte_08009] ⌈If the initValue of an unqueued data element equals the invalidValue and handleInvalid is set to keep and the handleNeverReceived is set to TRUE, the RTE APIs Rte_Read() and Rte_IStatus() shall return RTE_E_NEVER_RECEIVED until first reception of data element. In this case the APIs Rte_Read() and Rte_IRead() shall provide the initValue. ⌋*(SRS_Rte_00078, SRS_Rte_00184)*

[SWS_Rte_08007] ⌈The RTE Generator shall reject configurations in which the initValue of an unqueued data element equals the invalidValue and handleInvalid is set to replace. ⌋*(SRS_Rte_00078)*

[SWS_Rte_08046] ⌈If the initValue of an unqueued data element equals the invalidValue and handleInvalid is set to dontInvalidate and the handleNeverReceived is set to FALSE, the RTE APIs Rte_Read() and Rte_IStatus() shall return RTE_E_OK until first reception of data element. In this case the APIs

Rte_Read() and Rte_IRead() shall provide the initValue. ⌋(SRS_Rte_00078, SRS_Rte_00184)

[SWS_Rte_08047] ⌈ If the initValue of an unqueued data element equals the invalidValue and handleInvalid is set to dontInvalidate and the handleNeverReceived is not defined, the RTE APIs Rte_Read() and Rte_IStatus() shall return RTE_E_OK until first reception of data element. In this case the APIs Rte_Read() and Rte_IRead() shall provide the initValue. ⌋(SRS_Rte_00078, SRS_Rte_00184)

[SWS_Rte_08048] ⌈ If the initValue of an unqueued data element equals the invalidValue and handleInvalid is set to dontInvalidate and the handleNeverReceived is set to TRUE, the RTE APIs Rte_Read() and Rte_IStatus() shall return RTE_E_NEVER_RECEIVED until first reception of data element. In this case the APIs Rte_Read() and Rte_IRead() shall provide the initValue. ⌋(SRS_Rte_00078, SRS_Rte_00184)

[SWS_Rte_08096] ⌈ If the initValue of an unqueued data element equals the invalidValue and handleInvalid is set to externalReplacement and the handleNeverReceived is set to FALSE, the RTE APIs Rte_Read() and Rte_IStatus() shall return RTE_E_OK until first reception of data element. In this case the APIs Rte_Read() and Rte_IRead() shall provide the value sourced from the ReceiverComSpec.replaceWith. ⌋(SRS_Rte_00078, SRS_Rte_00184)

[SWS_Rte_08097] ⌈ If the initValue of an unqueued data element equals the invalidValue and handleInvalid is set to externalReplacement and the handleNeverReceived is not defined, the RTE APIs Rte_Read() and Rte_IStatus() shall return RTE_E_OK until first reception of data element. In this case the APIs Rte_Read() and Rte_IRead() shall provide the value sourced from the ReceiverComSpec.replaceWith. ⌋(SRS_Rte_00078, SRS_Rte_00184)

[SWS_Rte_08098] ⌈ If the initValue of an unqueued data element equals the invalidValue and handleInvalid is set to externalReplacement and the handleNeverReceived is set to TRUE, the RTE APIs Rte_Read() and Rte_IStatus() shall return RTE_E_NEVER_RECEIVED until first reception of data element. In this case the APIs Rte_Read() and Rte_IRead() shall provide the value sourced from the ReceiverComSpec.replaceWith. ⌋(SRS_Rte_00078, SRS_Rte_00184)

4.3.1.8.1 Data Element Invalidation in case of Inter-ECU communication

Sender:

If data element invalidation is enabled and the communication is Inter-ECU:

- explicit data transmission:
  - data transformation for this communication enabled: data element invalidation will be performed by RTE.

  - no data transformation enabled: data element invalidation will be performed by COM (COM needs to be configured properly).

- implicit data transmission: the RTE is responsible for flagging the implicit buffer in the case of invalidation. An implicit valid transmission may occur before the write back at the end of the task, resetting the invalidation flag. The actual data element invalidation after runnable termination is done in COM.

Receiver:

If data element invalidation is enabled and the communication is Inter-ECU and:

- if all receiving software components requesting the same value for handleInvalid attribute of the InvalidationPolicy associated to one dataElement and no data transformation is configured for the communication:
  data element invalidation will be performed by COM (COM needs to be configured properly), see [SWS_Rte_05026], [SWS_Rte_05048].

- if the receiving software components requesting different values for handleInvalid attribute of the InvalidationPolicy associated to one dataElement or data transformation is configured for the communication:
  data element invalidation will be performed by RTE, see [SWS_Rte_07031], [SWS_Rte_07032]. This can occur in case of 1:n communication where for one connector a VariableAndParameterInterfaceMapping is applied to two SenderReceiverInterfaces with different InvalidationPolicys for the mapped VariableDataPrototype.

[SWS_Rte_05026] ⌈ If a data element has been received invalidated in case of Inter-ECU communication and the attribute handleInvalid is set to keep for all receiving software components and no data transformation is configured for the communication – the query of the value shall return the value provided by COM together with an indication of the invalid case. ⌋*(SRS_Rte_00078)*

[SWS_Rte_08405] ⌈ In case of Inter-ECU communication with the attribute handleInvalid set to keep for all receiving software components, the RTE shall raise a DataReceiveErrorEvent in case of reception of a data element invalid. ⌋*(SRS_Rte_00078)*

[SWS_Rte_05048] ⌈ If a data element has been received invalidated in case of Inter-ECU communication and the attribute handleInvalid is set to replace for all receiving software components – the query of the value shall return the initValue (ComDataInvalidAction is *REPLACE* [SWS_Com_00314]). ⌋*(SRS_Rte_00078)*

[SWS_Rte_08406] ⌈ In case of Inter-ECU communication with the attribute handleInvalid set to replace for all receiving software components, in case of reception of a data element invalid, the RTE shall raise a DataReceivedEvent as if a valid value would have been received. ⌋*(SRS_Rte_00078)*

[SWS_Rte_07031] ⌈ If a data element has been invalidated in case of Inter-ECU communication where receiving software components requesting different values for handleInvalid and the attribute handleInvalid is set to keep for a particular r-port – the query of the value shall return for the r-port the same value as if COM would have handled the invalidation (copy COM behavior). ⌋*(SRS_Rte_00078)*

[SWS_Rte_08407] ⌈ In case of Inter-ECU communication where receiving software components requesting different values for the attribute handleInvalid and this attribute is set to keep for a particular R-Port, in case of reception of a data element invalid, the RTE shall raise a DataReceiveErrorEvent. ⌋*(SRS_Rte_00078)*

[SWS_Rte_07032] ⌈ If a data element has been received invalidated in case of Inter-ECU communication where receiving software components requesting different values for handleInvalid and the attribute handleInvalid is set to replace for an particular r-port – RTE shall perform the "invalid value substitution" with the initValue for the r-port. Then the reception will be handled as if a valid value would have been received (activation of runnable entities using the DataReceivedEvent). ⌋*(SRS_Rte_00078)*

[SWS_Rte_08049] ⌈ If a data element has been received invalidated in case of Inter-ECU communication and the attribute handleInvalid is set to dontInvalidate – the query of the value shall return the value provided by COM. Then the reception will be handled as if a valid value would have been received (activation of runnable entities using the DataReceivedEvent). ⌋*(SRS_Rte_00078)*

[SWS_Rte_08099] ⌈ If a data element has been received invalidated in case of Inter-ECU communication and the attribute handleInvalid is set to externalReplacement for all receiving software components – the query of the value shall return the value sourced from the ReceiverComSpec.replaceWith (e.g. constant, NVRAM parameter). ⌋*(SRS_Rte_00078)*

[SWS_Rte_08100] ⌈ In case of Inter-ECU communication with the attribute handleInvalid set to externalReplacement for all receiving software components, in case of reception of a data element invalid, the RTE shall raise a DataReceivedEvent as if a valid value would have been received. ⌋*(SRS_Rte_00078)*

[SWS_Rte_08101] ⌈ If a data element has been received invalidated in case of Inter-ECU communication where receiving software components requesting different values for handleInvalid and the attribute handleInvalid is set to externalReplacement for an particular r-port – RTE shall perform the "invalid value substitution" with the value sourced from the ReceiverComSpec.replaceWith for the r-port. Then the reception will be handled as if a valid value would have been received (activation of runnable entities using the DataReceivedEvent). ⌋*(SRS_Rte_00078)*

4.3.1.8.2 Data Element Invalidation in case of Intra-ECU communication

Sender:

[SWS_Rte_05025] ⌈ If data element invalidation is enabled, and the communication is Intra-ECU, data element invalidation shall be implemented by the RTE. ⌋ *(SRS_Rte_00078)*

The actual invalid value is specified in the SW-C template invalidValue.

Receiver:

[SWS_Rte_05030] ⌈ If a data element has been invalidated in case of Intra-ECU communication and the attribute handleInvalid is set to keep – the query of the value shall return the same value as if COM would have handled the invalidation (copy COM behavior). Then the reception of the invalid value will be handled as an error and the activation of runnable entities can be performed using the DataReceiveErrorEvent. ⌋ *(SRS_Rte_00078)*

[SWS_Rte_05049] ⌈ If a data element has been received invalidated in case of Intra-ECU communication and the attribute handleInvalid is set to replace – RTE shall perform the "invalid value substitution" with the initValue. Then the reception will be handled as if a valid value would have been received (activation of runnable entities using the DataReceivedEvent). ⌋ *(SRS_Rte_00078)*

[SWS_Rte_08050] ⌈ If a data element has been received invalidated in case of Intra-ECU communication and the attribute handleInvalid is set to dontInvalidate – the query of the value shall return the received value. Then the reception will be handled as if a valid value would have been received (activation of runnable entities using the DataReceivedEvent). ⌋ *(SRS_Rte_00078)*

[SWS_Rte_02308] ⌈ If data invalidation is enabled for a composite VariableDataPrototype, and the communication is Intra-ECU, the RTE shall invalidate all invalidateable primitive elements of the VariableDataPrototype. ⌋ *()*

[SWS_Rte_02309] ⌈ The RTE generator shall reject configurations which are violating [constr_1302]. ⌋ *(SRS_Rte_00078)*

[SWS_Rte_08102] ⌈ If a data element has been received invalidated in case of Intra-ECU communication and the attribute handleInvalid is set to externalReplacement – RTE shall perform the "invalid value substitution" with the value sourced from the ReceiverComSpec.replaceWith (e.g. constant, NVRAM parameter). Then the reception will be handled as if a valid value would have been received (activation of runnable entities using the DataReceivedEvent). ⌋ *(SRS_Rte_00078)*

4.3.1.9 Filters

By means of the filter attribute [SRS_Rte_00121] an additional filter layer can be added on the receiver side of unqueued S/R-Communication. *Value-based* filters can be defined, i.e. only signal values fulfilling certain conditions are made available for the receiving component. The possible filter algorithms are taken from OSEK COM version 3.0.2. They are listed in the meta model (see [2]. According to the SW-C template [2], filters are only allowed for signals that are compatible to C language unsigned integer types (i.e. characters, unsigned integers and enumerations). Thus, filters cannot be applied to composite data types like for instance `ApplicationRecordDataType` or `ApplicationArrayDataType`.

[SWS_Rte_05503] ⌈ The RTE shall provide value-based filters on the receiver-side of unqueued S/R-Communication as specified in the SW-C template [2]. ⌋ *(SRS_Rte_00121)*

[SWS_Rte_05500] ⌈ For inter-ECU communication, the filter implementation is performed/done by the COM module. For intra-ECU and inter-Partition communication, the RTE shall perform the filtering itself. ⌋ *(SRS_Rte_00019, SRS_Rte_00121)*

[SWS_Rte_05501] ⌈ The RTE shall support a different filter specification for each `dataElement` in a component's AUTOSAR interface. ⌋ *(SRS_Rte_00121)*

[SWS_Rte_08077] ⌈ In case that filtering applies the input value shall be calculated from the "unfiltered buffer" before the `RunnableEntity` starts, the result of the filter calculation shall be stored in a "filtered buffer" and the `RunnableEntity` accessing a `dataElement` in a Receiver Port with a filter shall get access to the "filtered buffer" instead of the "unfiltered buffer". ⌋ *(SRS_Rte_00121)*

[SWS_Rte_08078] ⌈ For optimization reasons no "filtered buffer" should be provided, if filtering applies for a `dataElement` and the "unfiltered buffer" is not used at all. The "unfiltered buffer" should be used for filtering instead. ⌋ *(SRS_Rte_00121)*

[SWS_Rte_08079] ⌈ Separate "filtered buffers" shall be provided, if the same `dataElement` is accessed by `RunnableEntity`s via different Receiver Ports and filters with different semantics are applied in each Port. ⌋ *(SRS_Rte_00121)*

4.3.1.10 Buffering

[SWS_Rte_02515] ⌈ The buffering of sender-receiver communication shall be done on the receiver side. This does not imply that COM does no buffering on the sender side. On the receiver side, two different approaches are taken for the buffering of ‘data’ and of ‘events’, depending on the value of the software implementation policy. ⌋ *(SRS_Rte_00110)*

4.3.1.10.1 Last-is-Best-Semantics for ‘data’ Reception

[SWS_Rte_02516] ⌈ On the receiver side, the buffering of ‘data’ (`swImplPolicy` not `queued`) shall be realized by the RTE by a single data set for each data element instance. ⌋ *(SRS_Rte_00107)*

The use of a single data set provides the required semantics of a single element queue with overwrite semantics (new data replaces old). Since the RTE is required to ensure data consistency, the generated RTE should ensure that non-atomic reads and writes of the data set (e.g. for composite data types) are protected from conflicting concurrent access. RTE may use lower layers like COM to implement the buffer.

[SWS_Rte_02517] ⌈ The RTE shall initialize this data set [SWS_Rte_02516] with a startup value depending on the ports attributes and if the general initialization conditions in [SWS_Rte_07046] are fulfilled. ⌋*(SRS_Rte_00068, SRS_Rte_00108)*

[SWS_Rte_02518] ⌈ Implicit or explicit read access shall always return the last received data. ⌋*(SRS_Rte_00107)*

Requirement [SWS_Rte_02518] applies whether or not there is a `DataReceivedEvent` referencing the `VariableDataPrototype` for which the API is being generated.

[SWS_Rte_02519] ⌈ Explicit read access shall be non blocking in the sense that it does not wait for new data to arrive. The RTE shall provide mutual exclusion of read and write accesses to this data, e.g., by ExclusiveAreas. ⌋*(SRS_Rte_00109)*

[SWS_Rte_02520] ⌈ When new data is received, the RTE shall silently discard the previous value of the data, regardless of whether it was read or not. ⌋*(SRS_Rte_00107)*

4.3.1.10.2 Queueing for 'event' Reception

In case the `swImplPolicy` is set to queued the received 'events' have to be buffered in a queue.

Note: A loss of events might occur in inter-ECU communication even if the receiver queue length is sufficient. The timing of the system has to be set up in a way that it is ensured that the COM stack on the sender side is processed before the next event is written by the sender.

[SWS_Rte_02521] ⌈ The RTE shall implement a receive queue for each event-like data element (`swImplPolicy` = `queued`) of a receive port. ⌋*(SRS_Rte_00107)*

The queueLength attribute of the `QueuedReceiverComSpec` referencing the event assigns a constant length to the receive queue.

[SWS_Rte_02522] ⌈ The events shall be written to the end of the queue and read (consuming) from the front of the queue (i.e. the queue is first-in-first-out). ⌋*(SRS_Rte_00107, SRS_Rte_00110)*

[SWS_Rte_02523] ⌈ If a new event is received when the queue is already filled, the RTE shall discard the received event and set an error flag. ⌋*(SRS_Rte_00107, SRS_Rte_00110)*

[SWS_Rte_02524] ⌈ The error flag described in [SWS_Rte_02523] shall be reset during the next explicit read access on the queue. In this case, the status value

RTE_E_LOST_DATA shall be presented to the application together with the data. ⌋ *(SRS_Rte_00107, SRS_Rte_00110, SRS_Rte_00094)*

[SWS_Rte_02525] ⌈ If an empty queue is polled, the RTE shall return with a status RTE_E_NO_DATA to the polling function, (see chap. 5.5.1). ⌋*(SRS_Rte_00107, SRS_Rte_00110, SRS_Rte_00094)*

The minimum size of the queue is 1.

[SWS_Rte_02526] ⌈ The RTE generator shall reject a queueLength attribute of an `QueuedReceiverComSpec` with a queue length ≤ 0. ⌋*(SRS_Rte_00110, SRS_Rte_00018)*

4.3.1.10.3 Queueing of mode switches

The communication of `mode switch notifications` is typically event driven. Accordingly, RTE offers a similar queueing mechanism as for the 'queued' sender receiver communication, described above.

[SWS_Rte_02718] ⌈ The RTE shall implement a receive queue for the `mode switch notifications` of each `mode machine instance`. ⌋*(SRS_Rte_00107)*

The `queueLength` attribute of the `ModeSwitchSenderComSpec` referencing the `mode machine instance`, assigns a constant length to the receive queue. In contrast to the event communication, for mode switch communication, the length is associated with the sender side, the `mode manager`, because it is unique for the `mode machine instance`.

[SWS_Rte_02719] ⌈ The `mode switch notification` shall be written to the end of the queue and read (consuming) from the front of the queue (i.e. the queue is first-in-first-out). ⌋*(SRS_Rte_00107, SRS_Rte_00110)*

[SWS_Rte_02720] ⌈ If a new `mode switch notification` is received when the queue is already filled, the RTE shall discard the received notification. ⌋ *(SRS_Rte_00107, SRS_Rte_00110)* In this case, `Rte_Switch` will return an error, see [SWS_Rte_02675].

[SWS_Rte_02721] ⌈ RTE shall dequeue a `mode switch notification`, when the mode switch is completed. ⌋*(SRS_Rte_00107, SRS_Rte_00110, SRS_Rte_00094)*

The minimum size of the queue is 1.

[SWS_Rte_02723] ⌈ The RTE generator shall reject a queueLength attribute of an `ModeSwitchSenderComSpec` with a queue length ≤ 0. ⌋*(SRS_Rte_00110, SRS_Rte_00018)*

In case of a queue length of 1, RTE will reject new mode switch notifications during the mode transition.

4.3.1.11 Operation

4.3.1.11.1 Inter-ECU Mapping

This section describes the mapping from VariableDataPrototypes to COM signals or COM signal groups for sender-receiver communication. The mapping is described in the input of the RTE generator, in the DataMapping section of the System Template [8].

If a VariableDataPrototype is mapped to a COM signal or COM signal group but the communication is local, the RTE generator can use the COM signal/COM signal group for the transmission or it can use its own direct implementation of the communication for the transmission.

[SWS_Rte_04504] ⌈ If a sender/receiver communication is inter-ECU, then for each data element the DataMappings element shall contain a mapping to at least one COM signal or COM signal group, otherwise the data element shall be treated as if it is part of an unconnected port. ⌋*(SRS_Rte_00091)*

The mapping defines all aspects of the signal necessary to configure the communication service, for example, the network signal endianess and the communication bus either by the COM configuration or the configured data transformation. The RTE generator only requires the COM signal handle id since this is necessary for invoking the COM API and the configuration of the data transformation to execute it.

4.3.1.11.1.1 Primitive Data Types

[SWS_Rte_04505] ⌈ The RTE shall use the ComHandleId of the corresponding ComSignal when invoking the COM API for signal. ⌋*(SRS_Rte_00091)*

The actual COM handle id has to be gathered from the ECU configuration of the COM module. The input information ComSignalHandleId is used to establish the link between the ComSignal of the COM module's configuration and the corresponding ISignal of the System Template.

4.3.1.11.1.2 Composite Data Types

When a data prototype has a composite data type the RTE must marshall the data. This can be achieved by two means: Explicit mapping the atomic sub-elements of the composite type to their own COM signals or mapping of the whole composite type to one COM signal if data transformation is used.

The DataMappings element of the ECU configuration and configuration of the data transformer contain (or references) sufficient information to allow the data item or operation parameters to be transmitted by indicating the COM signals or signal groups to be used. It is not necessary to provide a mapping for each primitive typed leaf element within the composite type.

[SWS_Rte_03863] ⌈ The RTE generator shall support the partial mapping to SystemSignals of the leaf elements of a VariableDataPrototype (typed by a composite data type) in a PPort. ⌋*(SRS_Rte_00091)*

A partial mapping means that a subset of the composite data type's leaf elements are mapped to SystemSignals in the relevant SystemSignalGroup (e. g. a record with leaf elements A, B, C, D where only B and C are mapped to SystemSignals of the SystemSignalGroup). Elements omitted from the partial mapping are simply ignored by the RTE generator.

For RPorts it is necessary to define how the RTE generator handles the partial mapping of a composite data type, in particular, how elements omitted from the mapping are treated.

[SWS_Rte_03864] ⌈ For the included element of a partial mapping from SystemSignals to the leaf elements of a VariableDataPrototype (typed by a composite data type) in a RPort the RTE generator shall use the data provided by COM. ⌋*(SRS_Rte_00091)*

[SWS_Rte_03865] ⌈ For the omitted elements from a partial mapping from SystemSignals to the leaf elements of a VariableDataPrototype (typed by a composite data type) in a RPort the RTE generator shall use the initial value when receiving the composite data type. ⌋*(SRS_Rte_00091)*

[SWS_Rte_08793] ⌈ If a data element is a composite data type, the communication is inter-ECU and data transformation is used (except COM Based Transformer), the DataMapping element shall map the composite data type directly to one COM signal to use the data transformation. ⌋*(SRS_Rte_00091, SRS_Rte_00247)*

The above requirements for mapping atomic sub-elements for them own to distinct COM signals have two key features; firstly, COM is responsible for endianness conversion (if any is required) of primitive types and, secondly, differing structure member alignment between sender and receiver is irrelevant since the COM signals are packed into I-PDUs by the COM configuration.

The DataMappings shall contain sufficient COM signals to map each primitive element[7] of the AUTOSAR signal.

The above requirements for mapping the whole composite data type to one COM signal on the other hand leaves those features to the data transformation.

[SWS_Rte_04508] ⌈ The RTE generator shall reject configuration violating the constraint [constr_3059]. ⌋*(SRS_Rte_00091)*

[SWS_Rte_02557] ⌈

1. Each signal that is mapped to an element of the same composite data item shall be mapped to the same signal group.

[7] An AUTOSAR signal that is a primitive data type contains exactly one primitive element whereas a signal that is a composite data type one or more primitive elements.

2. If two signals are not mapped to an element of the same composite data item, they shall not be mapped to the same signal group.

3. If a signal is not mapped to an element of a composite data item, it shall not be mapped to a signal group.

⌋*(SRS_Rte_00091)*

[SWS_Rte_05081] ⌈ The RTE shall use the ComHandleId of the corresponding ComSignalGroup when invoking the COM API for signal groups. This also applies for the array based signal group access with the Com_SendSignalGroupArray() and Com_ReceiveSignalGroupArray(). ⌋*(SRS_Rte_00091)*

[SWS_Rte_05173] ⌈ The RTE shall use the ComHandleId of the corresponding ComGroupSignal when invoking the COM API for group signals. ⌋*(SRS_Rte_00091)*

The actual COM handle id has to be gathered from the ECU configuration of the COM module. The input information ComHandleId is used to establish the link between the ComSignalGroup of the COM module's configuration and the corresponding ISignalGroup of the System Template.

The input information ComHandleId of group signals is used to establish the link between the ComGroupSignal of the COM module's configuration and the corresponding ISignal of the System Template.

4.3.1.11.2 Atomicity

[SWS_Rte_04527] ⌈ The RTE is required to treat AUTOSAR signals transmitted using sender-receiver communication atomically [SRS_Rte_00073]. To achieve this

- either the "signal group" mechanisms provided by COM shall be utilized. See [SWS_Rte_02557] for the mapping.
- or the "Data Transformation" approach (see section 4.10) shall be utilized.

⌋*(SRS_Rte_00019, SRS_Rte_00073, SRS_Rte_00091)*

The RTE decomposes the composite data type into single signals as described above and passes them to the COM module by using the COM API call Com_SendSignal. As this set of single signals has to be treated as atomic, it is placed in a "signal group". A signal group has to be placed always in a single I-PDU. Thus, atomicity is established. When all signals have been updated, the RTE initiates transmission of the signal group by using the COM API call Com_SendSignalGroup.

As would be expected, the receiver side is the exact reverse of the transmission side: the RTE must first call Com_ReceiveSignalGroup precisely once for the signal group and then call Com_ReceiveSignal to extract the value of each signal within the signal group.

A signal group has the additional property that COM guarantees to inform the receiver by invoking a call-back about its arrival only after all signals belonging to the signal group have been unpacked into a buffer.

The Data Transformation approach is described in section 4.10.

4.3.1.11.3 Fan-out

Fan-out can be divided into two scenarios; *PDU fanout* where the same I-PDU is sent to multiple destinations and *signal fan-out* where the same signal, i.e. data element is sent in different I-PDUs to multiple receivers.

For Inter-ECU communication, the RTE does not perform PDU fan-out. Instead, the RTE invokes `Com_SendSignal` once for a primitive data element or for transformed data and expects the fan-out to multiple PDU destinations to occur lower down in the AUTOSAR communication stack. However, it is necessary for the RTE to support *signal fan-out* since this cannot be performed by any lower level layer of the AUTOSAR communication stack.

The data mapping in the System Template[8] is based on the `SystemSignal` and `SystemSignalGroup`. The COM module however uses the `ISignal` and `ISignalGroup` counterparts (`ComSignal`, `ComSignalGroup`, `ComGroupSignal`) to define the COM API. The RTE Generator needs to identify whether there are several `ISignal` or `ISignalGroup` elements defined for the `SystemSignal` or `SystemSignalGroup` and implement the fan-out accordingly. Then the corresponding elements in the COM ecu configuration (`ComSignal`, `ComSignalGroup`, `ComGroupSignal`) are required to establish the interaction between Rte and COM.

With the usage of “Data Transformation” a mixture of different serialization technologies for *signal fan-out* in the RTE can be used. This is determined by the `ISignal` or `ISignalGroup` association to `DataTransformation`.

[SWS_Rte_06023] ⌈ For inter-ECU transmission of a primitive data type, the RTE shall perform for each `ISignal` to which the primitive data element is mapped

- the transformation if the `ISignal` references a `TransformationTechnology`
- the invocation of `Com_SendSignal`

⌋*(SRS_Rte_00019, SRS_Rte_00028, SRS_Rte_00247)*

For the invocation the `ComHandleId` from the `ComSignal` of COM’s ecu configuration shall be used (see [SWS_Rte_04505]).

If the data element is typed by a composite data type several scenarios shall to be considered for each of the signal fan-out based on the `ISignal` or `ISignalGroup` association to `DataTransformation`:

- no “Data Transformation”: RTE invokes `Com_SendSignal` for each primitive element (`ISignal`) in the composite data type and each COM signal to which that primitive element is mapped, and Com_SendSignalGroup for each ISignalGroup that does not require a "Data Transformation" to which the data element is mapped.

- "Data Transformation" without COM Based Transformer: RTE performs the transformation and then invokes Com_SendSignal for each ISignal that has the dataTransformation association to the DataTransformation defined.
- "Data Transformation" with COM Based Transformer: RTE performs the transformation and then invokes Com_SendSignalGroupArray for each ISignalGroup that has the comBasedSignalGroupTransformation association to the DataTransformation defined.

Note:
It is also possible to configure the system to use multiple of these scenarios at the same time. Then the RTE executes all configured scenarios.

[SWS_Rte_04526] Inter-ECU transmission of composite data without Data Transformation ⌈ For inter-ECU transmission of composite data type where

- a SenderReceiverToSignalGroupMapping to the VariableDataPrototype is defined
- and the respective ISignalGroup has no comBasedSignalGroupTransformation defined

the RTE shall invoke Com_SendSignal for each ISignal to which an element in the composite data type is mapped and Com_SendSignalGroup for each ISignalGroup to which the composite data element is mapped. ⌋*(SRS_Rte_00019, SRS_Rte_00028)*

For the invocation the ComHandleId from the ComGroupSignal and ComSignalGroup of COM's ecu configuration shall be used (see [SWS_Rte_05173] and [SWS_Rte_05081]).

[SWS_Rte_08586] Inter-ECU transmission of composite data with COM Based Data Transformation ⌈ For inter-ECU transmission of composite data type where

- a SenderReceiverToSignalGroupMapping to the VariableDataPrototype is defined
- and the respective ISignalGroup has a comBasedSignalGroupTransformation reference defined

the RTE shall perform the transformation and then invoke Com_SendSignalGroupArray for the ISignalGroup to which the composite data type is mapped. ⌋*(SRS_Rte_00019, SRS_Rte_00028, SRS_Rte_00251)*

For the invocation the ComHandleId from the ComSignalGroup of COM's ecu configuration shall be used (see [SWS_Rte_05081]).

[SWS_Rte_08587] Inter-ECU transmission of composite data with Data Transformation ⌈ For inter-ECU transmission of composite data type where

- a SenderReceiverToSignalMapping to the VariableDataPrototype is defined
- and the respective ISignal has a dataTransformation reference defined

the RTE shall perform the transformation and then invoke Com_SendSignal for the ISignal to which composite data type is mapped. ⌋*(SRS_Rte_00019, SRS_Rte_00028, SRS_Rte_00247)*

Note:
A SystemSignal can be added to a SystemSignalGroup in the role transformingSystemSignal to support the configuration where a complex data element is transferred via Sender/Receiver communication both using transformation and traditional mapping of RTE and COM.

For the invocation the ComHandleId from the ComSignal of COM's ecu configuration shall be used (see [SWS_Rte_04505]).

For intra-ECU transmission of data elements, the situation is slightly different; the RTE handles the communication (the lower layers of the AUTOSAR communication stack are not used) and therefore must ensure that the data elements are routed to all receivers. For inter-partition communication, RTE may use the IOC.

[SWS_Rte_06024] ⌈ For inter-partition transmission of data elements, the RTE shall perform the fan-out to each receiver. ⌋*(SRS_Rte_00019, SRS_Rte_00028)*

4.3.1.11.4 Fan-in

When receiving data from multiple senders in inter-ECU communication, either the RTE on the receiver side has to collect data received in different COM signals or COM signal groups and pass it to one receiver or the RTE on the sender side has to provide shared access to a COM signal or COM signal group to multiple senders. The receiver RTE, which has to handle multiple COM signals or signal groups, is notified about incoming data for each COM signal or COM signal group separately but has to ensure data consistency when passing the data to the receiver. The sender RTE, which has to handle multiple senders sharing COM signals or signal groups, has to ensure consistent access to the COM API, since COM API calls for the same signal are not reentrant.

[SWS_Rte_03760] ⌈ If multiple senders use different COM signals or signal groups for inter-ECU transmission of a data element prototype with swImplPolicy different from queued to a receiver, the RTE on the receiver side has to pass the last received value to the receiver component while ensuring data consistency. ⌋*(SRS_Rte_00019, SRS_Rte_00131)*

[SWS_Rte_03761] ⌈ If multiple senders use different COM signals or signal groups for inter-ECU transmission of a data element prototype with `event semantic`s to a receiver, the RTE on the receiver side has to queue all incoming values while ensuring data consistency. ⌋*(SRS_Rte_00019, SRS_Rte_00131)*

[SWS_Rte_03762] ⌈ If multiple senders share COM signals or signal groups for inter-ECU transmission of a data element prototype to a receiver, the RTE on the sender side shall ensure that the COM API for those signals is not invoked concurrently. ⌋*(SRS_Rte_00019, SRS_Rte_00131)*

4.3.1.11.5 Sequence diagrams of Sender Receiver communication

Figure 4.39 shows a sequence diagram of how Sender Receiver communication for data transmission and non-blocking reception may be implemented by RTE. The sequence diagram also shows the `Rte_Read` API behavior if an `initValue` is specified.

In case the COM Based Transformer [23] is used the sequence in figure 4.39 is the same, but `Com_SendSignalGroupArray()` is used instead of `Com_SendSignal()` and `Com_ReceiveSignalGroupArray()` is used instead of `Com_ReceiveSignal()`.

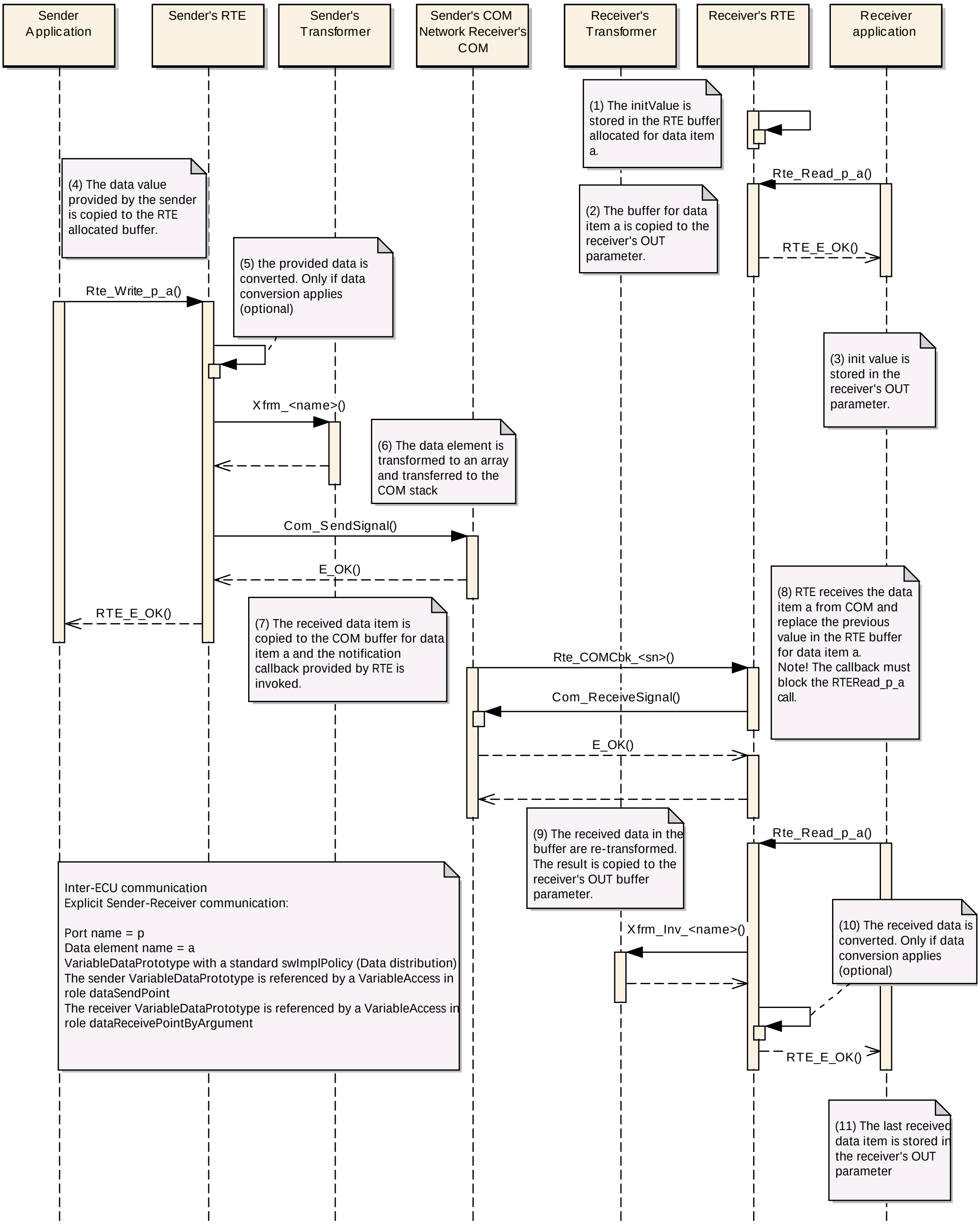


Figure 4.39: Sender Receiver communication with data semantics and dataReceivePointByArgument as reception mechanism

Figure 4.40 shows a sequence diagram of how Sender Receiver communication for event transmission and non-blocking reception may be implemented by RTE. The sequence diagram shows the Rte_Receive API behavior when the queue is empty.

In case the COM Based Transformer [23] is used the sequence in figure 4.40 is the same, but Com_SendSignalGroupArray() is used instead of Com_SendSignal() and Com_ReceiveSignalGroupArray() is used instead of Com_ReceiveSignal().

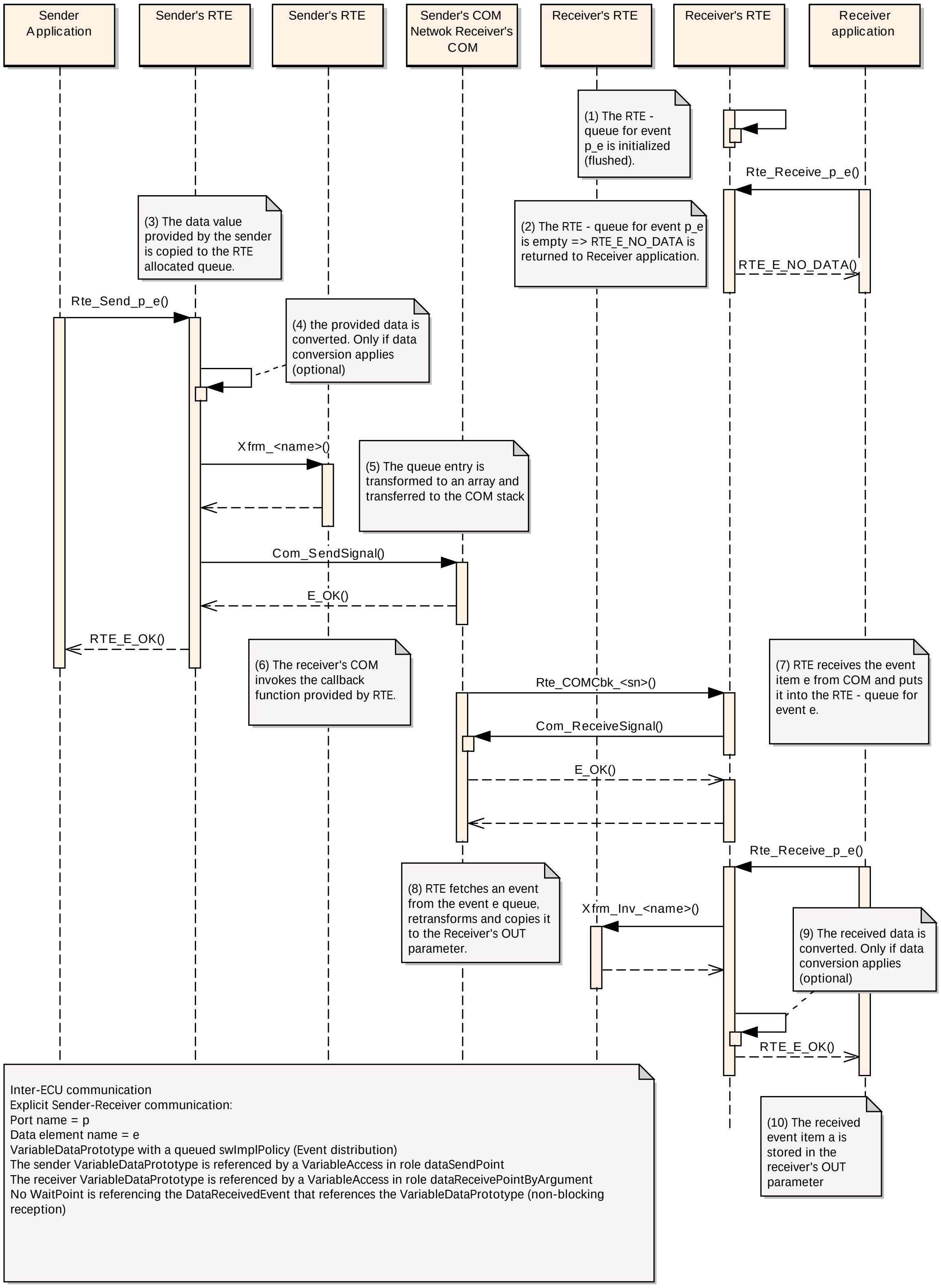


Figure 4.40: Sender Receiver communication with `event semantics` and dataReceivePointByArgument as reception mechanism

Figure 4.41 shows a sequence diagram of how Sender Receiver communication for event transmission and activation of runnable entity on the receiver side may be implemented by RTE.

In case the COM Based Transformer [23] is used the sequence in figure 4.41 is the same, but `Com_SendSignalGroupArray()` is used instead of `Com_SendSignal()` and `Com_ReceiveSignalGroupArray()` is used instead of `Com_ReceiveSignal()`.

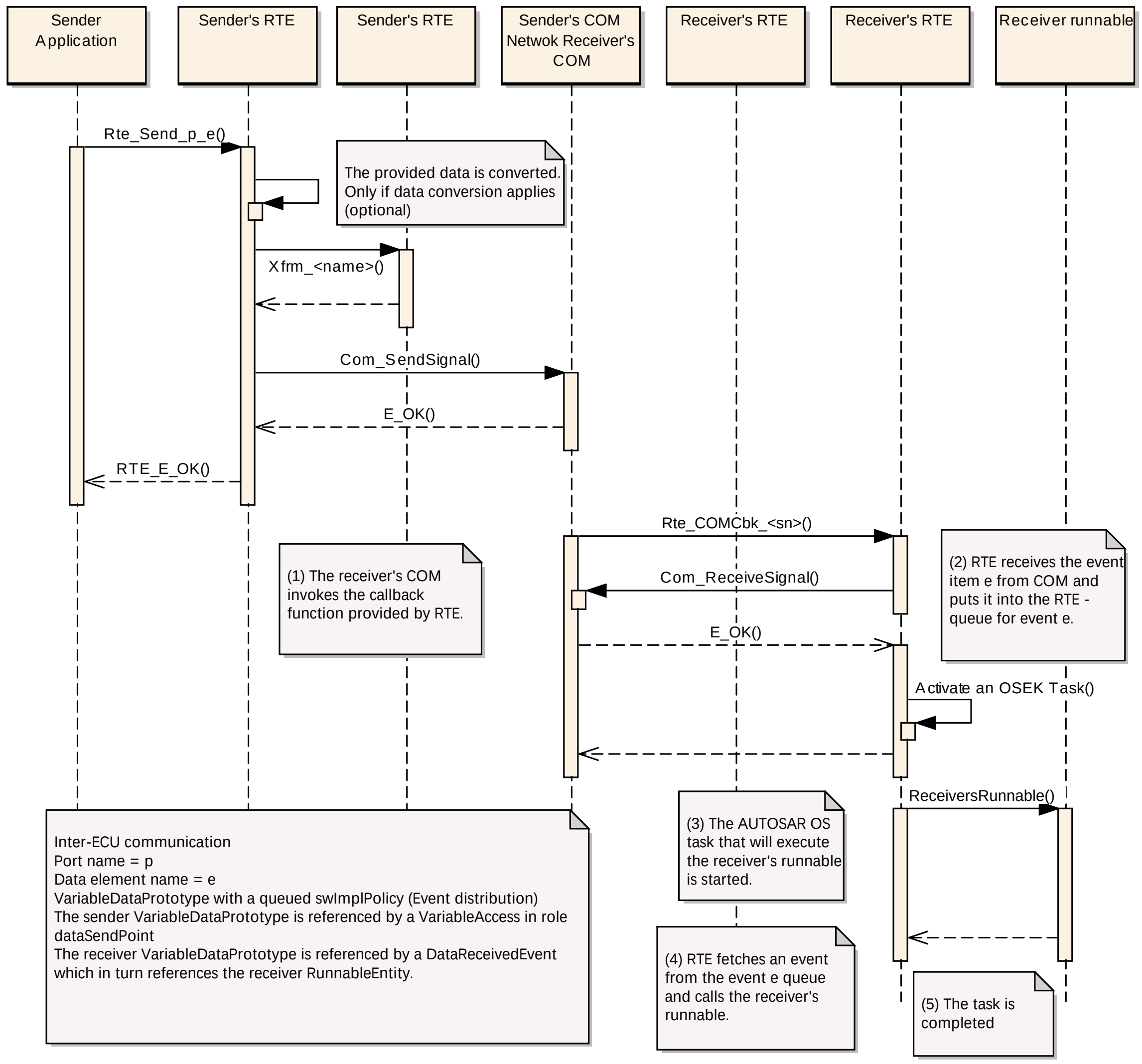


Figure 4.41: Sender Receiver communication with `event semantic`s and activation of runnable entity as reception mechanism

Figure 4.42 shows a sequence diagram of how Sender Receiver communication for data transmission and non-blocking reception may be implemented by RTE when using LdCom.

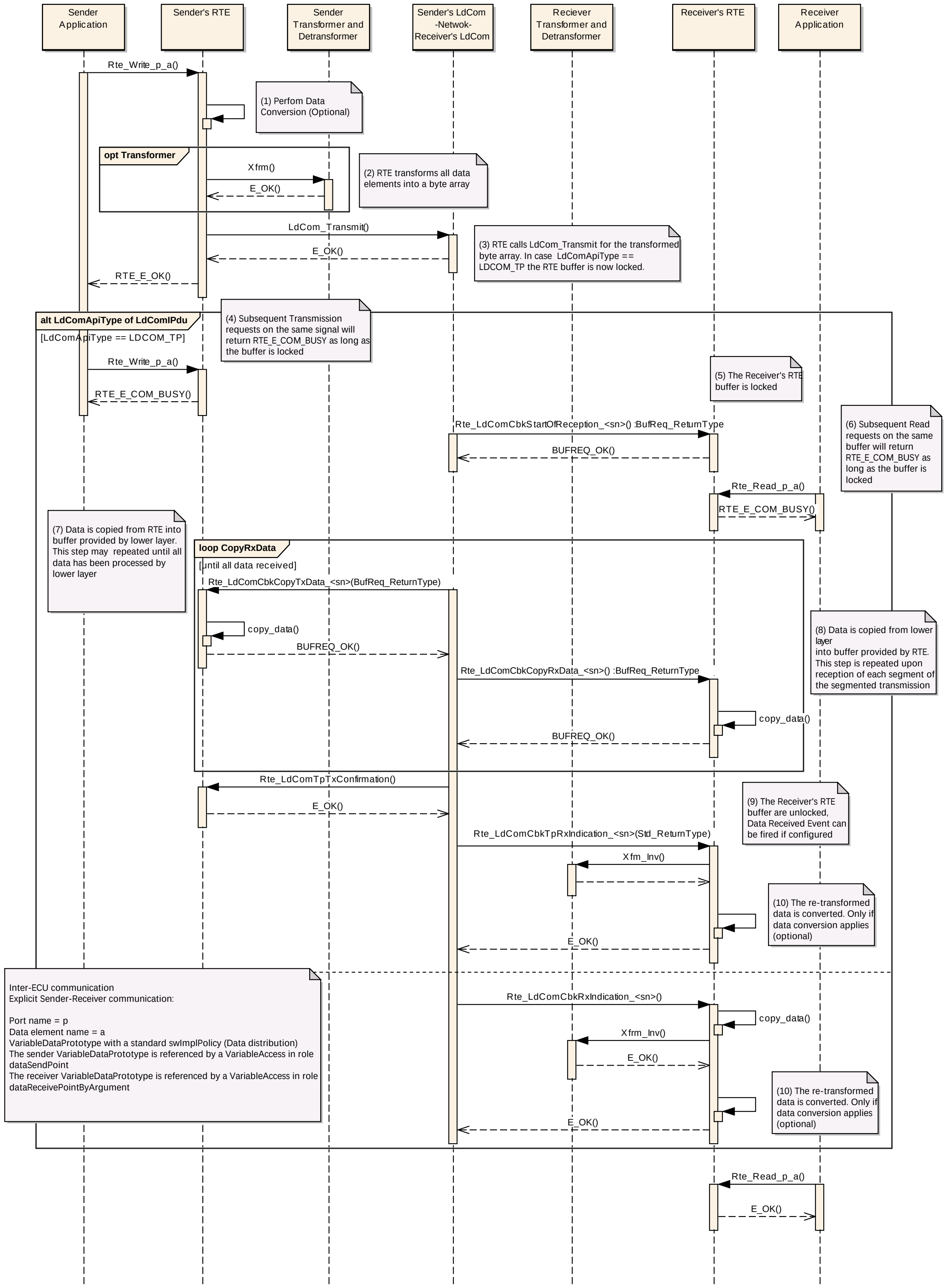


Figure 4.42: Sender Receiver communication with `data semantics` over LdCom

4.3.1.12 “Never received status” for Data Element

The Software Component template allows specifying whether an unqueued data, defined in an AUTOSAR Interface, has been updated since system start (or partition restart) or not. This additional optional status establishes the possibility to check whether a data element has been changed since system start (or partition restart).

[SWS_Rte_07381] ⌈ On receiver side the handleNeverReceived attribute of the NonqueuedReceiverComSpec shall specify the handling of the never received status. ⌋ *(SRS_Rte_00184)*

[SWS_Rte_07382] ⌈ The initial status of the data elements with the attribute handleNeverReceived set to TRUE shall be RTE_E_NEVER_RECEIVED. ⌋ *(SRS_Rte_00184)*

[SWS_Rte_07383] ⌈ The initial status of the data elements with the attribute handleNeverReceived set to TRUE shall be cleared when the first reception occurs. ⌋ *(SRS_Rte_00184)*

[SWS_Rte_07645] ⌈ The status of data elements shall be reset on the receiver side to RTE_E_NEVER_RECEIVED when the receiver's partition is restarted. ⌋ *(SRS_Rte_00184, SRS_Rte_00224)*

[SWS_Rte_04529] ⌈ The configuration of the attribute handleNeverReceived to TRUE shall have no effect for data elements received from an NvBlockSwComponentType, since these data elements are automatically received during initialization of the RTE. ⌋ *(SRS_Rte_00184)*

4.3.1.13 “Update flag” for Data Element

The Software Component template allows specifying whether an unqueued data, defined in an AUTOSAR Interface, has been updated since last read or not. This additional optional status establishes the possibility to check, whether a data element has been updated since last read.

On receiver side the “enableUpdate” attribute of the NonqueuedReceiverComSpec has to activate the handling of the update flag.

[SWS_Rte_07385] ⌈ The RTE shall provide one update flag per dataElement in a RPortPrototype where the “enableUpdate” attribute of the NonqueuedReceiverComSpec is set to true and where at least one RunnableEntity defines a VariableAccess in the dataReceivePointByArgument or dataReceivePointByValue role. ⌋ *(SRS_Rte_00179)*

[SWS_Rte_07386] ⌈ The update flag of the data elements configured with the “enableUpdate” attribute shall be set by receiving new data from COM or from a local software-component (including NvBlockSwComponentType). ⌋ *(SRS_Rte_00179)*

[SWS_Rte_01413] ⌈ In case a data element with configured "enableUpdate" attribute is received as "invalid" the status of it's update flag shall be determined according to the handling of the DataReceivedEvent/DataReceiveErrorEvent:

- The update flag shall be set, if the DataReceivedEvent is triggered.
- The update flag shall keep the previous state, if the DataReceiveErrorEvent is triggered.

⌋*(SRS_Rte_00179)*

[SWS_Rte_07387] ⌈ The update flag of a particular dataElement in a RPortPrototype shall be cleared after each read by Rte_Read or Rte_DRead of the data element. ⌋*(SRS_Rte_00179)*

Please note that the "UpdateFlag" for dataElements is only available for explicit communication, see [SWS_Rte_07391].

[SWS_Rte_07689] ⌈ The update flag shall be cleared when the RTE is started or when the partition of the software-component is restarted. ⌋*(SRS_Rte_00179)*

The update flag can be queried by the Rte_IsUpdated API, see 5.6.35.

[SWS_Rte_04528] ⌈ Update flags of data elements which are received by an NvBlockSwComponentType shall be set to TRUE after the data was copied from the NvM module to the NVRAM Block by the execution of the according Rte_SetMirror callback or after an SW-C has written new data to the NVRAM Block by the execution of the Rte_Write API. ⌋*(SRS_Rte_00179)*

4.3.1.14 Dynamic data type

Dynamic data are data whose length varies at runtime.

This includes:

- arrays with variable number of elements
- structures including arrays with variable number of elements

This excludes:

- structures including variable number of elements

The length information which specifies how many elements of the dynamic size array are valid has to be provided by the SWC to the RTE. This is achieved by the usage of a dynamic size array with explicit size indicator (see [2] chapter "ApplicationArrayDataType").

The dynamic size array is represented in the implementation by a structure which contains the size indicator and the dynamic size array with the payload. The size indicator shall be hold consistent to the number of valid elements in the dynamic size array by the SWC.

In case of inter-ECU communication, dynamic data are mapped to dynamic signals and received/transmitted through the TP by the COM stack.

With the current release of SWS_COM, COM limits the dynamic signals to the `ComSignalType` UINT_8DYN (see the requirement COM569).

The usage of dynamic size arrays together with data transformation with inter-ECU communication circumvents these restrictions and allows dynamic size arrays also for other data types because the output of data transformation is of the type uint8[n] which is supported by COM.

In order to respect the VFB concept the capability of inter-ECU and intra-ECU communication should be equal. So it has been decided to extend these limitation from COM also to the intra-ECU communication.

As a consequence dynamic data types different from uint8[n] are only supported by the RTE (independent whether the communication is intra or inter-ECU) if data transformation for inter-ECU communication is used. See [SWS_Rte_07810].

4.3.1.15 Inter-ECU communication through TP

Inter-ECU communication can be configured in COM to be supported by the TP. This is especially necessary if:

- Size of the signal exceed the size of the L-PDU (large signals)
- Size of the signal group exceed the size of the L-PDU

In the current release of SWS_COM, COM APIs to access signal values might return the error code COM_BUSY for the signals mapped to N-PDU. This error code indicates that the access to the signal value has failed (internally rejected by COM) and should be retried later. This situation might only be possible when the transmission or the reception of the corresponding PDU is in progress in COM at the time the access to the signal value is requested.

This is a problem for the handling of data with `data semantic` (last is best behavior) because:

- "COM_BUSY like" errors are not compatible with real time systems that should have predictable response time.
- Forwarding this error code to the application implies that every applications should handle it (implement a retry) even if it will never comes (data is not be mapped to N-PDU).
- Error code can not be forwarded to the application in case of direct read or implicit write.

This is not a problem for the handling of data with `event semantic` (queued behavior) because:

- The COM_BUSY error should not be possible during the execution of COM call-backs (Rx indication and Tx confirmation) that can be used by the RTE to handle the queue.
- Data are queued internally by RTE and accessible at any time by the application.

Note: First point is especially true if the ComIPduSignalProcessing is configured as IMMEDIATE. But if the ComIPduSignalProcessing is configured as DEFFERED and 2 events are closely received, it is possible that at the time the RTE tries to access the corresponding COM signal the second event reception has already started. In this case the RTE will received COM_BUSY and the event will be lost but it is more a problem of configuration than a limitation from COM.

As a consequence it has been decided to limit the data mapped to N-PDU to the event semantic (queued behavior). See [SWS_Rte_07811].

Note: As the data mapping is not mandatory for the RTE contract phase, it is possible that a configuration is accepted at contract phase but rejected at generation phase when the data mapping is known.

Dynamic data are always mapped to N-PDU in case of inter-ECU communication. So in order to avoid such situation (late rejection at generation phase) and in order to respect the VFB concept (intra and inter-ECU should be equal) it has been decided to extend this limitation to every dynamic data whatever the communication is intra or inter-ECU. See [SWS_Rte_07812].

4.3.1.16 Inter-ECU communication of arrays of bytes

4.3.1.16.1 COM

Generally the communication of arrays in the case of inter-ECU communication must make use of the signal group mechanisms to send an array to COM. This implies sending each array element to a buffer in COM (with with Com_SendSignal() API, and in the end send the signal group (with Com_SendSignalGroup() API).

An exception to this general rule is for arrays of bytes. In this case, the RTE shall use the native COM interface to send directly the data.

[SWS_Rte_07408] ⌈ The RTE shall use the Com_SendSignal or Com_ReceiveSignal APIs to send or receive fixed-length arrays of bytes if the according VariableDataPrototype is mapped to a SystemSignal. ⌋ *(SRS_Rte_00231)*

[SWS_Rte_07817] ⌈ The RTE shall use the Com_SendDynSignal or Com_ReceiveDynSignal APIs to send or receive variable-length arrays of bytes if the according VariableDataPrototype is mapped to a SystemSignal. ⌋ *(SRS_Rte_00231)*

If the VariableDataPrototype of a fixed-length or variable-length array is mapped to a SystemSignalGroup then requirement [SWS_Rte_04526] applies.

4.3.1.16.2 Efficient COM for large data

The rules for the decision whether to use Efficient COM for large data (LdCom) are described in System Template [8], chapter 6.2.

[SWS_Rte_01376] ⌈ The RTE shall use LdCom for sending/receiving arrays of bytes if the corresponding ComSignal is mapped to LdComIPdu. ⌋*(SRS_Rte_00246)*

Transmission

[SWS_Rte_01377] ⌈ The RTE shall use the LdCom_Transmit API if LdComApiType is set to LDCOM_IF in LdComIPdu. ⌋*(SRS_Rte_00231)*

In case If-API is used upon LdCom_Transmit, the transmit request is passed immediately to the lower layer. After return of the API the data does not need to be locked.

[SWS_Rte_01378] ⌈ The RTE shall use the LdCom_Transmit API if LdComApiType is set to LDCOM_TP in LdComIPdu. ⌋*(SRS_Rte_00231)*

In case TP-API is used, after LdCom_Transmit one or more invocations of Rte_LdComCbkCopyTxData_<sn> by LdCom will occur asynchronously. The Transmission is finalized by Rte_LdComCbkTpTxConfirmation_<sn>.

During this time the data has to be available for being passed to LdCom.

[SWS_Rte_01379] ⌈ The RTE shall lock the signal buffer after it initiated a Tp Transmission (LdCom_Transmit returned E_OK). ⌋*(SRS_Rte_00246)*

During the signal buffer is locked no further transmit requests are permitted on that item. For data semantics this means that Rte_Write/Rte_Call will return RTE_E_COM_BUSY.

[SWS_Rte_01380] ⌈ The RTE shall unlock the signal buffer after Rte_LdComCbkTpTxConfirmation_<sn> has been invoked (independent of the result). ⌋*(SRS_Rte_00246)*

[SWS_Rte_01381] ⌈ The RTE shall copy the indicated number of bytes to the provided destination in each invocation of Rte_LdComCbkCopyTxData_<sn>. ⌋*(SRS_Rte_00246)*

[SWS_Rte_01382] ⌈ For signals for which the Rte_LdComCbkTriggerTransmit_<sn> API is configured the data of the corresponding signal has to be available during the whole runtime of the RTE. ⌋*(SRS_Rte_00246)*

Rationale: A call to TriggerTransmit may happen at any time, since it originates from lower BSW layers.

Hint: Main use case for [SWS_Rte_01382] is the transmission of the current value for newly (late) subscribed receivers in ServiceDiscovery.

[SWS_Rte_01383] ⌈ If Rte_LdComCbkTriggerTransmit_<sn> is invoked, data shall be copied to the provided destination. ⌋*(SRS_Rte_00246)*

Reception

[SWS_Rte_01384] ⌈ If Rte_LdComCbkRxIndication_<sn> is invoked RTE shall provide the following steps:

- copy the passed signal data to the buffer
- fire a DataReceivedEvent (if configured)
- return

⌋*(SRS_Rte_00246)*

[SWS_Rte_01385] ⌈ If Rte_LdComCbkStartOfReception_<sn> is invoked RTE shall lock the corresponding reception buffer. ⌋*(SRS_Rte_00246)*

[SWS_Rte_01386] ⌈ If Rte_LdComCbkCopyRxData_<sn> is invoked RTE shall copy the passed signal data (or the indicated portion) to the previously locked reception buffer. ⌋*(SRS_Rte_00246)*

[SWS_Rte_01387] ⌈ If Rte_LdComCbkTpRxIndication_<sn> is invoked RTE shall unlock the previously locked reception buffer. ⌋*(SRS_Rte_00246)*

[SWS_Rte_01388] ⌈ When Rte_LdComCbkTpRxIndication_<sn> is invoked and the passed result code is RTE_E_OK, it shall fire the DataReceivedEvent. Otherwise the signal value shall be set to the invalidValue for data elements with a swImplPolicy different from queued. ⌋*(SRS_Rte_00246)*

4.3.1.17 Handling of acknowledgment events

As a general rule, the acknowledgment events DataWriteCompletedEvent and DataSendCompletedEvent shall be raised immediately after the sending to all receivers has been performed and in case of Inter-ECU communication all acknowledgments from COM or LdCom have been received. As part of the implementation detailed rules for the following communication scenarios have to be considered:

Intra-Partition communication

[SWS_Rte_08017] ⌈ For intra-partition communication with implicit dataWriteAccess the DataWriteCompletedEvent shall be fired if and only if a task terminates and the write-back copy actions to the global RTE-buffer are completed. The transmission status shall be RTE_E_TRANSMIT_ACK and can be collected with Rte_IFeedback API. ⌋*(SRS_Rte_00122)*

[SWS_Rte_08043] ⌈ For intra-partition communication with incoherent implicit dataWriteAccess no write-back copy actions to a global RTE-buffer will be performed, if the involved runnables are all running in one preemption area. In this case the DataWriteCompletedEvent shall be fired after the termination of the last sending runnable in the sending task. The transmission status shall be RTE_E_TRANSMIT_ACK and can be collected with Rte_IFeedback API. ⌋ *(SRS_Rte_00122)*

[SWS_Rte_08018] ⌈ For intra-partition communication with explicit dataSendPoint the DataSendCompletedEvent shall be fired if and only if the sending to all receivers has been performed. The transmission status shall be RTE_E_TRANSMIT_ACK and can be collected with Rte_Feedback API. ⌋ *(SRS_Rte_00122)*

Inter-Partition communication

[SWS_Rte_08020] ⌈ For inter-partition communication with implicit dataWriteAccess the DataWriteCompletedEvent shall be fired if and only if a task terminates and the write-back copy actions to the global RTE-buffer are completed. In addition the execution of the data write operations at the data receiver partitions must have taken place. Thereby the return status of the IOC for the different write operations can be neglected. The transmission status shall be RTE_E_TRANSMIT_ACK and can be collected with Rte_IFeedback API. ⌋ *(SRS_Rte_00122)*

[SWS_Rte_08044] ⌈ For inter-partition communication with incoherent implicit dataWriteAccess no write-back copy actions to a global RTE-buffer will be performed, if the involved runnables are all running in one preemption area. In this case the DataWriteCompletedEvent shall be fired after the termination of the last sending runnable in the sending task and after the execution of the data write operations at the data receiver partitions have taken place. Thereby the return status of the IOC for the different write operations can be neglected. The transmission status shall be RTE_E_TRANSMIT_ACK and can be collected with Rte_IFeedback API. ⌋ *(SRS_Rte_00122)*

[SWS_Rte_08021] ⌈ For inter-partition communication with explicit dataSendPoint the DataSendCompletedEvent shall be fired if and only if the sending to all receivers has been performed and the execution of the data write operations at the data receiver partitions have taken place. Thereby the return status of the IOC for the different write operations can be neglected. The transmission status shall be RTE_E_TRANSMIT_ACK and can be collected with Rte_Feedback API. ⌋ *(SRS_Rte_00122)*

Inter-ECU communication

[SWS_Rte_08022] ⌈ For inter-ECU communication with implicit dataWriteAccess the DataWriteCompletedEvent shall be fired if and only if a task terminates and the write-back copy actions to the global RTE-buffer are completed. In addition the transmission acknowledgment from COM or LdCom must be complete, i.e. the acknowledgment has been received and in case of RTE-fanout all acknowledgments have been received. The transmission status shall be RTE_E_TRANSMIT_ACK and can be collected with Rte_IFeedback API. ⌋*(SRS_Rte_00122)*

[SWS_Rte_08045] ⌈ For inter-ECU communication with incoherent implicit dataWriteAccess no write-back copy actions to a global RTE-buffer will be performed, if the involved runnables are all running in one preemption area. In this case the DataWriteCompletedEvent shall be fired after the termination of the last sending runnable in the sending task and after the transmission acknowledgment from COM or LdCom is complete, i.e. the acknowledgment has been received and in case of RTE-fanout all acknowledgments have been received. The transmission status shall be RTE_E_TRANSMIT_ACK and can be collected with Rte_IFeedback API. ⌋*(SRS_Rte_00122)*

[SWS_Rte_08023] ⌈ For inter-ECU communication with explicit dataSendPoint the DataSendCompletedEvent shall be fired if and only if the sending to all receivers has been performed and the transmission acknowledgment from COM or LdCom is complete, i.e. the acknowledgment has been received and in case of RTE-fanout all acknowledgments have been received. The transmission status shall be RTE_E_TRANSMIT_ACK and can be collected with Rte_Feedback API. ⌋*(SRS_Rte_00122)*

4.3.2 Client-Server

4.3.2.1 Introduction

Client-server communication involves two entities, the client which is the requirer (or user) of a service and the server that provides the service.

The client initiates the communication, requesting that the server performs a service, transferring a parameter set if necessary. The server, in the form of the RTE, waits for incoming communication requests from a client, performs the requested service and dispatches a response to the client's request. So, the direction of initiation is used to categorize whether a AUTOSAR software-component is a client or a server.

A single component can be both a client and a server depending on the software realization.

The invocation of a server is performed by the RTE itself when a request is made by a client. The invocation occurs synchronously with respect to the RTE (typically via a function call) however the client's invocation can be either synchronous (wait for server to complete) or asynchronous with respect to the server.

Note: servers which have an asynchronous operation (i.e. they accept a request and another provide a feedback by invoking a server of the caller) should be avoided as the RTE does not know the link between these 2 client-server communications. In particular, the server should have no OUT (or INOUT) parameters because the RTE cannot perform the copy of the result in the caller's environment when the request was processed.

[SWS_Rte_06019] ⌈ The only mechanism through which a `server` can be invoked is through a client-server invocation request from a `client`. ⌋ *(SRS_Rte_00029)*

The above requirement means that *direct invocation* of the function implementing the `server` outside the scope of the RTE is not permitted.

A `server` has a dedicated provide port and a `client` has a dedicated require port. To be able to connect a `client` and a `server`, both ports must be categorized by the same interface.

The `client` can be blocked (synchronous communication) respectively non-blocked (asynchronous communication) after the service request is initiated until the response of the `server` is received.

A `server` implemented by a `RunnableEntity` with attribute `canBeInvokedConcurrently` set to FALSE is not allowed to be invoked concurrently and since a `server` can have one or more `client`s the `server` may have to handle concurrent service calls (n:1 communication) the RTE must ensure that concurrent calls do not interfere.

[SWS_Rte_04515] ⌈ The RTE shall ensure that call serialization[8] of the operation is enforced when the `server` runnable attribute `canBeInvokedConcurrently` is FALSE. ⌋ *(SRS_Rte_00019, SRS_Rte_00033)*

Note that the same `server` may be called using both synchronous and asynchronous communication.

Note also that even when `canBeInvokedConcurrently` is FALSE, an `AtomicSwComponentType` might be instantiated multiple times. In this case, the implementation of the `RunnableEntity` can still be invoked concurrently from several tasks. However, there will be no concurrent invocations of the implementation with the same instance handle.

[SWS_Rte_04516] ⌈ The RTE's implementation of the client-server communication shall ensure that a service result is dispatched to the correct `client` if more than one `client` uses a service. ⌋ *(SRS_Rte_00019, SRS_Rte_00080)*

The result of the client/server operation can be collected using "wake up of wait point", "explicit data read access" or "activation of runnable entity".

[SWS_Rte_07409] ⌈ If all the following conditions are satisfied:

- the `server` runnable's property `canBeInvokedConcurrently` is set to TRUE

[8] Call Serialization ensures at most one thread of control is executing an instance of a runnable entity at any one time. An AUTOSAR software-component can have multiple instances (and therefore a runnable entity can also have multiple instances). Each instance represents a different `server` and can be executed in parallel by different threads of control thus serialization only applies to an individual instance of a runnable entity – multiple runnable entities within the same component instance may also be executed in parallel.

- the client and server execute in the same partition, i.e. intra-partition Client-Server communication
- the ServerCallPoint is Synchronous
- the OperationInvokedEvent is not mapped to an OsTask

the RTE Generator shall implement the Client-Server communication as a direct function call. ⌋*()*

Note: In case the conditions in [SWS_Rte_04522] are fulfilled the RTE Generator may implement a client-server call with a direct function call, even when the server runnable's property canBeInvokedConcurrently is set to FALSE.

Since the communication occurs conceptually via the RTE (it is initiated via an RTE API call) the optimization does not violate the requirement that servers are only invoked via client-server requests (see Sect. 5.6.13, [SWS_Rte_06019]).

[SWS_Rte_07662] ⌈ The RTE Generator shall reject configurations where an ClientServerOperation has an ArgumentDataPrototype whose ImplementationDataType is of category DATA_REFERENCE and whose direction is INOUT. ⌋*(SRS_Rte_00018, SRS_Rte_00019)*

[SWS_Rte_08731] ⌈ If the return value of the serialization call is not equal to E_OK the RTE shall not call Com_SendSignal ⌋*(SRS_Rte_00091)*

4.3.2.2 Multiplicity

Client-server interfaces contain two dimensions of multiplicity; multiple clients invoking a single server and multiple operations within a client-server interface.

4.3.2.2.1 Multiple Clients Single Server

Client-server communication involves an AUTOSAR software-component invoking a defined "server" operation in another AUTOSAR software-component which may or may not return a reply.

[SWS_Rte_04519] ⌈ The RTE shall support multiple clients invoking the same server operation ('n:1' communication where n $\geq$ 1). ⌋*(SRS_Rte_00029)*

4.3.2.2.2 Multiple operations

A client-server interface contains one or more operations. A port of a AUTOSAR software-component that *requires* an AUTOSAR client-server interface to the component can independently invoke any of the operations defined in the interface [SRS_Rte_00089].

[SWS_Rte_04517] ⌈ The RTE API shall support independent access to operations in a client-server interface. ⌋*(SRS_Rte_00029)*

Example 4.9

Consider a client-server interface that has two operations, `op1` and `op2` and that an AUTOSAR software-component definition requires a port typed by the interface. As a result, the RTE generator will create two API calls; one to invoke `op1` and another to invoke `op2`. The calls can invoke the server operations either synchronously or asynchronously depending on the configuration.

Recall that each data element in a sender-receiver interface is transmitted independently (see Section 4.3.1.3) and that the coherent transmission of multiple data items is achieved through combining multiple items into a single composite data type. The transmission of the parameters of an operation in a client-server interface is similar to a record since the RTE guarantees that all parameters are handled atomically [SRS_Rte_00073].

[SWS_Rte_04518] ⌈ The RTE shall treat the parameters and the results of a client-server operation atomically. ⌋*(SRS_Rte_00033)*

However, unlike a sender-receiver interface, there is no facility to combine multiple client-server operations so that they are invoked as a group.

4.3.2.2.3 Single Client Multiple Server

The RTE is *not* required to support multiple server operations invoked by a single client component request ('1:n' communication where n $>$ 1) (see [constr_1037] in [2]).

4.3.2.2.4 Call Serialization

Each client can invoke the server simultaneously and therefore the RTE is required to support multiple requests of servers. If the server requires call serialization, the RTE has to ensure it.

[SWS_Rte_04520] ⌈ The RTE shall support simultaneous invocation requests of a server operation. ⌋*(SRS_Rte_00019, SRS_Rte_00080)*

[SWS_Rte_04522] ⌈ The RTE shall ensure that the `RunnableEntity` implementing a server operation has completed the processing of a request before it begins processing the next request, if serialization is required by the server operation, i.e `canBeInvokedConcurrently` attribute of the server is set to FALSE and client `RunnableEntity`s to `OsTask` mapping (`RteEventToTaskMapping`) may lead to concurrent invocations of the server. ⌋*(SRS_Rte_00019, SRS_Rte_00033)*

When this requirement is met the operation is said to be “call serialized”. A call serialized server only accepts and processes requests atomically and thus avoids the potential for conflicting concurrent access.

Client requests that cannot be serviced immediately due to a server operation being “busy” are required to be queued pending processing. The presence and depth of the queue is configurable.

If the `RunnableEntity` implementing the server operation is reentrant , i.e. `canBeInvokedConcurrently` attribute set to TRUE, no serialization is necessary. This allows to implement invocations of reentrant server operations as direct function calls without involving the RTE.

But even when the `canBeInvokedConcurrently` attribute is set to FALSE the RTE Generator still can utilize a direct function call, if the mapping of the client `RunnableEntity`s to `OsTask`s will not imply a concurrent execution of the server.

[SWS_Rte_08001] ⌈ If multiple operations are mapped to the same `RunnableEntity`, and [SWS_Rte_04522] requires a call serialization, then the operation invoked events shall be mapped to same task and they shall have the same position in task. Otherwise the RTE Generator shall reject configuration. ⌋*(SRS_Rte_00019, SRS_Rte_00033)*

[SWS_Rte_08002] ⌈ If multiple operations are mapped to the same `RunnableEntity`, and [SWS_Rte_04522] requires a call serialization, then a single queue is implemented for invocations coming from any of the operations. ⌋*(SRS_Rte_00019, SRS_Rte_00033)*

4.3.2.3 Communication Time-out

The `ServerCallPoint` allows to specify a timeout so that the client can be notified that the server is not responding and can react accordingly. If the client invokes the server synchronously, the RTE API call to invoke the server reports the timeout. If the client invokes the server asynchronously, the timeout notification is passed to the client by the RTE as a return value of the API call that collects the result of the server operation.

[SWS_Rte_03763] ⌈ The RTE shall ensure that timeout monitoring is performed for client-server communication, regardless of the receive mode for the result. ⌋*(SRS_Rte_00069, SRS_Rte_00029)*

If the server is invoked asynchronously and a `WaitPoint` is specified to collect the result, two timeout values have to be specified, one for the `ServerCallPoint` and one for the `WaitPoint`.

[SWS_Rte_03764] ⌈ The RTE generator shall reject the configuration if different timeout values are specified for the `AsynchronousServerCallPoint` and for the `WaitPoint` associated with the `AsynchronousServerCallReturnsEvent` for this `AsynchronousServerCallPoint`. ⌋*(SRS_Rte_00018)*

In asynchronous client-server communication the AsynchronousServerCallReturnsEvent associated with the AsynchronousServerCallPoint for an ClientServerOperation indicates that the server communication is finished or that a timeout occurred. The status information about the success of the server operation is available as the return value of the RTE API call generated to collect the result.

[SWS_Rte_03765] ⌈ For each asynchronous invocation of an operation prototype only one AsynchronousServerCallReturnsEvent shall be passed to the client component by the RTE. The AsynchronousServerCallReturnsEvent shall indicate either that the transmission was successful or that the transmission was not successful. ⌋*(SRS_Rte_00079)*

[SWS_Rte_03766] ⌈ The status information about the success or failure of the asynchronous server invocation shall be available as the return value of the RTE API call to retrieve the result. ⌋*(SRS_Rte_00079)*

After a timeout was detected, no result shall be passed to the client.

[SWS_Rte_03770] ⌈ In case Rte_Call API returns RTE_E_LIMIT, RTE_E_TRANSFORMER_LIMIT, RTE_E_COM_STOPPED, RTE_E_TIMEOUT, RTE_E_UNCONNECTED, RTE_E_IN_EXCLUSIVE_AREA or RTE_E_SEG_FAULT, the RTE shall not modify the OUT and INOUT parameters. ⌋*(SRS_Rte_00069, SRS_Rte_00029)*

[SWS_Rte_08310] ⌈ In case Rte_Result API returns RTE_E_NO_DATA,RTE_E_HARD_TRANSFORMER_ERROR, RTE_E_COM_STOPPED, RTE_E_TIMEOUT, RTE_E_UNCONNECTED, RTE_E_IN_EXCLUSIVE_AREA or RTE_E_SEG_FAULT, the RTE shall not modify the OUT and INOUT parameters. ⌋*(SRS_Rte_00069, SRS_Rte_00029)*

Since an asynchronous client can have only one outstanding server invocation at a time, the RTE has to monitor when the server can be safely invoked again.

If a server is invoked asynchronously, no timeout occurs and an AsynchronousServerCallResultPoint exists then the RTE returns RTE_E_LIMIT for subsequent invocations of the Rte_Call API until the server's result has been successfully passed to the client (See [SWS_Rte_01105]).

If a server is invoked asynchronously, no timeout occurs and no AsynchronousServerCallResultPoint exists then the RTE returns RTE_E_LIMIT for subsequent invocations of the Rte_Call API until the server has finished to process the last request of the client (See [SWS_Rte_01105]).

In intra-partition client-server communication, the RTE can determine whether the server runnable is still running or not.

[SWS_Rte_03771] ⌈ If a timeout was detected in asynchronous intra-partition client-server communication, the RTE shall ensure that the server is not invoked again by the same client until the server runnable has terminated. ⌋*(SRS_Rte_00069, SRS_Rte_00079)*

In inter-ECU communication, the client RTE has no knowledge about the actual status of the server. The response of the server could have been lost because of a communication error or because the server itself did not respond. Since the client-side RTE cannot distinguish the two cases, the client must be able to invoke the server again after a timeout expired. As partitions in one ECU are decoupled in a similar way like separate ECUs, and can be restarted separately, client server communication should behave similar for inter-ECU and intra-partition communication.

[SWS_Rte_03772] ⌈ If a timeout was detected in asynchronous `inter-ECU` or `inter-partition` client-server communication, the RTE shall ensure that the server can be invoked again by the same client after the timeout notification was passed to the client. ⌋*(SRS_Rte_00069, SRS_Rte_00079)*

Note that this might lead to client and server running out of sync, i.e. the response of the server belongs to the previous, timed-out invocation of the client. The application has to handle the synchronization of client and server after a timeout occurred.

[SWS_Rte_03767] ⌈ If the timeout value of the `ServerCallPoint` is 0, no timeout monitoring shall be performed. ⌋*(SRS_Rte_00069, SRS_Rte_00029)*

[SWS_Rte_03768] ⌈ If the canBeInvokedConcurrently attribute of the server runnable is set to TRUE, no timeout monitoring shall be performed if the RTE API call to invoke the server is implemented as a direct function call. ⌋*(SRS_Rte_00069, SRS_Rte_00029)*

[SWS_Rte_02709] ⌈ In case of inter partition communication, if the partition of the server is stopped or restarting at the invocation time of the server call or during the operation of the server call, the RTE shall immediately provide a timeout indication to the client. ⌋*()*

Note: In case of inter-ECU or interpartition client-server communication it is recommended to always specify a timeout>0 when synchronous server calls are used. Otherwise in case of a full server queue the client would wait for the server response infinitely.

4.3.2.4 Port-Defined argument values

Port-defined argument values exist in order to support interaction between Application Software Components and Basic Software Modules.

Several Basic Software Modules use an integer identifier to represent an object that should be acted upon. For instance, the NVRAM Manager uses an integer identifier to represent the `NVRAM block` to access. This identifier is not known to the client, as the client must be location independent, and the `NVRAM block` to access for a given application software component cannot be identified until components have been mapped onto ECUs.

There is therefore a mismatch between the information available to the client and that required by the server. Port-defined argument values bridge that gap.

The required port-defined arguments (the fact that they are required, their data type and their values) are specified within the input to the RTE generator.

[SWS_Rte_01360] ⌈ When invoking the runnable entity specified for an OperationInvokedEvent, the RTE shall include the port-defined argument values between the instance handle (if it is included) and the operation-specific parameters, in the order they are given in the Software Component Template Specification [2]. ⌋*(SRS_Rte_00152)*

Requirement [SWS_Rte_01360] means that a client will make a request for an operation on a require (Client-Server) port including only its instance handle (if required) and the explicit operation parameters, yet the server will be passed the implicit parameters as it requires.

Note that the values of implicit parameters are constant for a particular server runnable entity; it is therefore expected that using port-defined argument values imposes no RAM overhead (beyond any extra stack required to store the additional parameters).

4.3.2.5 Buffering

Client-Server-Communication is a two-way-communication. A request is sent from the client to the server and a response is sent back.

The buffering mechanisms described here also apply to the serialization of server calls in the Basic Software Scheduler.

Unless a server call is implemented as direct function call, the RTE has to store or buffer the communication on the corresponding receiving sides, requests on server side and responses on client side, respectively:

- **[SWS_Rte_02527]** ⌈ Unless a server call is implemented as a direct function call, the RTE shall buffer a request on the server side in a first-in-first-out queue as described in chapter 4.3.1.10.2 for queued data elements.

  Note: The data that shall be buffered is implementation specific but at least RTE should store the IN parameters, the IN/OUT parameters and a client identifer. ⌋ *(SRS_Rte_00019, SRS_Rte_00033, SRS_Rte_00110)*

- **[SWS_Rte_02528]** ⌈ Unless a server call is implemented as a direct function call, RTE shall keep the response on the client side in a queue with queue length 1.

  Note: The data that shall be buffered is implementation specific but at least RTE should store the IN/OUT parameters, the OUT parameters and the error code. ⌋ *(SRS_Rte_00019, SRS_Rte_00033)*

[SWS_Rte_02314] ⌈ The RTE shall determine the queue length for the server side according to the following priority rules (highest priority first):

1. value of the ECU-C parameter `RteServerQueueLength`
2. value of the `queueLength` attribute of the `ServerComSpec`

⌋()

[SWS_Rte_02315] ⌈ The Basic Software Scheduler shall take the queue length for the server from the ECU-C parameter `RteBswServerQueueLength`. ⌋()

[SWS_Rte_02529] ⌈ The RTE generator shall reject a `queueLength` attribute of a `ServerComSpec` with a queue length ≤ 0. ⌋*(SRS_Rte_00033, SRS_Rte_00110, SRS_Rte_00018)*

[SWS_Rte_02530] ⌈The RTE shall use the queue of requests to call serialise access to a server. ⌋*(SRS_Rte_00033, SRS_Rte_00110)*

A buffer overflow of the server is not reported to the client. The client will receive a time out.

[SWS_Rte_07008] ⌈ If a server call is implemented by direct function call the RTE shall not create any copy for parameters passed by reference. ⌋*(SRS_Rte_00033, SRS_Rte_00110)*

Therefore, it is the responsibility of the application to provide consistency mechanisms for referenced parameters if necessary.

4.3.2.6 Inter-ECU and Inter-Partition Response to Request Mapping

RTE is responsible to map a response to the corresponding request. With this mapping, RTE can activate or resume the corresponding runnable and provide the response to the correct client. The following situations can be distinguished:

- Mapping of a response to the correct request within one ECU. In general, this is solved already by the call stack. The details are implementation specific and will not be discussed in this document.
- Mapping of a response coming from a different partition or a different ECU.

The problem of request to response mapping in inter-ECU and inter-Partition communication can be split into:

- Mapping of a response to the correct client. This is discussed in 4.3.2.6.1.
- Mapping of a response to the correct request within of one client. This is discussed in 4.3.2.6.2.

The general approach for the inter-ECU and inter-Partition request response mapping is to use transaction handles.

[SWS_Rte_02649] ⌈ In case of inter-ECU client-server communication, the transaction handle shall contain two parts of unsigned integer type:

- Client Identifier
- Client Sequence Counter

⌋*(SRS_Rte_00027, SRS_Rte_00082)*

[SWS_Rte_04544] ⌈ In case of inter-ECU client-server communication, where MetaData is configured for the PDU associated to the SystemSignal, the transaction handle shall additionally contain the item MetaData of unsigned integer type. The size shall be equal to the size of the configured MetaData. ⌋*(SRS_Rte_00027, SRS_Rte_00082)*

[SWS_Rte_08711] ⌈ The Client Identifier of the transaction handle used for an inter-ECU client server communication shall be of type uint16. ⌋*(SRS_Rte_00082, SRS_Rte_00091)*

[SWS_Rte_07413] ⌈ The Client Identifier of the transaction handle used for an inter-ECU client server communication may be defined at the ClientIdDefinition belonging to the Ecu Extract and referring the operation instance. If defined the RTE generator shall take the clientId from the ClientIdDefinition. If not defined the RTE generator shall set the clientId to 0. ⌋*(SRS_Rte_00082, SRS_Rte_00091)*

[SWS_Rte_08712] ⌈ The Client Sequence Counter part of the transaction handle used for an inter-ECU client server communication shall be of type uint16. ⌋*(SRS_Rte_00082, SRS_Rte_00091)*

[SWS_Rte_07346] ⌈ In case of inter-Partition client-server communication, the RTE shall not communicate any response to the client if the client is part of a partition that was restarted since the request was sent. ⌋*(SRS_Rte_00027, SRS_Rte_00082)*

[SWS_Rte_07346] could be implemented with a transaction handle that contains a sequence counter.

[SWS_Rte_02651] ⌈ In case of inter-ECU client-server communication, the transaction handle shall be used for the identification of client server transactions communicated via COM or LdCom. ⌋*(SRS_Rte_00027, SRS_Rte_00082)*

[SWS_Rte_02653] ⌈ The RTE on the server side shall return the transaction handle of the request without modification together with the response. The MetaData item (if contained) in the transaction handle shall be passed to LdCom when invoking the transmission of the response ⌋*(SRS_Rte_00027, SRS_Rte_00082)*

Note: MetaData handling is currently only supported for LdCom. When using Com still one dedicated SystemSignal has to be used for each calling ECU.

Since there is always at most one open request per client (see [SWS_Rte_02658]), the transaction handle can be kept within the RTE and does not have to be exposed to the *AUTOSAR SW-C*.

4.3.2.6.1 Client Identifier

In case of a server on one ECU with clients on other ECUs, the inter-ECU client-server communication has to use different unique SystemSignals for each client-ECU to allow the identification of the client-ECU associated with each client call. However

Client ECUs for which *MetaData* is configured for distinction of calling ECUs can be configured sharing one unique `SystemSignal` if LdCom is used. The interface to the COM module currently doesn't support it.

With this mechanism, the server-side RTE must handle the fan-in. This is done in the same way as for sender-receiver communication.

However it is allowed to have several clients in one client-ECU communicating using inter-ECU client-server communication with a server on a different ECU, if the client identifier is used to distinguish the different clients (see [constr_3264]).

[SWS_Rte_03769] ⌈ If multiple clients have access to one server, the RTE on the server side has to queue all incoming server invocations while ensuring data consistency. ⌋*(SRS_Rte_00019, SRS_Rte_00029, SRS_Rte_00080)*

4.3.2.6.2 SequenceCounter

The purpose of sequence counters is to map a response to the correct request of a known client.

[SWS_Rte_02658] ⌈ In case of inter-ECU and inter-Partition communication, RTE shall allow only one request per client and server operation at any time. ⌋*(SRS_Rte_00079)*

[SWS_Rte_02658] does not apply to intra-partition communication because there can be several `execution-instances`.

[SWS_Rte_02658] implies under normal operation that a response can be mapped to the previous request. But, when a request or response is lost or delayed, this order can get out of phase. To allow a recovery from lost or delayed signals, a sequence counter is used. The sequence counter can also be used to detect stale responses after a restart of the client side RTE and SW-C.

[SWS_Rte_02654] ⌈ RTE shall support a sequence counter for the inter ECU client server connection where configured in the input information. ⌋*(SRS_Rte_00027, SRS_Rte_00082)*

[SWS_Rte_02655] ⌈ RTE shall initialize all sequence counters with zero during `Rte_Start`. ⌋*(SRS_Rte_00082)*

[SWS_Rte_02656] ⌈ RTE shall increase each sequence counter in a cyclic manner after a client server operation has finished successfully or with a timeout. ⌋*(SRS_Rte_00082)*

[SWS_Rte_02657] ⌈ RTE shall ignore incoming responses that do not match the sequence counter. ⌋*(SRS_Rte_00027, SRS_Rte_00082)*

4.3.2.7 Parameter Serialization

Within an input configuration an unconnected or an `intra-ECU` client will have zero `ClientServerToSignalMapping` and an `inter-ECU` client will have exactly one such mapping (since a client can connect to exactly one server). Fan-out is not supported for clients and therefore multiple mappings are not permitted.

[SWS_Rte_08700] ⌈ The RTE generator shall reject an input configuration where a `ClientServerOperation` owned by an `RPortPrototype` is referenced by more than one `ClientServerToSignalMapping` with identical values of the attribute `ClientServerOperation` . ⌋*(SRS_Rte_00018, SRS_Rte_00027, SRS_Rte_00082, SRS_Rte_00091)*

[SWS_Rte_08703] ⌈ For an inter-ECU client-server communication, the RTE of the client ECU shall communicate the request to a remote server using the `callSignal` of the `ClientServerToSignalMapping` which references the operation instance. ⌋ *(SRS_Rte_00027, SRS_Rte_00082, SRS_Rte_00091)*

[SWS_Rte_08705] ⌈ For an inter-ECU client-server communication, the RTE of the client ECU shall receive the results of a remote server using the `returnSignal` of the `ClientServerToSignalMapping` which references the operation instance. ⌋ *(SRS_Rte_00027, SRS_Rte_00082, SRS_Rte_00091, SRS_Rte_00123)*

[SWS_Rte_08707] ⌈ For an inter-ECU client-server communication, the RTE of the server ECU shall receive a request of a remote client using the `callSignal` of the `ClientServerToSignalMapping` which references the operation instance. ⌋ *(SRS_Rte_00027, SRS_Rte_00082, SRS_Rte_00091)*

[SWS_Rte_08709] ⌈ For inter-ECU client-server communication, the RTE of the server ECU shall communicate the results to a remote client using the `returnSignal` of the `ClientServerToSignalMapping` which references the operation instance. ⌋ *(SRS_Rte_00027, SRS_Rte_00082, SRS_Rte_00091, SRS_Rte_00123)*

4.3.2.8 Operation

4.3.2.8.1 Inter-ECU Mapping

The client server protocol defines how a client call and the server response are mapped onto the communication infrastructure of AUTOSAR in case of inter-ECU communication. This allows RTE implementations from different vendors to interpret the client server communication in the same way.

The AUTOSAR System Template [8] does specify a protocol for the client server communication in AUTOSAR.

4.3.2.8.2 Atomicity

The requirements for atomicity from Section 4.3.1.11.2 also apply for the composite data types described in Section 4.3.2.8.1.

4.3.2.8.3 Fault detection and reporting

Client Server communication may encounter interruption like:

- Buffer overflow at transformation
- Buffer overflow at the server side.
- Communication interruption.
- Server might be inaccessible for some reason.

The client specifies a timeout that will expire in case the server or communication fails to complete within the specified time. The reporting method of an expired timeout depends on the communication attributes:

- If the C/S communication is synchronous the RTE returns `RTE_E_TIMEOUT` on the `Rte_Call` function (see section 5.6.13).
- If the C/S communication is asynchronous the RTE returns `RTE_E_TIMEOUT` on the `Rte_Result` function (see section 5.6.14).

In the case that RTE detects that the COM service is not available when forwarding signals to COM, the RTE returns `RTE_E_COM_STOPPED` on the `Rte_Call` (see section 5.6.13).

In the case a transmission is ongoing (e.g. `LdCom` transmission using `TP`-API with pending TxConfirmation) when forwarding signals to LdCom, the RTE returns `RTE_E_COM_BUSY` on the `Rte_Call` (see section 5.6.13).

If the client still has an outstanding server invocation when the server is invoked again, the RTE returns `RTE_E_LIMIT` on the `Rte_Call` (see chapter 5.6.13).

In the absence of structural errors, application errors will be reported if present.

4.3.2.8.4 Asynchronous Client Server communication

Figure 4.43 shows a sequence diagram of how asynchronous client server communication may be implemented by RTE.

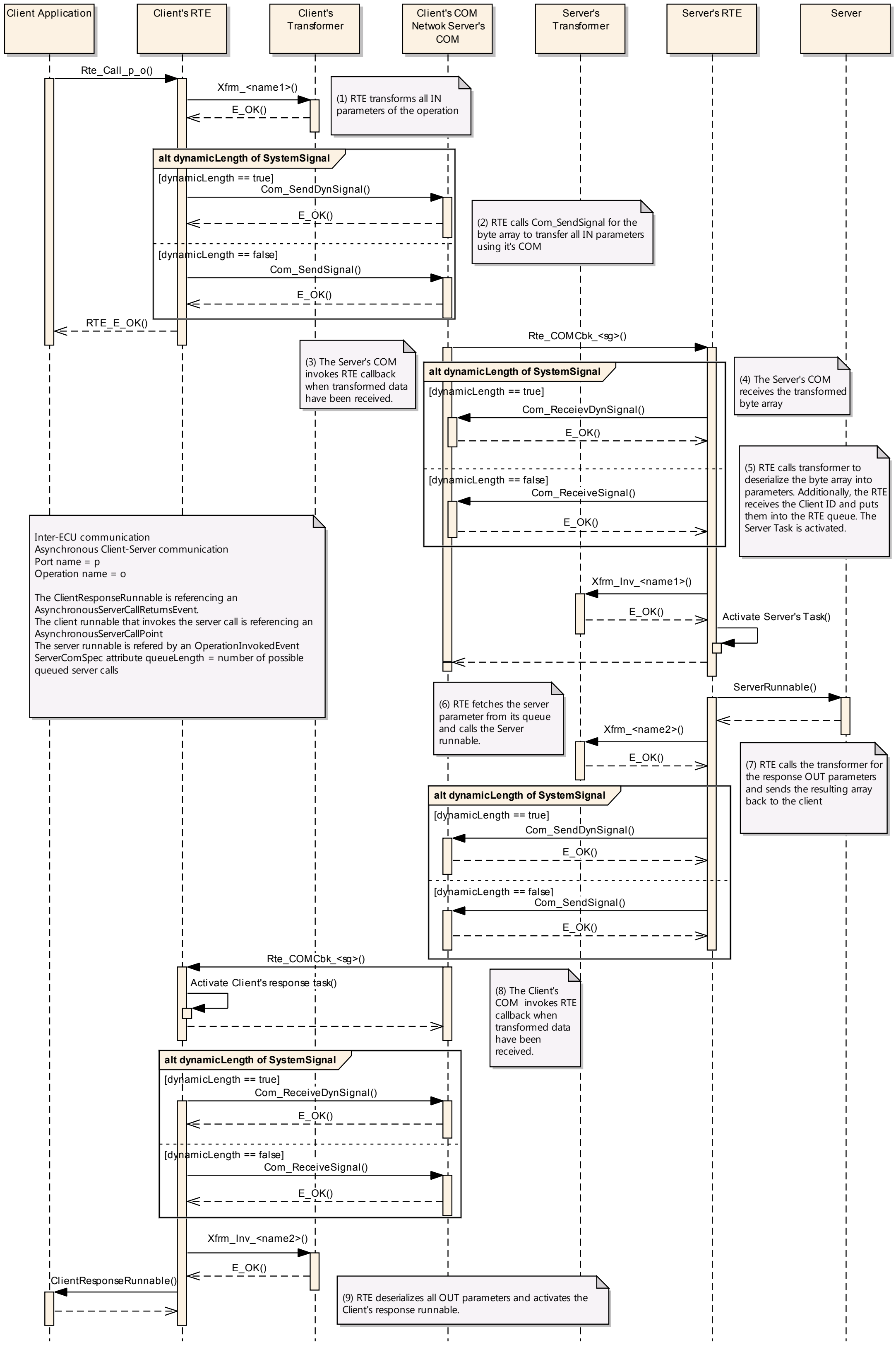


Figure 4.43: Client Server asynchronous

4.3.2.8.5 Synchronous Client Server communication

Figure 4.44 shows a sequence diagram of how synchronous client server communication may be implemented by RTE.

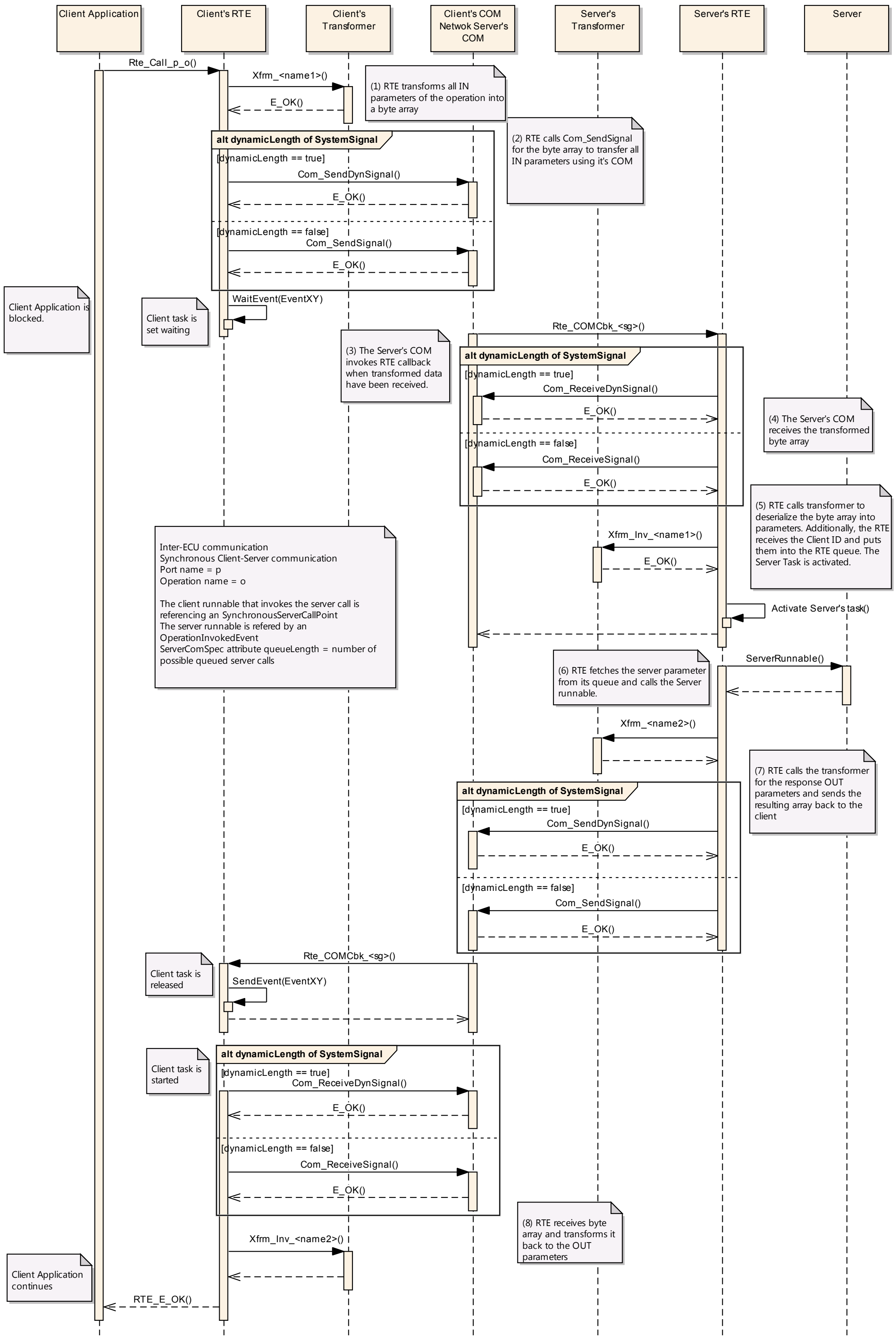


Figure 4.44: Client Server synchronous

4.3.3 SWC internal communication

4.3.3.1 Inter Runnable Variables

Sender/Receiver and Client/Server communication through AUTOSAR ports are the model for communication between AUTOSAR SW-Cs.

For communication between Runnables inside of an AUTOSAR SW-C the AUTOSAR SW-C Template [2] establishes a separate mechanism. AtomicSwComponents (except for NvBlockComponents) can reserve InterRunnableVariables which can only be accessed by the Runnables of this one AtomicSwComponent. The Runnables might be running in the same or in different task contexts. Read and write accesses are possible.

[SWS_Rte_03589] ⌈ The RTE shall support *Inter Runnable Variable*s for single and multiple instances of AUTOSAR SW-Cs. ⌋*(SRS_Rte_00142)*

[SWS_Rte_07187] ⌈ The generated RTE shall initialize a defined `implicitInterRunnableVariable` and `explicitInterRunnableVariable` according to the `ValueSpecification` of the `VariableDataPrototype` defining the `implicitInterRunnableVariable` respectively `explicitInterRunnableVariable` if the general initialization conditions in [SWS_Rte_07046] and [SWS_Rte_03852] are fulfilled. ⌋*(SRS_Rte_00142)*

InterRunnableVariables have a behavior corresponding to Sender/Receiver communication *between* AUTOSAR SW-Cs (or rather between Runnables of different AUTOSAR SW-Cs).

But why not use Sender/Receiver communication directly instead? Purpose is data encapsulation / data hiding. Access to InterRunnableVariables of an AUTOSAR SW-C from other AUTOSAR SWCs is not possible and not supported by RTE. InterRunnableVariable content stays SW-C internal and so no other SW-C can use it. Especially not misuse it without understanding how the data behaves.

Like in Sender/Receiver (S/R) communication between AUTOSAR SW-Cs two different behaviors exist:

1. *Inter Runnable Variable*s with *implicit* behavior (`implicitInterRunnableVariable`)
   This behavior corresponds with `VariableAccess`es in the `dataReadAccess` and `dataWriteAccess` roles of Sender/Receiver communication and is supported by *implicit S/R API* in this specification.

   Note:
   If a `VariableAccess` in the `writtenLocalVariable` role referring to a `VariableDataPrototype` in the `implicitInterRunnableVariable` role is specified for a certain interrunnable variable, but no RTE API for implicit write of this interrunnable variable is called during an execution of the runnable, an undefined value is written back when the runnable terminates.

For more details see section 4.2.5.6.1.
For APIs see sections 5.6.23 and 5.6.24.

Note 2:
As for the Implicit Sender/Receiver communication, the implicit concept for Inter-RunnableVariables implies that the runnable does terminate. For runnable entities of category 2, the behavior is guaranteed only if it has a finite execution time. A category 2 runnable that runs forever will not have its data updated.

2. *Inter Runnable Variable*s with *explicit* behavior (`explicitInterRunnableVariable`)
   This behavior corresponds with `VariableAccess`es in the `dataSendPoint`, `dataReceivePointByValue`, or `dataReceivePointByArgument` roles of Sender/Receiver communication and is supported by *explicit S/R API* in this specification.

   For more details see section 4.2.5.6.2
   For APIs see sections 5.6.26 and 5.6.27.

4.3.4 Inter-Partition communication

`Partition`s are used to decompose an ECU into functional units. Partitions can contain both SW-Cs and BSW modules. The partitioning is done to protect the software contained in the partitions against each other or to increase the performance by running the partitions on different cores of a multi core controller.

Since the partitions may be separated by core boundaries or memory boundaries and since the partitions can be stopped and restarted independently, the observable behavior to the SW-Cs for the communication between different partitions is rather similar to the inter ECU communication than to the intra partition communication. The RTE needs to use special mechanisms to communicate from one partition to another.

Like for the inter ECU communication, inter partition communication uses the connectionless communication paradigm. This means, that a send operation is successful for the sender, even if the receiving partition is stopped. A receiver will only, by means of a timeout, be notified if the partition of the sender is stopped.

Unlike most basic software, the RTE does not have a main processing function. The execution logic of the RTE is contained in the generated task bodies, the wrapper code around the runnables whose execution RTE manages.

As the tasks that contain the SW-Cs runnables are uniquely assigned to partitions (see page 11EER of [15]), the execution logic of the RTE is split among the partitions. It can not be expected that the RTE generated wrapper code running in one partition can directly access the memory objects assigned to the RTE part of another partition.

In this sense, there is one RTE per partition, that contains runnable entities.

Still, RTE is responsible to support the communication between SW-Cs allocated to the different partitions. According to the AUTOSAR software layered architecture, RTE has to be independent of the micro controller architecture. AUTOSAR supports a wide variety of multi core and memory protection architectures.

[SWS_Rte_02734] ⌈ The RTE generator shall support a mode in which the generated code is independent of the micro controller. ⌋*(SRS_BSW_00161)*

It can not be generally assumed that a cache coherent, shared memory is available for the communication between partitions. Direct memory access and function calls across partition boundaries are generally not possible. In the extreme case, communication might even be limited to a message passing interface.

To allow memory protection and multi core support in spite of [SWS_Rte_02734], the AUTOSAR OS provides a list of mechanisms, that can be used for the communication across cores (see [4]). Especially, the IOC has been designed to support the communication needs of RTE in a way that should not introduce additional run time overhead.

If a communication between Basic Software Modules is necessary for which the IOC does not suffice, for example Sender-Receiver or Client-Server communication, there are also mechanisms provided by the Basic Software Scheduler. These mechanisms follow the Client-Server communication pattern or the Sender-Receiver communication pattern of the VFB but cannot be used for inter-ECU communication. The Basic Software Scheduler can internally use the IOC to cross the partition boundaries. See [24].

The following sections describe the use of some OS mechanisms that are designed for inter partition communication.

4.3.4.1 Inter partition data communication using IOC

The general idea to allow the data communication between partitions in a most efficient way and still be independent of the micro controller implementation is to take the buffers and queues from the intra partition communication case and replace them with so called IOC communication objects in the inter partition communication case.

In the ideal case, the access macros to the IOC communication object resolve to a direct access to shared memory.

The IOC (Inter OS-Application Communication) is a feature of the AUTOSAR OS, which provides a data oriented communication mechanism between partitions. The IOC provides communication buffers, queues, and protected access functions/macros to these buffers that can be used from any pre-configured partitions concurrently.

The IOC offers communication of data to another core or between memory protected partitions with guarantee of data consistency.

All data communications including the passing of parameters and return values in client server communication, can be implemented by using the IOC. The basic principle for using the IOC is to replace the RTE internal communication buffers by IOC buffers.

The IOC supports 1:1 and N:1 communication. For 1:N communication, N IOC communication objects have to be used. The IOC is configured and provides generated APIs for each IOC communication object. In case of N:1 communication, each sender has a separate API.

The IOC API is not reentrant.

[SWS_Rte_02737] ⌈ RTE shall prevent concurrent access to the same IOC API from different `ExecutableEntity` `execution-instances`. ⌋*()*

The IOC will use the appropriate mechanism to communicate between the partitions, whether it requires communicating with another core, communicating with a partition with a different level of trust, or communicating with another memory partition.

The IOC channels are configured in the OS Configuration. Their configurations has to be provided as inputs for the RTE generator when the external configuration switch `strictConfigurationCheck` [SWS_Rte_05148] is set to true, and can be provided by the RTE Generator or RTE Configuration Editor when `strictConfigurationCheck` is set to false (see [SWS_Rte_05150]).

The IOC APIs use:

1. types declared by user on input to RTE (sender-receiver communication across OsApplication boudaries).
2. types created by RTE to collect client-server operation arguments into single data structure.

For the second item, RTE uses internal types that have to be described as `ImplementationDataType`s (see [SWS_Rte_08400]).

The signaling between partitions is not covered by the IOC. The callbacks of IOC are in interrupt context and are mainly intended for direct use by BSW. For the signaling between partitions, RTE can use the activation of tasks or setting of events, see section 4.3.4.4.

[SWS_Rte_02736] ⌈ The RTE shall not execute `ExecutableEntity`s in the context of IOC callbacks. ⌋*()*

This is necessary to ensure that `ExecutableEntity`s will not be executed in interrupt context or when a partition is terminated or restarted.

4.3.4.2 Inter partition data communication using Basic Software Scheduler

The Basic Software Scheduler provides Sender-Receiver and Client-Server communications mechanisms for communication between Basic Software Modules in different partitions. Therefore these communication paradigms can be used by Basic Software Modules in a multi core environment.

The usage is described in [9].

For Sender-Receiver communication currently only "explicit" transmission of data elements with "event" semantic (queued) is supported.

[SWS_Rte_08763] ⌈ For inter-ECU Sender-Receiver communication the length of the queue is specified by the attribute `queueLength` of the `BswQueuedDataReceptionPolicy` which references through `receivedData` the `VariableDataPrototype` of the Sender-Receiver communication. ⌋*(SRS_Rte_00243)*

[SWS_Rte_08764] ⌈ The RTE generator shall reject a `queueLength` attribute of a `BswQueuedDataReceptionPolicy` with a queue length ≤ 0. ⌋*(SRS_Rte_00243)*

4.3.4.3 Accessing Ld(Com) and Det in multicore/multipartition configuration

In a multicore ECU it might be possible for a software component to send data to another ECU via the communication stack which might be located in a different partition than the sending software component. In this case, different approaches for the Rte are possible:

1. It is assumed that Ld(Com) and Det can be called from everywhere—they are in every partition—in case shared buffer is available for the ECU.
2. Ld(Com) and Det are called via the CallTrustedFunction. It is assumed they can be called from each core but they are in different partitions. In this case, the application calling the Com is in an untrusted `OsApplication` and the Com in a trusted `OsApplication`. This approach requires a MPU configuration.
3. Ld(Com) and Det are only in one partition. Here, the Rte could first transmit the data to the Ld(Com) partition and then calls the required Ld(Com) APIs in the context of the Ld(Com) partition e.g. via an `OsTask`.

Please note that the 3 exemplary scenarios do not exhaustively show all possible scenarios. For instance an ECU may host different safety levels and / or BSW modules might be available only in QM or for specific safety levels.

4.3.4.4 Signaling and control flow support for inter partition communication

The OS representation of a partition is an OS Application.

This is a (non-exhaustive) summary of OS features that can be used for signaling and control flow across partition boundaries:

- activation of tasks
- start and stop of schedule tables
- event signaling
- alarms
- spin locks (for inter core synchronization)

The following are not available for inter core signaling:

- OS Resource
- DisableAllInterrupts

For inter core synchronization, spin locks are provided. But, for efficiency reasons they should be used with care.

4.3.4.5 Trusted Functions

The call-trusted-function mechanism of AUTOSAR OS can be used in a memory protected controller to implement a function call from an untrusted to a trusted partition.

This Trusted Partition is a partition that may have full access to the OS objects of other partitions on the same core. The Basic Software is assumed to reside in a trusted partition. It is assumed that the trusted partition cannot be terminated or restarted.

The typical use case for the call-trusted-function mechanism are AUTOSAR services which are usually provided by a client/server interface where the service side resides together with the basic software in the trusted partition.

Beware that this mechanism can not be used between two untrusted partitions or between cores.

The trusted functions are configured in the OS Configuration. Their configurations shall be provided as inputs for the RTE generator when the external configuration switch `strictConfigurationCheck` [SWS_Rte_05148] is set to true, and can be provided by the RTE Generator or RTE Configuration Editor when `strictConfigurationCheck` is set to false (see [SWS_Rte_05150]).

[SWS_Rte_07606] ⌈ Direct start of an `ExecutableEntity` execution-instance by the mean of a trusted function shall only be used for the start of an `ExecutableEntity` in the Trusted Partition. ⌋ *(SRS_Rte_00195, SRS_Rte_00210)*

The OS ensures that the partition of the caller is not terminated or restarted when a trusted function is executed unless the termination of the partition calling the trusted function is caused by another TRUSTED partition. If needed, the termination or restart of the caller's partition is delayed after the trusted function returns.

RTE has to ensure, that the OS does not kill an RTE-generated task due to stopping or restarting a partition while this task is executing a function call to BSW or to the software component of another partition when this call is not a pure function.

For this purpose, RTE can use either the OS mechanism of trusted function call, or it can allocate the server to a different task than the client.

[SWS_Rte_02761] ⌈ In a partitioned system that supports stop or restart of partitions, the RTE shall not use a direct function call (without use of OS call trusted function) from a task of an untrusted partition to BSW or to the SW-C of another partition unless this is a pure function. ⌋*(SRS_Rte_00196)*

Please note that [SWS_Rte_02761] might require the use of OS call trusted function for a partitioned system even without memory protection.

4.3.4.6 Memory Protection and Pointer Type Parameters in RTE API

In a memory protected ECU, a SW-C from an untrusted partition might misuse the transition to the trusted context to modify memory in another partition. This can occur when a pointer to a different memory partition is passed from the untrusted partition to the trusted context. The RTE shall avoid this misuse by at least checking the validity of the address of the pointer, and, where possible, also checking the integrity of the associated memory object.

[SWS_Rte_02752] ⌈ When a SW-C in an untrusted partition receives (OUT parameter) or provides (IN parameter with composite data type) an `ArgumentDataPrototype` or `VariableDataPrototype`, it hands over a pointer to a memory object to an RTE API. The RTE shall only forward this pointer to a trusted SW-C after it has checked that the whole memory object is owned by the caller's partition. ⌋*(SRS_Rte_00210)*

[SWS_Rte_02753] ⌈ When a SW-C in an untrusted partition passes an `ArgumentDataPrototype` or `VariableDataPrototype`, as a reference type to a SW-C in a trusted partition (`DATA_REFERENCE` as an IN parameter), the RTE shall only check that the caller's partition owns the start address of the referenced memory. ⌋*(SRS_Rte_00210)*

Note to [SWS_Rte_02753]: The RTE only checks whether the start address referenced directly by the `DataPrototype`s belongs to the calling partition. Because the RTE is not aware of the semantic of the pointed reference, it cannot check if the referenced object is completely contained in the calling partition (e.g. the RTE does not know the size and does not know if the referenced object also contains references to other objects). The BSW is responsible to make sure that the referenced memory object does not cross memory section boundaries.

The OS API CheckTaskMemoryAccess can be used to fulfill [SWS_Rte_02752] and [SWS_Rte_02753].

4.3.5 PortInterface Element Mapping and Data Conversion

AUTOSAR supports the connection of an R-port to a P-port with an interface that is not compatible in the sense of the AUTOSAR compatibility rules. In addition, for sender-receiver communication it is possible to specify how data elements are represented given that the communication requires the usage of a dedicated communication bus. In these cases the generated RTE has to support the conversion and re-scaling of data.

4.3.5.1 PortInterface Element Mapping

Per default the shortNames of PortInterface elements are used to identify the matching element pairs of connected ports. In case of non fitting names — might be caused due to distributed development, off-the-shelf development, or re-use of software components — it is required to explicitly specify which PortInterface elements shall correlate. This is modelled with PortInterfaceMappings. A connection of two ports can be associated with a set of PortInterfaceMappings. If two ports are connected and a PortInterfaceMapping for the pair of interfaces of the two ports is associated with the connection, the interface elements are mapped and converted as specified in the PortInterfaceMapping. If no PortInterfaceMapping for the respective pair of interfaces is associated with the connection, the ordinary interface compatibility rules are applied.

The general approach is to perform the data conversion in the RTE of the ECU implementing the R-port. The reason for this design decision is that in case of 1:n sender-receiver communication it is inefficient to perform all the data conversions for the multiple receivers on the sender side and then send multiple sets of the same data just in different representations over the communication bus.

[SWS_Rte_03815] ⌈ The RTE shall support the mapping of sender-receiver interfaces, parameter interfaces and non-volatile data interface elements. ⌋*(SRS_Rte_00182)*

[SWS_Rte_03816] ⌈ If a P-port specified by a SenderReceiverInterface or NvDataInterface is connected to an R-port with an incompatible interface and a VariableAndParameterInterfaceMapping for both interfaces is associated with the connection, the RTE of the ECU implementing the R-port shall map and convert the data elements of the sender's interface to the data elements of the receiver's interface. ⌋*(SRS_Rte_00182)*

[SWS_Rte_07091] ⌈ The RTE shall support the *Mapping of elements of composite data types* in the context of a mapping of SenderReceiverInterface, NvDataInterface or ParameterInterface elements. ⌋*(SRS_Rte_00182, SRS_Rte_00234)*

[SWS_Rte_07092] ⌈ The RTE of the ECU implementing the R-port shall map and convert the composite data type elements of DataPrototypes of the sender's interface to the composite data type elements of DataPrototypes of the receiver's interface according the SubElementMapping
if a P-port specified by a SenderReceiverInterface, NvDataInterface or ParameterInterface is connected to an R-port with an incompatible interface and a VariableAndParameterInterfaceMapping exists for both interfaces and is associated with the connection and
the SubElementMapping maps composite data type elements of the provided interface to composite data type elements of the required interface. ⌋*(SRS_Rte_00182, SRS_Rte_00234)*

[SWS_Rte_07099] ⌈ The RTE of the ECU implementing the R-port shall map and convert the composite data type elements of DataPrototype of the sender's interface to the primitive DataPrototype of the receiver's interface according the SubElementMapping
if a P-port specified by a SenderReceiverInterface, NvDataInterface or ParameterInterface is connected to a R-port with an incompatible interface and a VariableAndParameterInterfaceMapping exists for both interfaces and is associated with the connection and the SubElementMapping exclusively maps one composite data type element of the provided interface ⌋*(SRS_Rte_00182, SRS_Rte_00234)*

According to [TPS_SWCT_01551], incomplete SubElementMappings are allowed for unqueued communication, when unmapped dataElements on the receiver side have an initValue.

Please note that the DataPrototypes of the provide port and DataPrototypes of the require port might use exclusively ApplicationDataTypes, exclusively ImplementationDataTypes or both kinds of AutosarDataTypes in a mixed manner.

[SWS_Rte_02307] ⌈ The RTE generator shall reject configurations that violate [constr_1300]. ⌋*()*

[SWS_Rte_03817] ⌈ If a P-port specified by a SenderReceiverInterface or NvDataInterface is connected to an R-port with an incompatible interface and no VariableAndParameterInterfaceMapping for this pair of interfaces is associated with the connection, the RTE generator shall reject the input as an invalid configuration. ⌋*(SRS_Rte_00182, SRS_Rte_00018)*

[SWS_Rte_03818] ⌈ The RTE shall support the mapping of client-server interface elements. ⌋*(SRS_Rte_00182)*

[SWS_Rte_03819] ⌈ If a P-port specified by a ClientServerInterface is connected to an R-port with an incompatible interface and a ClientServerInterfaceMapping for both interfaces is associated with the connection, the RTE of the ECU implementing the R-port, i. e. the client, shall map the operation and map and convert the operation arguments of the client's interface to the operation arguments of the server's interface. ⌋*(SRS_Rte_00182)*

[SWS_Rte_07925] ⌈ If a ClientServerApplicationErrorMapping exists, the RTE shall translate the error codes of the server into the corresponding error codes described by the mapping. ⌋*(SRS_Rte_00182, SRS_Rte_00123)*

[SWS_Rte_07926] ⌈ If a ClientServerApplicationErrorMapping exists and a particular error of the server is not mapped, this error shall be translated to RTE_E_OK. ⌋*(SRS_Rte_00182, SRS_Rte_00123)*

[SWS_Rte_03820] ⌈ If a P-port specified by a ClientServerInterface is connected to an R-port with an incompatible interface and no ClientServerInterfaceMapping for this pair of interfaces is associated with the connection, the RTE generator shall reject the input as an invalid configuration. ⌋*(SRS_Rte_00182, SRS_Rte_00018)*

[SWS_Rte_03821] ⌈ The RTE shall support the mapping of ModeSwitchInterface elements. ⌋*(SRS_Rte_00182)*

[SWS_Rte_03822] ⌈ If a P-port specified by a ModeSwitchInterface is connected to an R-port with an incompatible interface and a ModeInterfaceMapping for both interfaces is associated with the connection, the RTE of the ECU implementing the R-port shall map and convert the mode elements of the sender's interface to the mode elements of the receiver's interface. ⌋*(SRS_Rte_00182)*

[SWS_Rte_03823] ⌈ If a P-port specified by a ModeSwitchInterface is connected to an R-port with an incompatible interface and no ModeInterfaceMapping for this pair of interfaces is associated with the connection, the RTE generator shall reject the input as an invalid configuration. ⌋*(SRS_Rte_00182, SRS_Rte_00018)*

[SWS_Rte_03824] ⌈ The RTE shall support the mapping of trigger interface elements. ⌋*()*

[SWS_Rte_03825] ⌈ If a P-port specified by a TriggerInterface is connected to an R-port with an incompatible interface and a TriggerInterfaceMapping for both interfaces is associated with the connection, the RTE of the ECU implementing the R-port shall map the trigger of the sender's interface to the trigger of the receiver's interface. ⌋*()*

[SWS_Rte_03826] ⌈ If a P-port specified by a TriggerInterface is connected to an R-port with an incompatible interface and no TriggerInterfaceMapping for this pair of interfaces is associated with the connection, the RTE generator shall reject the input as an invalid configuration. ⌋*(SRS_Rte_00018)*

In order to generate the RTE for the ECU implementing the R-ports, the RTE generator has to know the interfaces of the P-ports that are connected over the bus. This information is provided in the ECU extract via the networkRepresentationProps (see section 4.3.6) specified at the ISignal representing the data element.

4.3.6 Network Representation

4.3.6.1 Network Representation with no data transformation

For sender-receiver communication where no data transformation applies, it is possible to specify how data elements are represented given that the communication requires the usage of a dedicated communication bus. For this purpose networkRepresentationProps and physicalProps can be specified at the ISignal respectively SystemSignal, describing the representation of the data element on the communication bus via the attributes baseType and compuMethod.

[SWS_Rte_07842] ⌈ The RTE generator shall reject any input that violates [TPS_SYST_02001] as an invalid configuration. ⌋*(SRS_Rte_00018)*

[SWS_Rte_03827] ⌈ The RTE of the transmitting ECU shall perform the conversion of the data element that has to be sent over a communication bus to the representation specified by the baseType of the networkRepresentationProps of the ISignal and the compuMethod of the physicalProps of the respective SystemSignal if the dataTypePolicy of the ISignal is set to override or legacy. The converted data shall be passed to COM. ⌋*(SRS_Rte_00181)*

[SWS_Rte_06737] ⌈ If the dataTypePolicy of the respective ISignal is set to networkRepresentationFromComSpec and the networkRepresentation of the respective SenderComSpec is defined, the RTE of the transmitting ECU shall perform the conversion of the data element that has to be sent over a communication bus to the representation specified by the baseType and compuMethod of the networkRepresentation of the respective SenderComSpec. The converted data shall then be passed to COM. ⌋*(SRS_Rte_00181)*

[SWS_Rte_03828] ⌈ The RTE of the receiving ECU shall perform the conversion of the data element that is received over a communication bus from the representation specified by the baseType of the networkRepresentationProps of the ISignal and the compuMethod of the physicalProps of the respective SystemSignal to the data element's application data type if the dataTypePolicy of the ISignal is set to override or legacy. In this case [SWS_Rte_03816] shall not be applied ⌋*(SRS_Rte_00181)*

[SWS_Rte_06738] ⌈ If the dataTypePolicy of the respective ISignal is set to networkRepresentationFromComSpec and the networkRepresentation of the respective ReceiverComSpec is defined, the RTE of the receiving ECU shall perform the conversion of the data element that is received over a communication bus from the representation specified by the baseType and compuMethod of the networkRepresentation of the respective ReceiverComSpec. In this case [SWS_Rte_03816] shall not be applied. ⌋*(SRS_Rte_00181)*

[SWS_Rte_07844] ⌈ If the dataTypePolicy of the respective ISignal is set to networkRepresentationFromComSpec but there is no networkRepresentation defined by the ReceiverComSpec (respectively SenderComSpec) then no conversion shall be performed by RTE. ⌋*(SRS_Rte_00181)*

As an alternative to networkRepresentationProps the representation of the VariableDataPrototypes and ArgumentDataPrototypes on the communication bus can be expressed by the used DataTypes in the PortInterfaces on the outerPorts of the CompositionSwComponentType describing the ecu extract. In this case the conversion between the network representation and the representation for the software components on the ecu are described by a PortInterfaceMapping which in turn is referenced by the DelegationSwConnector connecting the innerPort of the software component and the outerPort. These supports especially conversions of texttable data representation where a TextTableMapping is needed to describe the particular conversion rule.

[SWS_Rte_07828] ⌈ If a PortInterfaceMapping is specified at the DelegationSwConnector of a P-port, the RTE of the transmitting ECU shall perform the conversion of the VariableDataPrototypes or ArgumentDataPrototypes that has to be sent over a communication bus to the representation specified by the outerPort. The converted data shall be passed to COM. ⌋ *(SRS_Rte_00181)*

[SWS_Rte_07829] ⌈ d If a PortInterfaceMapping is specified at the DelegationSwConnector of a R-port, the RTE of the receiving ECU shall perform the conversion of the VariableDataPrototypes or ArgumentDataPrototypes that is received over a communication bus from the representation specified by the outerPort to the representation specified by the innerPort. In this case [SWS_Rte_03816] shall not be applied. ⌋ *(SRS_Rte_00181)*.

4.3.6.2 Network Representation with data transformation

For sender-receiver communication where data transformation applies, it is possible, to specify how data elements are represented given that the communication requires the usage of a dedicated communication bus. For this purpose ISignal.TransformationISignalProps. DataPrototypeTransformationProps.networkRepresentationProps can be specified describing the representation of the data element on the communication bus via the attributes baseType and compuMethod.

[SWS_Rte_04536] ⌈ The RTE of the transmitting ECU shall perform the conversion of each primitive element, which belongs to the data to be transformed and sent over a communication bus to the representation specified by the baseType and compuMethod of the ISignal.TransformationISignalProps. DataPrototypeTransformationProps.networkRepresentationProps for the respective primitive element. The converted data shall be passed to the first transformer in the chain. ⌋ *(SRS_Rte_00181)*

[SWS_Rte_04537] ⌈ If the ISignal.TransformationISignalProps. DataPrototypeTransformationProps.networkRepresentationProps is not defined for a primitive element of a transformed ISignal, the RTE of the transmitting ECU shall perform the conversion of that primitive element based on the baseType specified at the ImplementationDataType used by the PPortPrototype. The converted data shall be passed to the first transformer in the chain. ⌋ *(SRS_Rte_00181)*

[SWS_Rte_04538] ⌈ The RTE of the receiving ECU shall perform the conversion of each primitive element that is received over a communication bus and then re-transformed from the representation specified by the baseType and the compuMethod of the ISignal.TransformationISignalProps.DataPrototypeTransformationProps. networkRepresentationProps. ⌋*(SRS_Rte_00181)*

[SWS_Rte_04539] ⌈ If the ISignal.TransformationISignalProps. DataPrototypeTransformationProps.networkRepresentationProps is not defined for a primitive element of a transformed networkRepresentationProps, the RTE of the receiving ECU shall perform the conversion of that primitive element based on the baseType specified at the ImplementationDataType used by the RPortPrototype. ⌋*(SRS_Rte_00181)*

4.3.7 Data Conversion

[SWS_Rte_03829] ⌈ The RTE shall support the conversion of an identical or linear scaled data representation to another identical or linear scaled data representation. In this context, the term "linear scaled data representation" also includes floating-point data representations. ⌋*(SRS_Rte_00182)*

[SWS_Rte_08801] ⌈ The RTE shall support the conversion integer-to-float and float-to-integer. It is recommended to consider implication of MISRA-C rule 10.3, in particular, the requirement for no implicit conversion. ⌋*(SRS_Rte_00182)*

Today the RTE Specification does not define any specific behavior supporting float to integer and integer to float conversions. This enables the RTE implementers to develop the most efficient, stable and robust solution.

[SWS_Rte_03830] ⌈ The RTE shall support the conversion of a texttable data representation (enumeration or bitfield) to another texttable data representation. ⌋*(SRS_Rte_00182)*

[SWS_Rte_03855] ⌈ The RTE shall support the conversion of a mixed linear scaled and texttable data representation to another mixed linear scaled and texttable data representation. ⌋*(SRS_Rte_00182)*

[SWS_Rte_03856] ⌈ The RTE shall support the conversion between a texttable data representation (enumeration) and a mixed linear scaled and texttable data representation. In this case only the enumeration part of the data representation shall be converted, the linear scaled part shall be handled as out of range data. ⌋*(SRS_Rte_00182)*

[SWS_Rte_03857] ⌈ The RTE shall support the conversion between an identical or linear scaled data representation and a mixed linear scaled and texttable data representation. A scale with a compuConst shall be handled as out of range data if the mapping to a value is not defined by a TextTableMapping. ⌋*(SRS_Rte_00182)*

[SWS_Rte_03860] ⌈ The RTE shall support the conversion of composite data representations. In this case, the respective requirements [SWS_Rte_03829], [SWS_Rte_03830], [SWS_Rte_03855], [SWS_Rte_03856], [SWS_Rte_03857], [SWS_Rte_03831], [SWS_Rte_03832], and [SWS_Rte_03833] are applicable to the individual composite elements. ⌋*(SRS_Rte_00182)*

[SWS_Rte_03831] ⌈ The RTE generator shall reject any input that requires a conversion which is not supported according to [SWS_Rte_03829], [SWS_Rte_03830], [SWS_Rte_03855], [SWS_Rte_03856], or [SWS_Rte_03860] as an invalid configuration. ⌋*(SRS_Rte_00182, SRS_Rte_00018)*

[SWS_Rte_07928] ⌈ The data conversion shall be supported for data types that refer to `CompuMethod`s of category `LINEAR`, `IDENTICAL`, `SCALE_LINEAR_AND_TEXTTABLE`, `TEXTTABLE` , `BITFIELD_TEXTTABLE` and CompuMethods of category `RAT_FUNC` with a reciprocal linear data scaling. ⌋*(SRS_Rte_00182)*

Note: The definition of a reciprocal linear data scaling is given in Software Component Template [2], [TPS_SWCT_01550]

[SWS_Rte_03832] ⌈ For the conversion between two data representations with linear scaling described either by an `ApplicationDataType` or a combination of `BaseType` and `CompuMethod` (used for the specification of the network representation at the `ComSpec` respectively the `SystemSignal`) the RTE generator shall derive the data conversion code automatically from the referred `CompuMethod`s of the two representations. In this context the scaling of a data representation is linear if the referred `CompuMethod` is of category `IDENTICAL`, `LINEAR`, `RAT_FUNC` or `SCALE_LINEAR_AND_TEXTTABLE`. In case of a `CompuMethod` of category `SCALE_LINEAR_AND_TEXTTABLE` this requirement applies to the linear scaled part only. ⌋*(SRS_Rte_00182)*

For a linear conversion the linear conversion factor can be calculated out of the `factorSiToUnit` and `offsetSiToUnit` attributes of the referred `Unit`s and the `CompuRationalCoeffs` of a `compuInternalToPhys` of the referred `CompuMethod`s.

Further information about Linear Data Scaling is given in document Software Component Template [2].

Example 4.10

A software component `SwcA` on an ECU `EcuA` sends a data element `u` of a uint16 type `t_VoltageAtSender` via its port `SenderPort`. The referenced `CompuMethod` is `cm_VoltageAtSender`, describing a fixpoint representation with offset 0 and LSB $\frac{1}{4} = 2^{-2}$. The port `SenderPort` is connected to the port `ReceiverPort` of a software component `SwcB` that is deployed on a different ECU `EcuB`. The sent data element `u` is mapped to a data element `u` of a uint16 type `t_VoltageAtReceiver` on the receiving side that references a `CompuMethod` named `cm_VoltageAtReceiver`. `cm_VoltageAtReceiver` describes a fixpoint representation with offset $\frac{16}{8} = 2$ and LSB $\frac{1}{8} = 2^{-3}$. For transportation over the bus a `networkRepresentation` that references a uint8 type `t_VoltageOnNetwork` is specified, using a fixpoint representation described by the `CompuMethod` `cm_VoltageOnNetwork` with offset $\frac{1}{2} = 0.5$ and LSB $\frac{1}{2} = 2^{-1}$.

Definition of the CompuMethods in *XML*:

```
<COMPU-METHOD>
  <SHORT-NAME>cm_VoltageAtSender</SHORT-NAME>
  <CATEGORY>LINEAR</CATEGORY>
  <COMPU-INTERNAL-TO-PHYS>
    <COMPU-SCALES>
      <COMPU-SCALE>
        <COMPU-RATIONAL-COEFFS>
          <COMPU-NUMERATOR><V>0</V><V>1</V></COMPU-NUMERATOR>
          <COMPU-DENOMINATOR><V>4</V></COMPU-DENOMINATOR>
        </COMPU-RATIONAL-COEFFS>
      </COMPU-SCALE>
    </COMPU-SCALES>
  </COMPU-INTERNAL-TO-PHYS>
</COMPU-METHOD>

<COMPU-METHOD>
  <SHORT-NAME>cm_VoltageAtReceiver</SHORT-NAME>
  <CATEGORY>LINEAR</CATEGORY>
  <COMPU-INTERNAL-TO-PHYS>
    <COMPU-SCALES>
      <COMPU-SCALE>
        <COMPU-RATIONAL-COEFFS>
          <COMPU-NUMERATOR><V>16</V><V>1</V></COMPU-NUMERATOR>
          <COMPU-DENOMINATOR><V>8</V></COMPU-DENOMINATOR>
        </COMPU-RATIONAL-COEFFS>
      </COMPU-SCALE>
    </COMPU-SCALES>
  </COMPU-INTERNAL-TO-PHYS>
</COMPU-METHOD>

<COMPU-METHOD>
  <SHORT-NAME>cm_VoltageOnNetwork</SHORT-NAME>
  <CATEGORY>LINEAR</CATEGORY>
  <COMPU-INTERNAL-TO-PHYS>
    <COMPU-SCALES>
      <COMPU-SCALE>
        <COMPU-RATIONAL-COEFFS>
          <COMPU-NUMERATOR><V>1</V><V>1</V></COMPU-NUMERATOR>
          <COMPU-DENOMINATOR><V>2</V></COMPU-DENOMINATOR>
        </COMPU-RATIONAL-COEFFS>
      </COMPU-SCALE>
    </COMPU-SCALES>
  </COMPU-INTERNAL-TO-PHYS>
</COMPU-METHOD>
```

Implementation of Rte_Send on the sending ECU EcuA:

```
Std_ReturnType
Rte_Send_SwcA_SenderPort_u(t_voltageAtSender u)
{
  ...
  /*
  u_NetworkRepresentation
   = ((u * LSB_sender + off_sender) - off_network) / LSB_network
   = ((u / 4          + 0         ) - 0.5        ) * 2
```

```
   =  (u / 2                      ) - 1
  */
  u_NetworkRepresentation = (uint8) ((u >> 1) - 1);
  ...
}
```

Implementation of `Rte_Receive` on the receiving ECU `EcuB`:

```
Std_ReturnType
Rte_Receive_SwcB_ReceiverPort_u(t_voltageAtReceiver * u)
{
  ...
  /*
  *u
  *u = ((u_NetworkRepresentation * LSB_network + off_network)
         - off_receiver) / LSB_receiver
     = ((u_NetworkRepresentation / 2           + 0.5         )
         - 2            ) * 8
     =  (u_NetworkRepresentation * 4           + 4           )
         - 16
     =   u_NetworkRepresentation * 4           - 12
  */
  *u = (uint16) ((u_NetworkRepresentation << 2) - 12);
  ...
}
```

Following examples show possible implementations for a table conversion where `DataPrototype`s with a `CompuMethod` of category `BITFIELD_TEXTTABLE` are involved.

Example 4.11

Conversion between a `DataPrototype` with a `CompuMethod` of category `TEXTTABLE` (in this case describing a `Boolean`) and a `DataPrototype` with a `CompuMethod` of category `BITFIELD_TEXTTABLE`:

Definition of the `TextTableMapping` in *XML*:

```
<PORT-INTERFACE-MAPPING-SET>
  <SHORT-NAME>PortMappingSet</SHORT-NAME>
  <PORT-INTERFACE-MAPPINGS>
    <VARIABLE-AND-PARAMETER-INTERFACE-MAPPING>
      <SHORT-NAME>Mapping_LDW_BF</SHORT-NAME>
      <DATA-MAPPINGS>
        <DATA-PROTOTYPE-MAPPING>
          <FIRST-DATA-PROTOTYPE-REF DEST="VARIABLE-DATA-PROTOTYPE">
            /Example/Interfaces/One/LDW
          </FIRST-DATA-PROTOTYPE-REF>
          <SECOND-DATA-PROTOTYPE-REF DEST="VARIABLE-DATA-PROTOTYPE">
            /Example/Interfaces/Two/bitfield
          </SECOND-DATA-PROTOTYPE-REF>
          <TEXT-TABLE-MAPPINGS>
            <TEXT-TABLE-MAPPING>
              <IDENTICAL-MAPPING>false</IDENTICAL-MAPPING>
```

```
              <MAPPING-DIRECTION>bidirectional</MAPPING-DIRECTION>
              <BITFIELD-TEXTTABLE-MASK-SECOND>
                0b00000100
              </BITFIELD-TEXTTABLE-MASK-SECOND>
              <VALUE-PAIRS>
                <TEXT-TABLE-VALUE-PAIR>
                  <FIRST-VALUE>0</FIRST-VALUE>
                  <SECOND-VALUE>0</SECOND-VALUE>
                </TEXT-TABLE-VALUE-PAIR>
                <TEXT-TABLE-VALUE-PAIR>
                  <FIRST-VALUE>1</FIRST-VALUE>
                  <SECOND-VALUE>4</SECOND-VALUE>
                </TEXT-TABLE-VALUE-PAIR>
              </VALUE-PAIRS>
            </TEXT-TABLE-MAPPING>
          </TEXT-TABLE-MAPPINGS>
        </DATA-PROTOTYPE-MAPPING>
      </DATA-MAPPINGS>
    </VARIABLE-AND-PARAMETER-INTERFACE-MAPPING>
  </PORT-INTERFACE-MAPPINGS>
</PORT-INTERFACE-MAPPING-SET>
```

C code for Implementation of Rte_Write:

```
Std_ReturnType Rte_Write_<p>_<o>(boolean v) {
  /* fetch the bit field from the RAM Block */
  uint32 *bitfield = Rte_RamBlk_<BlkNr>.bitfield;
  /* data consistency block on */
  /* bit operation (masking & conversion) - bit position 6 is deduced
     from BITFIELD-TEXTTABLE-MASK-SECOND */
  if(v == 0) Bfx_ClrBit_u8u8(*bitfield, 6);
  else Bfx_SetBit_u8u8(*bitfield, 6);
  /* data consistency block off */
}
```

C code for Implementation of Rte_Read:

```
Std_ReturnType Rte_Read_<p>_<o>(boolean *v) {
  /* fetch the bit field from the RAM Block */
  uint32 bitfield = Rte_RamBlk_<BlkNr>.bitfield;
  /* bit operation (masking & conversion) - bit position 6 is deduced
     from  BITFIELD-TEXTTABLE-MASK-SECOND */
  *v = Bfx_GetBit_u8u8u8(bitfield, 6);
}
```

Example 4.12

Conversion between two DataPrototypes with a CompuMethod of category BIT-FIELD_TEXTTABLE (mapping of 32bit bitfield of type uint32 to 4bit bitfield of type uint8):

Definition of the TextTableMapping in *XML*:

```
<PORT-INTERFACE-MAPPING-SET>
  <SHORT-NAME>PortMappingSet</SHORT-NAME>
```

```
  <PORT-INTERFACE-MAPPINGS>
    <VARIABLE-AND-PARAMETER-INTERFACE-MAPPING>
      <SHORT-NAME>Mapping_BF32_BF4</SHORT-NAME>
      <DATA-MAPPINGS>
        <DATA-PROTOTYPE-MAPPING>
          <FIRST-DATA-PROTOTYPE-REF DEST="VARIABLE-DATA-PROTOTYPE">
            /Example/Interfaces/One/BF32
          </FIRST-DATA-PROTOTYPE-REF>
          <SECOND-DATA-PROTOTYPE-REF DEST="VARIABLE-DATA-PROTOTYPE">
            /Example/Interfaces/Two/BF4
          </SECOND-DATA-PROTOTYPE-REF>
          <TEXT-TABLE-MAPPINGS>
            <TEXT-TABLE-MAPPING>
              <IDENTICAL-MAPPING>true</IDENTICAL-MAPPING>
              <MAPPING-DIRECTION>firstToSecond</MAPPING-DIRECTION>
              <BITFIELD-TEXTTABLE-MASK-FIRST>
                0b00000000000000000000000000001111
              </BITFIELD-TEXTTABLE-MASK-FIRST>
              <BITFIELD-TEXTTABLE-MASK-SECOND>
                0b00001111
              </BITFIELD-TEXTTABLE-MASK-SECOND>
            </TEXT-TABLE-MAPPING>
          </TEXT-TABLE-MAPPINGS>
        </DATA-PROTOTYPE-MAPPING>
      </DATA-MAPPINGS>
    </VARIABLE-AND-PARAMETER-INTERFACE-MAPPING>
  </PORT-INTERFACE-MAPPINGS>
</PORT-INTERFACE-MAPPING-SET>
```

C code for Implementation of Rte_Read:

```
Std_ReturnType Rte_Read_<p>_<o>(uint8 *v) {
  /* fetch the bit field from the RAM Block */
  uint32 bitfield = Rte_RamBlk_<BlkNr>.bitfield;
  /* bit operation (masking & shifting) - start position 28 and length
     4 are deduced from BITFIELD-TEXTTABLE-MASK-FIRST */
  *v = Bfx_GetBits_u8u8u8_u32(bitfield, 28, 4) &
       BitfieldTexttableMaskSecond;
}
```

The intention of this specification is not to describe any mechanism that supports the generation of identical conversion code for each implementation of an RTE generator. Even if the generated C code for the conversion would be the same, the numerical result of the conversion still depends on the microcontroller target and the compiler.

Strategies how to handle the conversion of values that are out of range of the target representation are described in section 4.3.8.

[SWS_Rte_03833] ⌈ For the conversion between two texttable data representations (enumerations or bitfields) described either by an ApplicationDataType or an ImplementationDataType (used for the specification of the network representation) the RTE generator shall generate the data conversion code according to the TextTableMapping. This requirement also applies to the texttable part of a mixed linear scaled and texttable data representation. ⌋*(SRS_Rte_00182)*

4.3.8 Range Checks during Runtime

A software component might try to send a value that is outside the range that is specified at a dataElement or ISignal. In case of different ranges the result of a data conversion might also be a value that is out of range of the target representation. For a safe handling of these use cases the RTE provides range checks during runtime. For an overview see figure 4.45.

[SWS_Rte_08024] ⌈ Range checks during runtime shall occur after data invalidation, i.e. first the handleNeverReceived check, then the invalidation check and lastly the range check shall be effected. ⌋*(SRS_Rte_00180)*

[SWS_Rte_03861] ⌈ The range check is intended to be performed according to the following rule: If a upper/lower limit is specified at the DataConstr, this value shall be taken for the range check. If it is not specified at the DataConstr, the highest/lowest representable value of the datatype shall be used. ⌋*(SRS_Rte_00180)*

Whether a range check is required is specified in case of intra ECU communication at the handleOutOfRange attribute of the respective SenderComSpec or ReceiverComSpec and in case of inter ECU communication at the handleOutOfRange attribute of ISignalProps of the sending or receiving ISignal.

Range checks at sender's side

Range checks during runtime for intra ECU communication at the sender's side are described in the following requirements:

[SWS_Rte_08026] ⌈ The RTE shall implement a range check of sent data in the sending path of a particular component if the handleOutOfRange is defined at the SenderComSpec and has any value other than none. In this case all receivers receive the value after the range check was applied. ⌋*(SRS_Rte_00180)*

[SWS_Rte_08039] ⌈ The RTE shall use the preceding limits ([SWS_Rte_07196]) from the DataPrototype in the PPortPrototype or PRPortPrototype for the range check of sent data in the sending path of a particular component if the handleOutOfRange is defined at the SenderComSpec. ⌋*(SRS_Rte_00180)*

[SWS_Rte_03839] ⌈ If for a dataElement to be sent a SenderComSpec with handleOutOfRange=ignore is provided, a range check shall be implemented in the sending component. If the value is out of bounds, the sending of the dataElement shall not be propagated. This means for a non-queued communication that the last valid value will be propagated and for a queued communication that no value will be enqueued.

In case of a composite datatype the sending of the whole dataElement shall not be propagated, if any of the composite elements is out of bounds. ⌋*(SRS_Rte_00180)*

[SWS_Rte_03840] ⌈ If for a dataElement to be sent a SenderComSpec with handleOutOfRange=saturate is provided, a range check shall be implemented in the sending component. If the value is out of bounds, the value actually sent shall be set to the lower respectively the upper limit.

In case of a composite datatype each composite element whose actual value is out of bounds shall be saturated. ⌋*(SRS_Rte_00180)*

[SWS_Rte_03841] ⌈ If for a dataElement to be sent a NonqueuedSenderComSpec with handleOutOfRange=default is provided, a range check shall be implemented in the sending component. If the value is out of bounds and the initValue is not equal to the invalidValue, the value actually sent shall be set to the initValue.

In case of a composite datatype each composite element whose actual value is out of bounds shall be set to the initValue. ⌋*(SRS_Rte_00180)*

[SWS_Rte_03842] ⌈ If for a dataElement to be sent a NonqueuedSenderComSpec with handleOutOfRange=invalid is provided, a range check shall be implemented in the sending component. If the value is out of bounds, the value actually sent shall be set to the invalidValue.

In case of a composite datatype each composite element whose actual value is out of bounds shall be set to the invalidValue. ⌋*(SRS_Rte_00180)*

[SWS_Rte_03843] ⌈ If for a dataElement to be sent a QueuedSenderComSpec with handleOutOfRange set to default or invalid is provided, the RTE generator shall reject the input as an invalid configuration, since for a QueuedSenderComSpec the attribute initValue is not defined (see SW-C Template [2]) and data invalidation is not supported (see [SWS_Rte_06727]). ⌋*(SRS_Rte_00180)*

Range checks during runtime for inter ECU communication at the sender's side are described in the following requirements:

[SWS_Rte_08027] ⌈ The RTE shall implement a range check of sent data in the sending path of a particular signal if the handleOutOfRange is defined at the ISignalProps and has any value other than none. In this case only receivers of the specific ISignal receive the value after the range check was applied. ⌋*(SRS_Rte_00180)*

[SWS_Rte_08040] ⌈ The RTE shall use the limits from the ISignal for the range check of sent data in the sending path of a particular signal if the handleOutOfRange is defined at the ISignalProps. ⌋*(SRS_Rte_00180)*

[SWS_Rte_08030] ⌈ If for an ISignal to be sent an ISignalProps with handleOutOfRange=ignore is provided, a range check shall be implemented in the sending signal. If the value is out of bounds, the sending of the ISignal shall not be propagated. In this case the RTE shall behave as if no sending occurred. ⌋*(SRS_Rte_00180)*

[SWS_Rte_08031] ⌈ If for an ISignal to be sent an ISignalProps with handleOutOfRange=saturate is provided, a range check shall be implemented in the sending signal. If the value is out of bounds, the value actually sent shall be set to the lower respectively the upper limit. ⌋*(SRS_Rte_00180)*

[SWS_Rte_08032] ⌈ If for an ISignal to be sent an ISignalProps with handleOutOfRange=default is provided, a range check shall be implemented in the sending signal. If the value is out of bounds and the initValue is not equal to the invalidValue, the value actually sent shall be set to the initValue. ⌋*(SRS_Rte_00180)*

[SWS_Rte_08033] ⌈ If for an ISignal to be sent an ISignalProps with handleOutOfRange=invalid is provided, a range check shall be implemented in the sending signal. If the value is out of bounds, the value actually sent shall be set to the invalidValue. ⌋*(SRS_Rte_00180)*

Range checks at receiver's side

Range checks during runtime for intra ECU communication at the receiver's side are described in the following requirements:

[SWS_Rte_08028] ⌈ The RTE shall implement a range check in the receiving path of a particular component if the handleOutOfRange is defined at the ReceiverComSpec and has any value other than none. In this case the range check applies only for data received by the particular component. ⌋*(SRS_Rte_00180)*

[SWS_Rte_08041] ⌈ The RTE shall use the preceding limits ([SWS_Rte_07196]) from the DataPrototype in the rPort for the range check of received data in the receiving path of a particular component if the handleOutOfRange is defined at the ReceiverComSpec. ⌋*(SRS_Rte_00180)*

[SWS_Rte_03845] ⌈ If for a dataElement to be received a ReceiverComSpec with handleOutOfRange=ignore is provided, a range check shall be implemented in the receiving component. If the value is out of bounds, the reception of the dataElement shall not be propagated. This means for a non-queued communication that the last valid value will be propagated and for a queued communication that no value will be enqueued.

If the value of the received dataElement is out of bounds and a NonqueuedReceiverComSpec with handleOutOfRangeStatus=indicate is provided, the return value of the RTE shall be RTE_E_OUT_OF_RANGE.

In case of a composite datatype the reception of the whole dataElement shall not be propagated, if any of the composite elements is out of bounds. If the handleOutOfRangeStatus attribute is set to indicate, the return value of the RTE shall be RTE_E_OUT_OF_RANGE. ⌋*(SRS_Rte_00180)*

[SWS_Rte_03846] ⌈ If for a dataElement to be received a ReceiverComSpec with handleOutOfRange=saturate is provided, a range check shall be implemented in the receiving component. If the value is out of bounds, the value actually received shall be set to the lower respectively the upper limit.

If the value of the received dataElement is out of bounds and a NonqueuedReceiverComSpec with handleOutOfRangeStatus=indicate is provided, the return value of the RTE shall be RTE_E_OUT_OF_RANGE.

In case of a composite datatype each composite element whose actual value is out of bounds shall be saturated. If the handleOutOfRangeStatus attribute is set to indicate, the return value of the RTE shall be RTE_E_OUT_OF_RANGE, if any of the composite elements is out of bounds. ⌋*(SRS_Rte_00180)*

[SWS_Rte_03847] ⌈ If for a dataElement to be received a NonqueuedReceiverComSpec with handleOutOfRange=default is provided, a range check shall be implemented in the receiving component. If the value is out of bounds and the initValue is not equal to the invalidValue, the value actually received shall be set to the initValue.

If the value of the received dataElement is out of bounds and a NonqueuedReceiverComSpec with handleOutOfRangeStatus=indicate is provided, the return value of the RTE shall be RTE_E_OUT_OF_RANGE.

In case of a composite datatype each composite element whose actual value is out of bounds shall be set to the initValue. If the handleOutOfRangeStatus attribute is set to indicate, the return value of the RTE shall be RTE_E_OUT_OF_RANGE, if any of the composite elements is out of bounds. ⌋*(SRS_Rte_00180)*

[SWS_Rte_03848] ⌈ If for a dataElement to be received a NonqueuedReceiverComSpec with handleOutOfRange=invalid is provided, a range check shall be implemented in the receiving component. If the value is out of bounds, the value actually received shall be set to the invalidValue.

If the value of the received dataElement is out of bounds and a ReceiverComSpec with handleOutOfRangeStatus=indicate is provided, the return value of the RTE shall be RTE_E_INVALID.

In case of a composite datatype each composite element whose actual value is out of bounds shall be set to the invalidValue. If the handleOutOfRangeStatus attribute is set to indicate, the return value of the RTE shall be RTE_E_INVALID, if any of the composite elements is out of bounds. ⌋*(SRS_Rte_00180)*

[SWS_Rte_08016] ⌈ If for a dataElement to be received a ReceiverComSpec with handleOutOfRange=externalReplacement is provided, a range check shall be implemented in the receiving component. If the value is out of bounds, the value actually received shall be replaced by the value sourced from the ReceiverComSpec.replaceWith (e.g. constant, NVRAM parameter).

If the value of the received dataElement is out of bounds and a NonqueuedReceiverComSpec with handleOutOfRangeStatus=indicate is provided, the return value of the RTE shall be RTE_E_OUT_OF_RANGE.

In case of a composite datatype the value actually received shall be completely replaced by the external value, if any of the composite elements is out of bounds. If the `handleOutOfRangeStatus` attribute is set to `indicate`, the return value of the RTE shall be `RTE_E_OUT_OF_RANGE`. ⌋*(SRS_Rte_00180)*

[SWS_Rte_03849] ⌈ If for a `dataElement` to be received a `QueuedReceiverComSpec` with `handleOutOfRange` set to `default` or `invalid` is provided, the RTE generator shall reject the input as an invalid configuration, since for a `QueuedReceiverComSpec` the attribute `initValue` is not defined (see SW-C Template [2]) and data invalidation is not supported (see [SWS_Rte_06727]). ⌋*(SRS_Rte_00180)*

[SWS_Rte_08025] ⌈ If for a `dataElement` to be received a `QueuedReceiverComSpec` is provided and the `handleOutOfRangeStatus` attribute is set to `indicate`, the RTE generator shall reject the input as an invalid configuration. ⌋*(SRS_Rte_00180)*

Range checks during runtime for inter ECU communication at the receiver's side are described in the following requirements:

[SWS_Rte_08029] ⌈ The RTE shall implement a range check in the receiving path of a particular signal if the `handleOutOfRange` is defined at the `ISignalProps` and has any value other than `none`. In this case all receivers of the specific `ISignal` on that ECU receive the value after the range check was applied. ⌋*(SRS_Rte_00180)*

[SWS_Rte_08042] ⌈ The RTE shall use the limits from the `ISignal` for the range check of received data in the receiving path of a particular signal if the `handleOutOfRange` is defined at the `ISignalProps`. ⌋*(SRS_Rte_00180)*

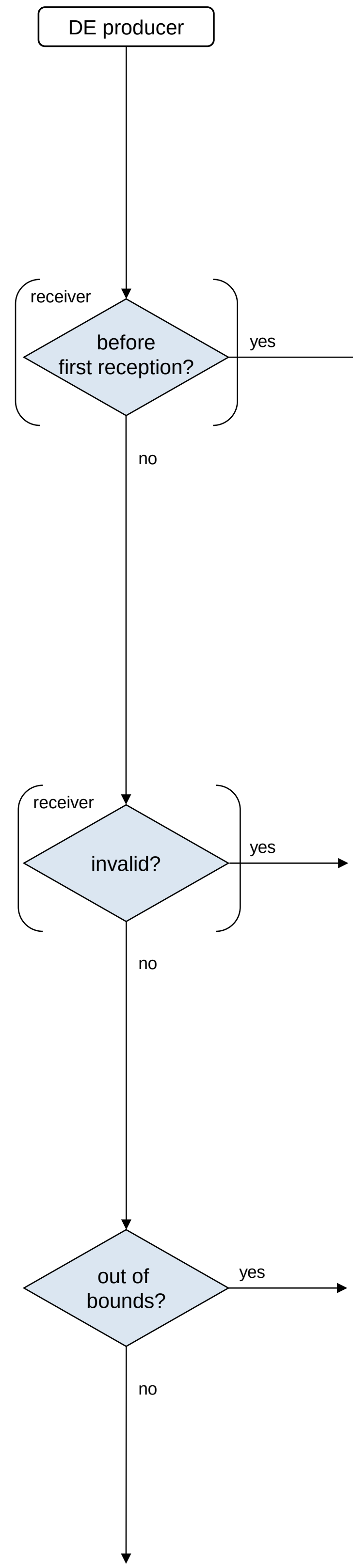
[SWS_Rte_08034] ⌈ If for an `ISignal` to be received an `ISignalProps` with `handleOutOfRange=ignore` is provided, a range check shall be implemented in the receiving signal. If the value is out of bounds, the reception of the `ISignal` shall not be propagated. In this case the RTE shall behave as if no reception occurred. ⌋*(SRS_Rte_00180)*

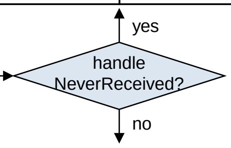
[SWS_Rte_08035] ⌈ If for an `ISignal` to be received an `ISignalProps` with `handleOutOfRange=saturate` is provided, a range check shall be implemented in the receiving signal. If the value is out of bounds, the value actually received shall be set to the lower respectively the upper limit. ⌋*(SRS_Rte_00180)*

[SWS_Rte_08036] ⌈ If for an `ISignal` to be received an `ISignalProps` with `handleOutOfRange=default` is provided, a range check shall be implemented in the receiving signal. If the value is out of bounds and the `initValue` is not equal to the `invalidValue`, the value actually received shall be set to the `initValue`. ⌋*(SRS_Rte_00180)*

[SWS_Rte_08037] ⌈ If for an `ISignal` to be received an `ISignalProps` with `handleOutOfRange=invalid` is provided, a range check shall be implemented in the receiving signal. If the value is out of bounds, the value actually received shall be set to the `invalidValue`. ⌋*(SRS_Rte_00180)*

[SWS_Rte_08038] ⌈ If for an `ISignal` to be received an `ISignalProps` with `handleOutOfRange`=`externalReplacement` is provided, a range check shall be implemented in the receiving signal. If the value is out of bounds, the value actually received shall be replaced by the value sourced from the `ReceiverComSpec`.`replaceWith` (e.g. constant, NVRAM parameter). ⌋*(SRS_Rte_00180)*





Configuration handleInvalid	RTE status		DE propagation
	init != invalid	init == invalid	
keep	RTE_E_ NEVER_RECEIVED	RTE_E_ NEVER_RECEIVED	init value
replace	RTE_E_ NEVER_RECEIVED	REJECT	init value
dontInvalidate	RTE_E_ NEVER_RECEIVED	RTE_E_ NEVER_RECEIVED	init value
external Replacement	RTE_E_ NEVER_RECEIVED	RTE_E_ NEVER_RECEIVED	external replacement value

Configuration handleInvalid	RTE status		DE propagation
	init != invalid	init == invalid	
keep	RTE_E_OK	RTE_E_INVALID	init value
replace	RTE_E_OK	REJECT	init value
dontInvalidate	RTE_E_OK	RTE_E_OK	init value
external Replacement	RTE_E_OK	RTE_E_OK	external replacement value

Configuration handleInvalid	RTE status		DE propagation
	init != invalid	init == invalid	
keep	RTE_E_INVALID	RTE_E_INVALID	last valid value[1]
replace	RTE_E_OK	REJECT	init value
dontInvalidate	RTE_E_OK	RTE_E_OK	value
external Replacement	RTE_E_OK	RTE_E_OK	external replacement value

Configuration handleOutOfRange	RTE status		DE propagation
	handleOutOfRange Status == silent[5]	handleOutOfRange Status == indicate[4,5]	
none	RTE_E_OK	RTE_E_OK	value
ignore	RTE_E_OK	RTE_E_ OUT_OF_RANGE	last valid value[2]
saturate	RTE_E_OK	RTE_E_ OUT_OF_RANGE	lower/upper limit
default[4]	RTE_E_OK	RTE_E_ OUT_OF_RANGE	init value[3]
invalid[4]	RTE_E_INVALID	RTE_E_INVALID	invalid value
external Replacement[5]	RTE_E_OK	RTE_E_ OUT_OF_RANGE	external replacement value

1. If no valid value was received previously then the init value shall be propagated
2. In case of queued communication the RTE behaves as if no value was enqueued
3. Init value shall not be equal to invalid value
4. Applicable only in combination with a non-queued COMSPEC
5. Applicable only in combination with a receiver COMSPEC

RTE status	DE propagation
RTE_E_OK	value

Figure 4.45: Overview for data invalidation and range checks

4.4 Modes

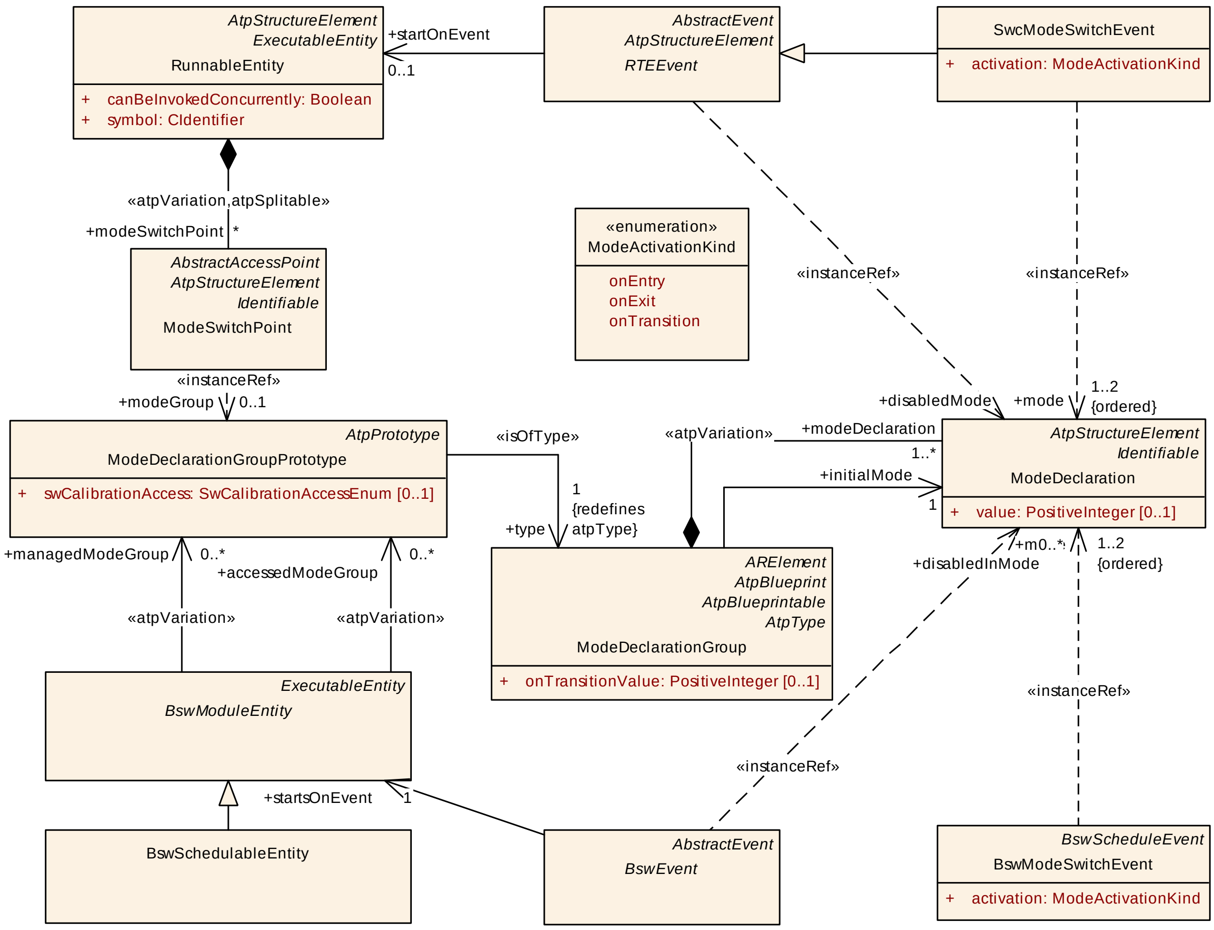


Figure 4.46: Summary of the use of ModeDeclarations by an AUTOSAR software-components and Basic Software Modules as defined in the *Software Component Template Specification* [2] and *Specification of BSW Module Description Template* [9].

The purpose of modes is to start `RunnableEntity`s and *Basic Software Schedulable Entities* on the transition between modes and to disable (/enable) specified triggers of `RunnableEntity`s and *Basic Software Schedulable Entities* in certain modes. Here, we use the specification of modes from the *Software Component Template Specification* [2]. Further on the document *Specification of BSW Module Description Template* [9] describes how modes are described for *Basic Software Modules*.

The first subsection 4.4.1 describes how modes can be used by an AUTOSAR software-component or *Basic Software Module* `mode user`. The role of the `mode manager` who initiates mode switches is described in section 4.4.2. How `ModeDeclaration`s are connected to a state machine is described in subsection 4.4.3. The behavior of the RTE and *Basic Software Scheduler* regarding mode switches is detailed in subsection 4.4.4.

One usecase of modes is described in section 4.6.2 for the initialization and finalization of AUTOSAR software-components. Modes can be used for handling of communication states as well as for specific application purposes. The specific definition of modes and their use is not in the scope of this document.

The status of the modes will be notified to the AUTOSAR software-component `mode user` by mode communication - `mode switch notifications` - as described in the subsection 4.4.7. The port for receiving (or sending) a `mode switch notification` is called

`mode switch port`.

A *Basic Software Module* `mode users` and the *Basic Software Module* `mode manager` are not necessarily using ports. *Basic Software Modules* without *AUTOSAR Interfaces* are connected via the configuration of the *Basic Software Scheduler*.

4.4.1 Mode User

To use modes, an AUTOSAR software-component (`mode user`) has to reference a `ModeDeclarationGroup` by a `ModeDeclarationGroupPrototype` of a require `mode switch port`, see section 4.4.7. The `ModeDeclarationGroup` contains the required modes. Alternatively the `mode manager` can also contain a `ModeAccessPoint` for a provided `mode switch port` and can combine the roles of `mode user` and `mode manager` for the same `ModeDeclarationGroupPrototype`.

An *Basic Software Module* (`mode user`) has to define a `requiredModeGroup` `ModeDeclarationGroupPrototype`.The `ModeDeclarationGroup` referred by these `ModeDeclarationGroupPrototype` contains the required modes. Similar to a software-component `mode user`, the Basic Software Module `mode manager` can also contain a `accessedModeGroup` for a `providedModeGroup` `ModeDeclarationGroupPrototype`. By this it combines the roles of `mode user` and `mode manager` for the same `ModeDeclarationGroupPrototype`.

The `ModeDeclaration`s can be used in two ways by the `mode user` (see also figure 4.46):

1. Modes can be used to trigger runnables: The `SwcInternalBehavior` of the AUTOSAR SW-C or the `BswInternalBehavior` of the BSW module can define a `SwcModeSwitchEvent` respectively a `BswModeSwitchEvent` referencing the required `ModeDeclaration`. This `SwcModeSwitchEvent` or `BswModeSwitchEvent` can then be used as trigger for a `RunnableEntity` / `BswSchedulableEntity`. Both `SwcModeSwitchEvent` and `BswModeSwitchEvent` carry an attribute `ModeActivationKind` which can be 'exit', 'entry', or 'transition'.

   A `RunnableEntity` or `BswSchedulableEntity` that is triggered by a `SwcModeSwitchEvent` or a `BswModeSwitchEvent` with `ModeActivationKind` 'exit' is triggered on exiting the mode. For simplicity it will be called on-exit ExecutableEntity. Correspondingly, an on-transition ExecutableEntity is triggered by a SwcModeSwitchEvent or a BswModeSwitchEvent with ModeActivationKind 'transition' and will be executed during the transition between two modes, and an

on-entry ExecutableEntity is triggered by a SwcModeSwitchEvent or a BswModeSwitchEvent with ModeActivationKind 'entry' and will be executed when the mode is entered.

Since a RunnableEntity as well as a BswSchedulableEntity can be triggered by multiple RTEEvents respectively BswEvents, both can be an *on-exit-*, *on-transition* and *on-entry ExecutableEntity* at the same time.

RTE does not support a WaitPoint for a SwcModeSwitchEvent (see [SWS_Rte_01358]).

2. An RTEEvent or BswEvent that starts an ExecutableEntity can contain a mode disabling dependency.

   [SWS_Rte_02503] ⌈ If a RunnableEntity *r* is referenced with startOnEvent by an RTEEvent *e* that has a mode disabling dependency on a mode *m*, then

   RTE shall not activate runnable *r* on any occurrence of *e* while the mode *m* is active.

   ⌋*(SRS_Rte_00143, SRS_Rte_00052)*

   [SWS_Rte_07530] ⌈ If a BswSchedulableEntity *r* is referenced with startsOnEvent by an BswEvent *e* that has a mode disabling dependency on a mode *m*, then *Basic Software Scheduler* shall not activate BswSchedulableEntitys *r* on any occurrence of *e* while the mode *m* is active. ⌋ *(SRS_Rte_00213)*

   Note: As a consequence of [SWS_Rte_02503] and [SWS_Rte_07530] in combination with [SWS_Rte_02661], RTE or *Basic Software Scheduler* will not start runnable or BswSchedulableEntity *r* on any occurrence of *e* while the mode *m* is active.

   The mode disabling is active during the transition to a mode, during the mode itself and during the transition for exiting the mode. For a precise definition see section 4.4.4.

   The existence of a mode disabling dependency prevents the RTE to start the mode disabling dependent ExecutableEntity by the disabled RTEEvent / BswEvent during the mode, referenced by the mode disabling dependency, and during the transitions from and to that mode. mode disabling dependencys override any activation of a RunnableEntity and BswSchedulableEntity by the disabled RTEEvents / BswEvents. This is also true for the SwcModeSwitchEvent and BswModeSwitchEvent.

A RunnableEntity as well as a BswSchedulableEntity can not be 'enabled' explicitly. RunnableEntitys are *Basic Software Schedulable Entities* are only 'enabled' by the absence of any active mode disabling dependencys.

Note that mode disabling dependencys do not prevent the wake up from a WaitPoint by the 'disabled' RTEEvent. This allows the wake-uped RunnableEntity to run until completion if a transition occurred during the RunnableEntitys execution.

[SWS_Rte_02504] ⌈ The existence of a mode disabling dependency shall not instruct the RTE to kill a running runnable at a mode switch. ⌋ *(SRS_Rte_00143)*

[SWS_Rte_07531] ⌈ The existence of a mode disabling dependency shall not instruct the *Basic Software Scheduler* to kill a running BswSchedulableEntity at a mode switch. ⌋ *(SRS_Rte_00213)*

The RTE and the *Basic Software Scheduler* can be configured to switch schedule tables to implement mode disabling dependencies for cyclic triggers of RunnableEntitys or *Basic Software Schedulable Entities*. Sets of mutual exclusive modes can be mapped to different schedule tables. The RTE shall implement the switch between schedule tables according to the mapping of modes to schedule tables in RteModeScheduleTableRef, see [SWS_Rte_05146].

The mode user can specify in the ModeSwitchReceiverComSpec (software components) or BswModeReceiverPolicy (BSW modules) that it is able to deal with asynchronous mode switch behavior (supportsAsynchronousModeSwitch == TRUE). If all mode users connected to the same ModeDeclarationGroupPrototype of the mode manager support the asynchronous mode switch behavior, the related mode machine instance can be implemented with the asynchronous mode switching procedure. Otherwise, the synchronous mode switching procedure has to be applied (see [SWS_Rte_07150]).

4.4.2 Mode Manager

Entering and leaving modes is initiated by a mode manager. A mode manager might be a basic software module, for example the Basic Software Mode Manager (BswM), the communication manager (ComM), or the ECU state manager (EcuM). The mode manager may also be an AUTOSAR SW-C. In this case, it is called an application mode manager.

The mode manager contains the master state machine to represent the modes.

To provide modes, an AUTOSAR software-component (mode manager) has to reference a ModeDeclarationGroup by a ModeDeclarationGroupPrototype of a provide mode switch port, see section 4.4.7. The ModeDeclarationGroup contains the provided modes.

An *Basic Software Module* (mode manager) has to define a providedModeGroup ModeDeclarationGroupPrototype. The ModeDeclarationGroup referred by these ModeDeclarationGroupPrototype contains the provided modes.

The RTE / *Basic Software Scheduler* will take the actions necessary to switch between the modes. This includes the termination and execution of several *ExecutableEntities* from all mode users that are connected to the same *ModeDeclarationGroupPrototype* of the mode manager. To do so, the RTE / *Basic Software Scheduler* needs a state machine to keep track of the currently active modes and transitions initiated by the mode manager. The RTE's / *Basic Software Scheduler*'s mode machine is called mode machine instance. There is exactly one mode machine instance for each *ModeDeclarationGroupPrototype* of a mode manager's provide mode switch port respectively providedModeGroup ModeDeclarationGroupPrototype.

It is the responsibility of the mode manager to advance the RTE's / *Basic Software Scheduler*'s mode machine instance by sending mode switch notifications to the mode users. The mode switch notifications are implemented by a non blocking API (see 5.6.6 / 6.5.7). So, the mode switch notifications alone provide only a loose coupling between the state machine of the mode manager and the mode machine instance of the RTE / *Basic Software Scheduler*. To prevent, that the mode machine instance lags behind and the states of the mode manager and the RTE / *Basic Software Scheduler* get out of phase, the mode manager can use acknowledgment feedback for the mode switch notification. RTE / *Basic Software Scheduler* can be configured to send an acknowledgment of the mode switch notification to the mode manager when the requested transition is completed.

At the mode manager, the acknowledgment results in an ModeSwitchedAckEvent. As with DataSendCompletedEvents, this event can be picked up with the polling or blocking Rte_SwitchAck API. And the event can be used to trigger a ModeSwitchAck ExecutableEntity to pick up the status. Note: The *Basic Software Scheduler* do not support WaitPoints. Therefore the SchM_SwitchAck never blocks.

Some possible usage patterns for the acknowledgement are:

- The most straight forward method is to use a sequence of Rte_Switch and a blocking Rte_SwitchAck to send the mode switch notification and wait for the completion. This requires the use of an extended task.
- Another possibility is to have a cyclic RunnableEntity / BswSchedulableEntity (maybe the same that switches the modes via Rte_Switch / SchM_Switch) to poll for the acknowledgement using Rte_SwitchAck / SchM_SwitchAck.
- The acknowledgement can also be polled from a RunnableEntity or BswSchedulableEntity that is started by the *ModeSwitchedAckEvent*.

The mode manager can also use the Rte_Mode / SchM_Mode API to read the currently active mode from the RTE's / *Basic Software Scheduler*'s perspective.

4.4.3 Refinement of the semantics of ModeDeclarations and ModeDeclarationGroups

To implement the logic of mode switches, the RTE / *Basic Software Scheduler* needs some basic information about the available modes. For this reason, RTE / *Basic Software Scheduler* will make the following additional assumptions about the modes of one ModeDeclarationGroup:

1. **[SWS_Rte_CONSTR_09013] Exactly one mode or one mode transition shall be active** ⌈ Whenever any RunnableEntity or BswSchedulableEntity is running, there shall always be exactly one mode or one mode transition active of each ModeDeclarationGroupPrototype. ⌋*()*

2. Immediately after initialization of a mode machine instance, RTE / *Basic Software Scheduler* will execute a transition to the initial mode of each ModeDeclarationGroupPrototype (see [SWS_Rte_02544]).

   RTE / *Basic Software Scheduler* will enforce the mode disablings of the initial modes and trigger the on-entry ExecutableEntitys (if any defined) of the initial modes of every ModeDeclarationGroupPrototype immediately after initialization of the RTE / *Basic Software Scheduler*.

In other words, RTE / *Basic Software Scheduler* assumes, that the modes of one ModeDeclarationGroupPrototype belong to exactly one state machine without nested states. The state machines cover the whole lifetime of the atomic AUTOSAR SW-Cs[9] and mode dependent AUTOSAR Basic Software Modules [10].

4.4.4 Order of actions taken by the RTE / *Basic Software Scheduler* upon interception of a mode switch notification

This section describes what the ‘communication’ of a mode switch to a mode user actually does. What does the RTE *Basic Software Scheduler* do to switch a mode and especially in which order.

Mode switch procedures

Depending on the needs of mode users for synchronicity, the mode machine instance can be implemented with two different realizations.

- synchronous mode switching procedure
- asynchronous mode switching procedure

The differences between these two realizations are the omitted waiting conditions in case of asynchronous mode switching procedure. For instance with asynchronous

[9] The lifetime of an atomic AUTOSAR SW-C is considered to be the time span in which the SW-C's runnables are being executed.

[10] The lifetime of an mode dependent AUTOSAR Basic Software Module is considered to be the time span in which the *Basic Software Schedulable Entities* are being executed.

behavior a software component can not rely that all mode disabling dependent ExecutableEntitys of the previous mode are terminated before on-entry ExecutableEntitys and on-exit ExecutableEntitys are started. On one hand this might put some effort to the software component designer to enable the components implementation to support this kind of scheduling but on the other hand it enables fast and lean mode switching.

[SWS_Rte_07150] ⌈ The RTE generator shall use the synchronous mode switching procedure if at least one mode user of the mode machine instance does not support the asynchronous mode switch behavior. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*

[SWS_Rte_07151] ⌈ The RTE generator shall apply the asynchronous mode switch behavior, if all mode users support the asynchronous mode switch behavior and if it is configured for the related mode machine instance. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*

Typical usage of modes to protect resources

RTE / *Basic Software Scheduler* can start and prevent the execution of RunnableEntitys and BswSchedulableEntity. In the context of mode switches,

- RTE / *Basic Software Scheduler* starts on-exit ExecutableEntitys for leaving the previous mode. This is typically used by ‘clean up ExecutableEntitys’ to free resources that were used during the previous mode.
- RTE / *Basic Software Scheduler* starts on-entry ExecutableEntitys for entering the next mode. This is typically used by ‘initialization ExecutableEntitys’ to allocate resources that are used in the next mode.
- And RTE / *Basic Software Scheduler* can prevent the execution of mode disabling dependent ExecutableEntitys within a mode. This is typically used with time triggered ‘work ExecutableEntity’ that use a resource which is not available in a certain mode.

According to this use case, during the execution of ‘clean up ExecutableEntitys’ and ‘initialization ExecutableEntitys’ the ‘work ExecutableEntitys’ should be disabled to protect the resource. Also, if the same resource is used (by different SW-C’s) in two successive modes, the ‘clean up ExecutableEntitys’ should be safely terminated before the ‘initialization ExecutableEntitys’ of the next mode are executed (synchronous mode switching procedure). In summary, this would lead to the following sequence of actions by the RTE / *Basic Software Scheduler* upon reception of the mode switch notification:

1. activate mode disablings for the next mode
2. wait for the newly disabled ExecutableEntitys to terminate in case of synchronous mode switching procedure
3. execute ‘clean up ExecutableEntitys’
4. wait for the ‘clean up ExecutableEntitys’ to terminate in case of synchronous mode switching procedure

5. execute ‘initialization ExecutableEntitys’
6. wait for the ‘initialization ExecutableEntitys’ to terminate in case of synchronous mode switching procedure
7. deactivate mode disablings for the previous modes and enable ExecutableEntitys that have been disabled in the previous mode.

RTE / *Basic Software Scheduler* can also start on-transition ExecutableEntitys on a transition between two modes which is not shown in this use case example.

Often, only a fraction of the SW-Cs, Runnable Entities, Basic Software modules and Basic Software Schedulable Entities of one ECU depends on the modes that are switched. Consequently, it should be possible to design the system in a way, that the mode switch does not influence the performance of the remaining software.

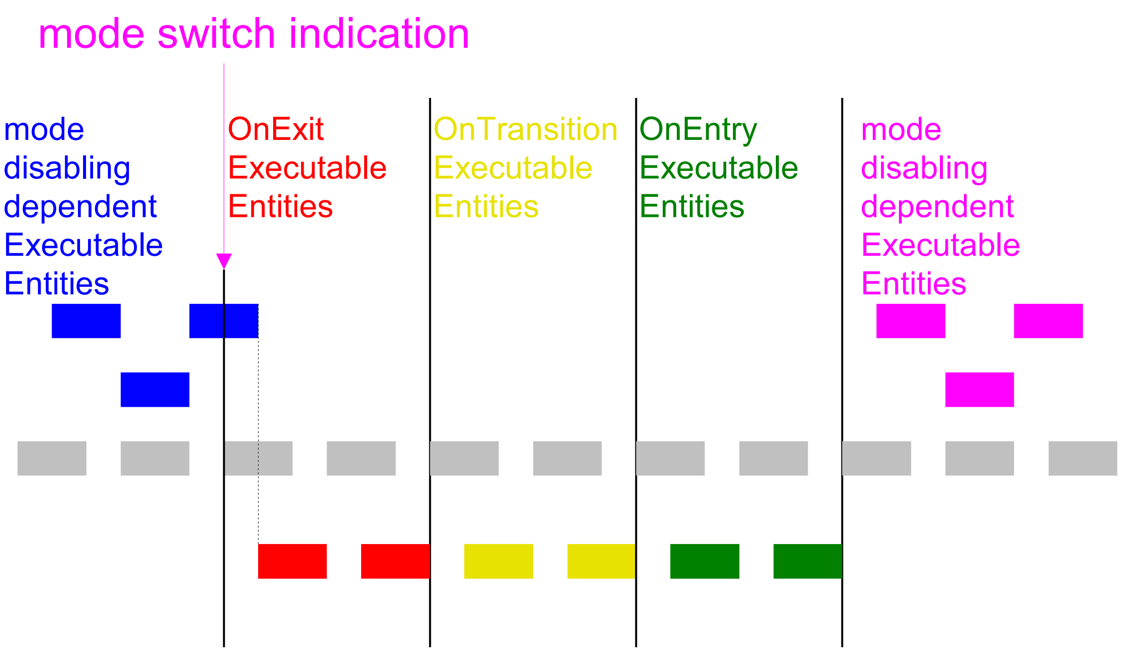


Figure 4.47: This figure shall illustrate what kind of ExecutableEntities will run in what order during a synchronous mode transition. The boxes indicate activated ExecutableEntities. Mode disabling dependant ExecutableEntities are printed in blue (old mode) and pink (new mode). on-exit, on-transition, and on-entry ExecutableEntity are printed in red, yellow, and green.

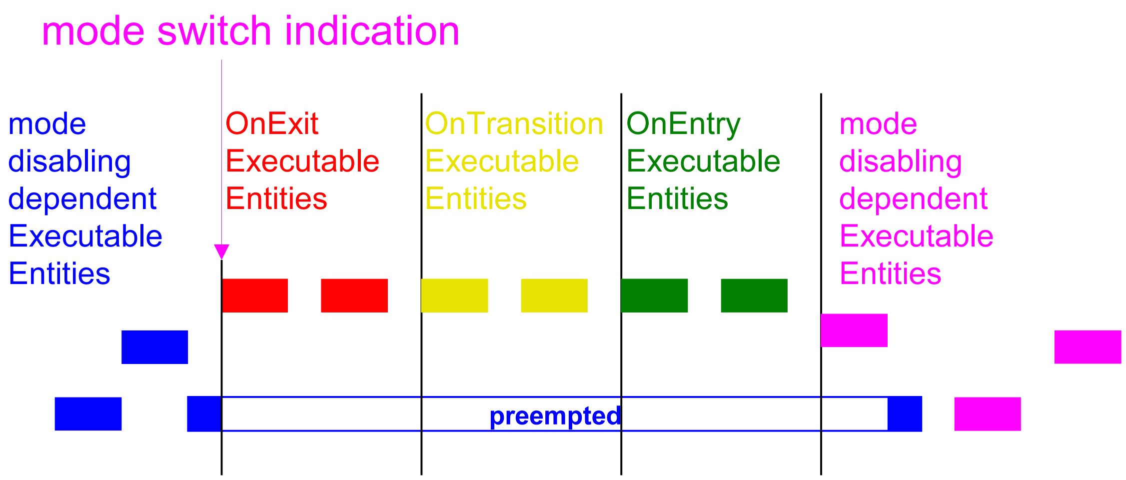


Figure 4.48: This figure shall illustrate what kind of ExecutableEntity will run in what order during an asynchronous mode transition where the ExecutableEntities are triggered on a mode change are mapped to a higher priority task than the Mode Dependent ExecutableEntity. The boxes indicate activated ExecutableEntity. Mode disabling dependant ExecutableEntity are printed in blue (old mode) and pink (new mode). on-exit, on-transition, and on-entry ExecutableEntity are printed in red, yellow, and green.

The remainder of this section lists the requirements that guarantee the behavior described above.

All runnables with dependencies on modes have to be executed or terminated during mode transitions. Restriction [SWS_Rte_02500] requires these runnables to be of category 1 to guarantee finite execution time.

For simplicity of the implementation to guarantee the order of runnable executions, the following restriction is made:

All `on-entry ExecutableEntitys`, `on-transition ExecutableEntitys`, and `on-exit ExecutableEntitys` of the same `mode machine instance` should be mapped to the same task in the execution order following on-exit, on-transition, on-entry (see [SWS_Rte_02662]).

A `mode machine instance` implementing an asynchronous mode switch procedure might be fully implemented inside the `Rte_Switch` or `SchM_Switch` API. In this case the `on-entry ExecutableEntitys`, `on-transition ExecutableEntitys`, `on-exit ExecutableEntitys` and `ModeSwitchAck ExecutableEntitys` are not mapped to tasks as described in chapter 8.5.1.

[SWS_Rte_07173] ⌈ The RTE generator shall support invocation of `on-entry ExecutableEntitys`, `on-transition ExecutableEntitys`, `on-exit ExecutableEntitys` and `ModeSwitchAck ExecutableEntitys` via direct function call, if all following conditions are fulfilled:

- if the asynchronous mode switch behavior is configured (see [SWS_Rte_07151])

- the on-entry ExecutableEntitys, on-transition ExecutableEntitys, on-exit ExecutableEntitys and ModeSwitchAck ExecutableEntitys do not define a 'minimum start distance'
- the mode manager and mode user are in the same Partition
- if the preconditions of [constr_4086] are fulfilled

⌋*(SRS_Rte_00143, SRS_Rte_00213)*

Further on the requirements [SWS_Rte_05083], [SWS_Rte_07155] and [SWS_Rte_07157] has to be considered.

[SWS_Rte_02667] ⌈ Within the mode manager's Rte_Switch / SchM_Switch API call to indicate a mode switch, one of the following shall be done:

1. If the corresponding mode machine instance is in a transition, and the queue for mode switch notifications is full, Rte_Switch / SchM_Switch shall return an error immediately.
2. If the corresponding mode machine instance is in a transition, and the queue for mode switch notifications is not full, the mode switch notification shall be queued.
3. If the mode machine instance is not in a transition, Rte_Switch / SchM_Switch shall initiate the transition as described by the sequence in [SWS_Rte_02665] which in turn activates the mode disablings (see [SWS_Rte_02661]) of the next mode.

⌋*(SRS_Rte_00143, SRS_Rte_00213)*

The following list holds the requirements for the steps of a mode transition.

- **[SWS_Rte_02661]** ⌈ At the beginning of a transition of a mode machine instance, the RTE / *Basic Software Scheduler* shall activate the mode disablings of the next mode (see also [SWS_Rte_02503]), if any mode disabling dependencys for that mode are defined. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*
- **[SWS_Rte_07152]** ⌈ If any mode disabling dependencys for the next mode are defined (as specified by [SWS_Rte_02661]), the RTE / *Basic Software Scheduler* shall wait until the newly disabled RunnableEntitys and *Basic Software Schedulable Entities* are terminated, in case of synchronous mode switching procedure. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*

  Note: To guarantee in case of synchronous mode switching all activated mode disabling dependent ExecutableEntitys of this core local mode user group have terminated before the start of the on-exit ExecutableEntitys of the transition, RTE generator can exploit the restriction [SWS_Rte_02663] that mode disabling dependent ExecutableEntitys run with higher or equal priority than the on-exit ExecutableEntitys and the on-entry ExecutableEntitys.

- **[SWS_Rte_02562]** ⌈ RTE / *Basic Software Scheduler* shall execute the on-exit ExecutableEntitys of the previous mode. ⌋*(SRS_Rte_00143, SRS_Rte_00052, SRS_Rte_00213)*
- **[SWS_Rte_07153]** ⌈ If any on-exit ExecutableEntity is configured the RTE / *Basic Software Scheduler* shall wait after its execution ([SWS_Rte_02562]) until all on-exit ExecutableEntitys are terminated in case of synchronous mode switching procedure. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*
- **[SWS_Rte_02707]** ⌈ RTE / *Basic Software Scheduler* shall execute the on-transition ExecutableEntitys configured for the transition from previous mode to next mode. ⌋*(SRS_Rte_00143, SRS_Rte_00052, SRS_Rte_00213)*
- **[SWS_Rte_02708]** ⌈ If any on-transition ExecutableEntity is configured, the RTE / *Basic Software Scheduler* shall wait after its execution ([SWS_Rte_02707]) until all on-transition ExecutableEntitys are terminated in case of synchronous mode switching procedure. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*
- **[SWS_Rte_02564]** ⌈ RTE / *Basic Software Scheduler* shall execute the on-entry ExecutableEntitys of the next mode. ⌋*(SRS_Rte_00143, SRS_Rte_00052, SRS_Rte_00213)*
- **[SWS_Rte_07154]** ⌈ If any on-entry ExecutableEntity is configured the RTE shall wait after its execution ([SWS_Rte_02564]) until all on-entry ExecutableEntitys are terminated in case of synchronous mode switching procedure. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*
- **[SWS_Rte_02563]** ⌈ The RTE / *Basic Software Scheduler* shall deactivate the previous mode disablings and only keep the mode disablings of the next mode. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*

  With this, the transition is completed.
- **[SWS_Rte_02587]** ⌈ At the end of the transition, RTE / *Basic Software Scheduler* shall trigger the ModeSwitchedAckEvents connected to the mode manager's *ModeDeclarationGroupPrototype*. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*

  This will result in an acknowledgment on the mode manager's side which allows the mode manager to wait for the completion of the mode switch.

  The dequeuing of the mode switch notification shall also be done at the end of the transition, see [SWS_Rte_02721].

[SWS_Rte_02665] ⌈ During a transition of a mode machine instance each applicable of the steps

1. [SWS_Rte_02661] (The transition is entered in parallel with this step),
2. [SWS_Rte_07152],

3. [SWS_Rte_02562],
4. [SWS_Rte_07153],
5. [SWS_Rte_02707],
6. [SWS_Rte_02708],
7. [SWS_Rte_02564],
8. [SWS_Rte_07154],
9. [SWS_Rte_02563] (The transition is completed with this step), and
10. immediately followed by [SWS_Rte_02587]

shall be executed in the order as listed for a core local mode user group. If a step is not applicable, the order of the remaining steps shall be unchanged.

If mode users are belonging to different core local mode user group the steps 1. - 9. may be executed in parallel on the different cores. The step 10. is executed if the step 1. - 9. is finished for the whole mode machine instance. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*

In the case that mode users belonging to the same mode machine instance are mapped to different partitions which in turn are scheduled on different micro controller cores the sequence described in [SWS_Rte_02665] can be parallelized.

[SWS_Rte_02668] ⌈ Immediately after the execution of a transition as described in [SWS_Rte_02665], RTE / *Basic Software Scheduler* shall check the queue for pending `mode switch notifications` of this `mode machine instance`. If a `mode switch notification` can be dequeued, the `mode machine instance` shall enter the corresponding transition directly as described by the sequence in [SWS_Rte_02665]. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*

In the case of a fast sequence of two mode switches, the `Rte_Mode` or `SchM_Mode` API will not indicate an intermediate mode, if a `mode switch notification` to the next mode is indicated before the transition to the intermediate mode is completed.

[SWS_Rte_02630] ⌈ In case of synchronous mode switch procedure, the RTE shall execute all steps of a mode switch (see [SWS_Rte_02665]) synchronously for the whole `mode machine instance`. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*

I.e., the mode transitions will be executed synchronously for all `mode users` that are connected to the same `mode manager`'s `ModeDeclarationGroupPrototype`.

[SWS_Rte_02669] ⌈ If the next mode and the previous mode of a transition are the same, the transition shall still be executed. ⌋*(SRS_Rte_00143, SRS_Rte_00213)*

4.4.5 Assignment of mode machine instances to RTE and Basic Software Scheduler

[SWS_Rte_07533] ⌈ A mode machine instance shall be assigned to the RTE if the correlating ModeDeclarationGroupPrototype is instantiated in a port of a software-component and if the ModeDeclarationGroupPrototype is not synchronized (*synchronizedModeGroup* of a *SwcBswMapping*) with a providedModeGroup ModeDeclarationGroupPrototype of a Basic Software Module instance. ⌋ *(SRS_Rte_00143)*

[SWS_Rte_07534] ⌈ A mode machine instance shall be assigned to the *Basic Software Scheduler* if the correlating ModeDeclarationGroupPrototype is a providedModeGroup ModeDeclarationGroupPrototype of a Basic Software Module instance. ⌋ *(SRS_Rte_00213)*

[SWS_Rte_07535] ⌈ The RTE Generator shall create only one mode machine instance if a *ModeDeclarationGroupPrototype* instantiated in a port of a software-component is synchronized (*synchronizedModeGroup* of a SwcBswMapping) with a providedModeGroup ModeDeclarationGroupPrototype of a Basic Software Module instance. The related common mode machine instance shall be assigned to the *Basic Software Scheduler*. ⌋ *(SRS_Rte_00143, SRS_Rte_00213, SRS_Rte_00214)*

In case of synchronized ModeDeclarationGroupPrototypes the correlating common mode machine instance is initialized during the execution of the SchM_Init. At this point of time the scheduling of RunnableEntitys is not enabled due to the uninitialized RTE. Therefore situation occurs, that the RunnableEntitys being on-entry ExecutableEntitys are not called if the mode machine instance is initialized. Further on the current mode of such mode machine instance might be still switched until the RTE gets initialized. Nevertheless the *on-entry Runnables* of the current active mode are executed.

[SWS_Rte_07582] ⌈ For common mode machine instances the *on-entry Runnable Entities* of the current active mode are executed during the initialization of the RTE if the common mode machine instance is not in transition. ⌋ *(SRS_Rte_00214)*

[SWS_Rte_07583] ⌈ A common mode machine instances is not allowed to enter transition phase during the RTE initialization if the common mode machine instances has *on-entry Runnable Entities*, *on-transition Runnable Entities* or *on-exit Runnable Entities* ⌋ *(SRS_Rte_00214)*

Note: [SWS_Rte_07582] and [SWS_Rte_07583] shall ensure a deterministic behavior that the software components receiving a Mode Switch Request from a common mode machine instances are receiving the current active mode during RTE initialization.

[SWS_Rte_07564] ⌈ The RTE generator shall reject configurations where ModeSwitchPoint(s) referencing a ModeDeclarationGroupPrototype in a mode switch port and a managedModeGroup association(s) to a providedModeGroup ModeDeclarationGroupPrototype are not defined mutual exclusively to one of two synchronized ModeDeclarationGroupPrototypes. ⌋*(SRS_Rte_00143, SRS_Rte_00213, SRS_Rte_00214, SRS_Rte_00018)*

[SWS_Rte_CONSTR_09014] *ModeSwitchPoint*(s) and *managedModeGroup*(s) are mutually exclusive for synchronized *ModeDeclarationGroupPrototypes* ⌈
Only one of two synchronized *ModeDeclarationGroupPrototype*s shall mutual exclusively be referenced by *ModeSwitchPoint*(s) or *managedModeGroup* association(s). ⌋*()*

Note: [SWS_Rte_CONSTR_09014] shall ensure in the combination with the existence conditions of the Rte_Switch, Rte_Mode, Rte_SwitchAck, SchM_Switch, SchM_Mode and SchM_SwitchAck that either the port based RTE API or the *Basic Software Scheduler* API ([SWS_Rte_07201] and [SWS_Rte_07264]) offered to the implementation of the mode manager.

4.4.6 Initialization of mode machine instances

A mode machine instance can either be initialized during Rte_Start or during Rte_Init. The initialization during Rte_Init enables a defined order when which mode machine instance gets initialized and the belonging *on-entry Runnable Entities* are scheduled.

[SWS_Rte_06766] ⌈ RTE shall initiate the transition to the initial modes of each mode machine instance belonging to the RTE during Rte_Start if the *on-entry Runnable Entities* for the initialMode are not mapped to any RteInitializationRunnableBatch container. ⌋*(SRS_Rte_00143, SRS_Rte_00144, SRS_Rte_00116)*

[SWS_Rte_06767] ⌈ RTE shall initiate the transition to the initial modes of each mode machine instance belonging to the RTE during Rte_Init if the *on-entry Runnable Entities* for the initialMode are mapped to one or several RteInitializationRunnableBatch container. ⌋*(SRS_Rte_00143, SRS_Rte_00144, SRS_Rte_00116, SRS_Rte_00240)*

Please note the restrictions on the mapping to RteInitializationRunnableBatch containers [SWS_Rte_CONSTR_09062], [SWS_Rte_CONSTR_09063] and [SWS_Rte_CONSTR_09064].

[SWS_Rte_02544] ⌈ During the transition to the initial modes of mode machine instances belonging to the RTE, the steps defined in the following requirements have to be omitted as no previous mode is defined:

- [SWS_Rte_02562],
- [SWS_Rte_07153],
- [SWS_Rte_02707],
- [SWS_Rte_02708],
- [SWS_Rte_02563],

- [SWS_Rte_02587]

If applicable, the steps described by the following requirements still have to be executed for entering the initial mode:

- [SWS_Rte_02661],
- [SWS_Rte_02564]

⌋*(SRS_Rte_00143, SRS_Rte_00144, SRS_Rte_00116)*

[SWS_Rte_07532] ⌈ *Basic Software Scheduler* shall initiate the transition to the initial modes of each `mode machine instance` belonging to the *Basic Software Scheduler* during `SchM_Init`. During the transition to the initial modes, the steps defined in the following requirements have to be omitted as no previous mode is defined:

- [SWS_Rte_02562],
- [SWS_Rte_07153],
- [SWS_Rte_02707],
- [SWS_Rte_02708],
- [SWS_Rte_02563],
- [SWS_Rte_02587]

If applicable, the steps described by the following requirements still have to be executed for entering the initial mode:

- [SWS_Rte_02661],
- [SWS_Rte_02564]

⌋*(SRS_Rte_00213)*

4.4.7 Notification of mode switches

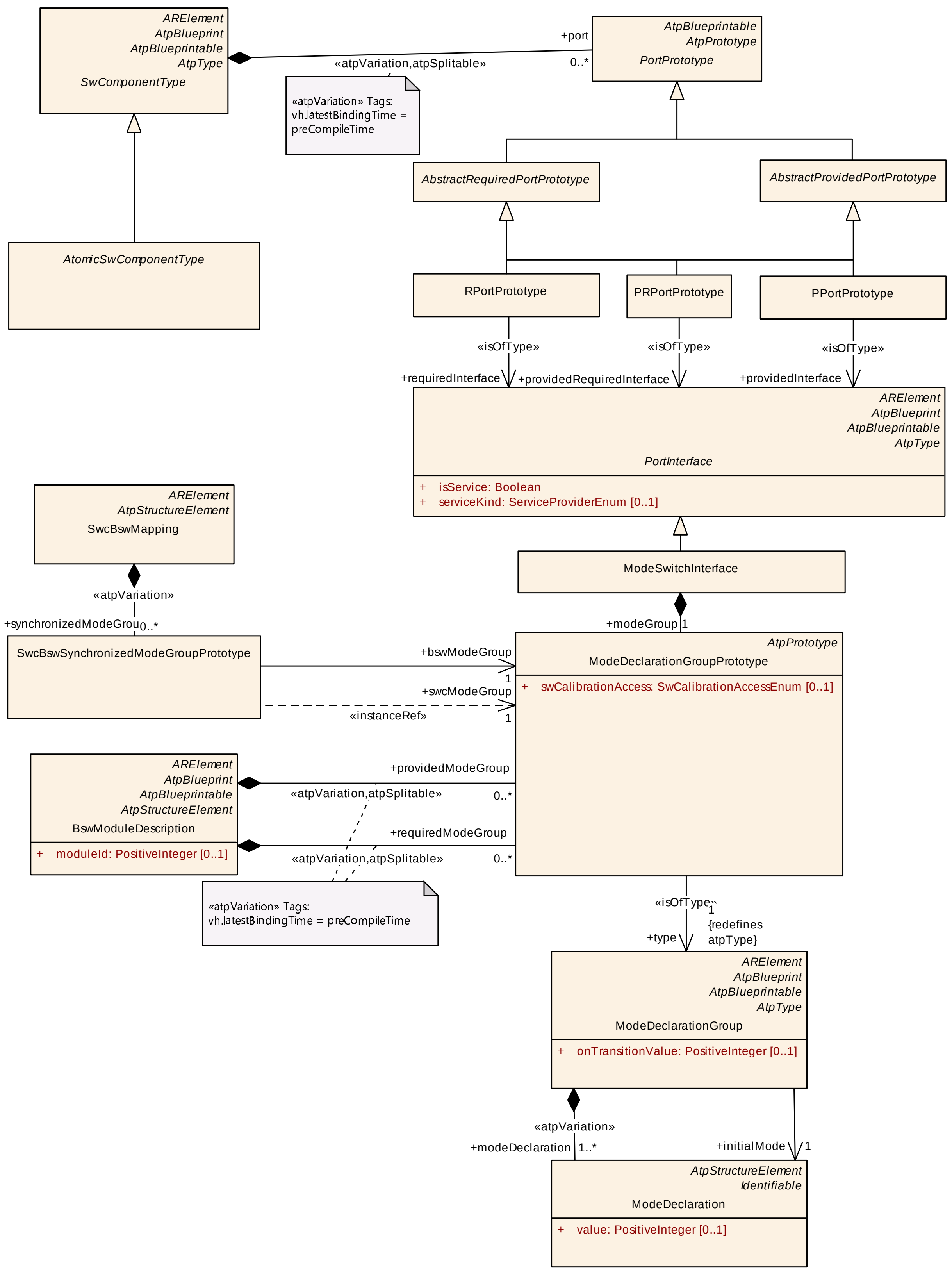


Figure 4.49: Definition of a ModeSwitchInterface.

- **[SWS_Rte_02549]** ⌈ Mode switches shall be communicated via RTE by `ModeDeclarationGroupPrototype`s of a `ModeSwitchInterface` as defined in [2], see Fig. 4.49. ⌋*(SRS_Rte_00144)*

  The `mode switch ports` of the `mode manager` and the `mode user` are of the type of a `ModeSwitchInterface`.

- **[SWS_Rte_07538]** ⌈ Mode switches shall be communicated via *Basic Software Scheduler* via `providedModeGroup` and `requiredModeGroup` *ModeDeclarationGroupPrototype*s as defined in [9], see Fig. 4.49. Which *ModeDeclarationGroupPrototype*s are connected to each other is defined by the configuration of the *Basic Software Scheduler*. ⌋*(SRS_Rte_00213)*

- RTE / *Basic Software Scheduler* only requires the notification of switches between modes.

- AUTOSAR does not support inter ECU communication of mode switch notifications.

  For the distributed mode management mode requests can be distributed via `ServiceProxySwComponentType`s and the BswM of each target ECU to the `mode users` of the BswMs.

- **[SWS_Rte_02508]** ⌈ A mode switch shall be notified asynchronously as indicated by the use of a `ModeSwitchInterface`. ⌋*(SRS_Rte_00144)*

  Rationale: This simplifies the communication. Due to [SWS_Rte_08788] the communication is ECU local and no handshake is required to guarantee reliable transmission.

  RTE offers the `Rte_Switch` API to the `mode manager` for this notification, see 5.6.6.

  Basic Software Scheduler offers the `SchM_Switch` API to the `mode manager` for this notification, see 6.5.7.

- The `mode manager` might still require a feedback to keep it's internal state machine synchronized with the RTE / *Basic Software Scheduler* view of active modes.

  The RTE generator shall support an AcknowledgementRequest from the `mode switch port` / `providedModeGroup` `ModeDeclarationGroupPrototype` of a `mode manager`, see [SWS_Rte_02587], to notify the `mode manager` of the completion of a mode switch.

- **[SWS_Rte_02566]** ⌈ A `ModeSwitchInterface` shall support 1:n communication. ⌋*(SRS_Rte_00144)*

  Rationale: This simplifies the configuration and the communication. One mode switch can be notified to all receivers simultaneously.

A ModeSwitchInterface does not support n:1 communication, see [SWS_Rte_02670].

- **[SWS_Rte_07539]** ⌈The connection of providedModeGroup and requiredModeGroup ModeDeclarationGroupPrototype shall support 1:n communication. ⌋*(SRS_Rte_00213)*

- **[SWS_Rte_02624]** ⌈ A mode switch shall be notified with event semantics, i.e., the mode switch notifications shall be buffered by RTE or *Basic Software Scheduler* to which the mode machine instance is assigned. ⌋*(SRS_Rte_00144)*

  The queueing of mode switches (and SwcModeSwitchEvents) depends like that of DataReceivedEvents on the settings for the receiving port, see section 4.3.1.10.2.

- **[SWS_Rte_02567]** ⌈ A ModeSwitchInterface shall only indicate the next mode of the transition. ⌋*(SRS_Rte_00144)*

- **[SWS_Rte_07541]** ⌈A providedModeGroup ModeDeclarationGroupPrototype shall only indicate the next mode of the transition. ⌋*(SRS_Rte_00213)*

  The API takes a single parameter (plus, optionally, the instance handle) that indicates the requested 'next mode'. For this purpose, RTE and *Basic Software Scheduler* will use identifiers of the modes as defined in [SWS_Rte_02568] and [SWS_Rte_07294].

- **[SWS_Rte_02546]** ⌈ The RTE shall keep track of the active modes of a mode manager's ModeDeclarationGroupPrototypes (mode machine instances) which is assigned to the RTE. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

- **[SWS_Rte_07540]** ⌈The *Basic Software Scheduler* shall keep track of the active modes of a mode manager's ModeDeclarationGroupPrototypes (mode machine instances) which is assigned to the *Basic Software Scheduler*. ⌋*(SRS_Rte_00213, SRS_Rte_00144)*

  Rationale: This allows the RTE / *Basic Software Scheduler* to guarantee consistency between the timing for firing of SwcModeSwitchEvents / BswModeSwitchEvents and disabling the start of ExecutableEntities by mode disabling dependency without adding additional interfaces to a mode manager with fine grained substates on the transitions.

- The RTE offers an Rte_Mode API to the SW-C to get information about the active mode, see section 5.6.30.

- The *Basic Software Scheduler* offers an SchM_Mode API to the Basic Software Module to get information about the active mode, see section 6.5.8.

- In addition to the mode switch ports, the mode manager may offer an AUTOSAR interface for requesting and releasing modes as a means to keep modes alive like for ComM and EcuM.

4.4.8 Mode switch acknowledgment

In case of mode switch communication, the mode manager may specify a ModeSwitchedAckEvent or BswModeSwitchedAckEvent to receive a notification from the RTE that the mode transition has been completed, see [SWS_Rte_02679] and [SWS_Rte_07559].

The ModeSwitchedAckEvent is triggered by the RTE regardless which runnable entity has requested the mode switch notification, even if the meta model implies a link to a specific ModeSwitchPoint.

[SWS_Rte_02679] ⌈ If acknowledgment is enabled for a provided ModeDeclarationGroupPrototype and a ModeSwitchedAckEvent references a RunnableEntity as well as the ModeDeclarationGroupPrototype, the RunnableEntity shall be activated when the mode switch acknowledgment occurs or when the RTE detects that any partition to which the mode users are mapped was stopped or restarted or when a timeout was detected by the RTE. ⌋*(SRS_Rte_00051, SRS_Rte_00143)*

The related *Entry Point Prototype* is defined in [SWS_Rte_02512].

[SWS_Rte_07559] ⌈ If acknowledgment is enabled for a provided (providedModeGroup) ModeDeclarationGroupPrototype and a BswModeSwitchedAckEvent references a BswSchedulableEntity as well as the ModeDeclarationGroupPrototype, the BswSchedulableEntity shall be activated when the mode switch acknowledgment occurs or when a timeout was detected by the *Basic Software Scheduler*. [SWS_Rte_02587]. ⌋*(SRS_Rte_00213, SRS_Rte_00143)*

The related *Entry Point Prototype* is defined in [SWS_Rte_04542].

Requirement [SWS_Rte_02679] and [SWS_Rte_07559] merely affects when the runnable is activated. The Rte_SwitchAck and SchM_SwitchAck shall still be created, according to requirement [SWS_Rte_02678] and [SWS_Rte_07558] to actually read the acknowledgment.

[SWS_Rte_02730] ⌈ A ModeSwitchedAckEvent that references a RunnableEntity and is referenced by a WaitPoint shall be an invalid configuration which is rejected by the RTE generator. ⌋*(SRS_Rte_00051, SRS_Rte_00018, SRS_Rte_00143)*

The attributes ModeSwitchedAckRequest and BswModeSwitchAckRequest allow to specify a timeout.

[SWS_Rte_07056] ⌈ If ModeSwitchedAckRequest or BswModeSwitchAckRequest with a timeout greater than zero is specified, the RTE shall ensure that timeout monitoring is performed, regardless of the receive mode of the acknowledgment. ⌋*(SRS_Rte_00069, SRS_Rte_00143)*

[SWS_Rte_07060] ⌈ Regardless of an occurred timeout during a mode transition the RTE shall complete the transition of a mode machine instance as defined in [SWS_Rte_02665]. ⌋*(SRS_Rte_00069, SRS_Rte_00143)*

If a WaitPoint is specified to collect the acknowledgment, two timeout values have to be specified, one for the ModeSwitchedAckRequest and one for the WaitPoint.

[SWS_Rte_07057] ⌈ The RTE generator shall reject configuration violating [constr_4012] in software component template [2]. ⌋*(SRS_Rte_00018, SRS_Rte_00143)*

[SWS_Rte_07058] ⌈ The status information about the success or failure of the mode transition shall be buffered with last-is-best semantics. When a new mode switch notification is sent or when the mode switch notification was completed after a timeout, the status information is overwritten. ⌋*(SRS_Rte_00143)*

[SWS_Rte_07058] implies that once the ModeSwitchedAckEvent or BswModeSwitchedAckEvent has occurred, repeated API calls (Rte_SwitchAck or SchM_SwitchAck to retrieve the acknowledgment can return different values.

[SWS_Rte_07059] ⌈ If the timeout value of the ModeSwitchedAckRequest or BswModeSwitchAckRequest is 0, no timeout monitoring shall be performed. ⌋*(SRS_Rte_00069, SRS_Rte_00143)*

4.4.9 Mode switch error handling

Since the mode switch communication may cross partitions basically two error scenarios are possible:

- The partition of the mode users gets terminated.
- The partition of the mode manager gets terminated.

In both cases additionally the terminated partition may be restarted. For both error scenarios the RTE offers functionality to handle the errors.

4.4.9.1 Mode User gets terminated

When a mode manager is getting out of sync with the mode user(s) (because the partition of the mode user has been terminated) a sequence of error reactions is defined.

This shall support on the one hand to inform the mode manager about the fact that the mode users are absent. This might be used by the mode manager to set internal states. This supports an active error handling by the mode manager as well as a synchronization of the mode manager to the mode user's partition restart.

Furthermore the RTE offers the ability to switch into a default mode automatically. This feature can be used to ensure that either the mode users are re-initialized as during ECU start (default mode is initial mode) or that the mode users are re-initialized by a dedicated mode (default mode is different from initial mode) which in turn may be used to ensure a secure behavior of the mode user's, for instance suppressing the actuator self tests in the running system.

Please note that the application of a default mode during mode user partition restart for modes communicated cross partitions cannot be applied since this would disturb the execution of the fault free partitions. For this scenario the only applicable error reaction is modeManagerErrorBehavior.errorReactionPolicy set to lastMode. Other configurations are rejected, see [SWS_Rte_08788].

[SWS_Rte_06794] ⌈ The RTE Generator shall take the modeManagerErrorBehavior from the ModeDeclarationGroup typing the ModeDeclarationGroupPrototype in the ModeSwitchInterface of the PPortPrototype/PRPortPrototype. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

[SWS_Rte_06772] ⌈ The RTE shall clear all mode switch notifications in the queue when all partitions of the mode userss are terminated. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

[SWS_Rte_06773] ⌈ The RTE shall activate RunnableEntitys triggered by a SwcModeManagerErrorEvent when all partitions of the mode userss are terminated. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

[SWS_Rte_06774] ⌈ If ModeSwitchedAckRequest or BswModeSwitchAckRequest is specified, the RTE shall detect a timeout when mode users partitions are terminated during an ongoing transition. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

Also see [SWS_Rte_02679], [SWS_Rte_07559], and [SWS_Rte_03853].

The further behavior of the mode machine instance depends on the attribute ModeDeclarationGroup.modeUserErrorBehavior.

[SWS_Rte_06775] ⌈ If the attribute modeManagerErrorBehavior.errorReactionPolicy is set to lastMode the mode machine instance stays in the last mode before the termination of the mode users. If the partition of the mode users gets terminated during an ongoing transition the last mode is the next mode of the transition. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

Please note: In case the partition of the mode users gets terminated during an ongoing transition logically the transition is still completed even if the mode users didn't "survive" the transition.

[SWS_Rte_06776] ⌈ If the attribute modeManagerErrorBehavior.errorReactionPolicy is set to defaultMode the RTE shall enqueue the mode defined by modeManagerErrorBehavior.defaultMode to the mode switch notification queue. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

If the ModeSwitchInterface does not define a specific modeManagerErrorBehavior the RTE uses the initialMode as a default mode.

[SWS_Rte_06777] ⌈ If the attribute modeManagerErrorBehavior is not defined the RTE shall enqueue the mode defined by initialMode to the mode switch notification queue. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

[SWS_Rte_06778] ⌈ The RTE shall execute the error reactions in case the partition of the mode users gets terminated in following order:

1. [SWS_Rte_06772]
2. [SWS_Rte_06773]
3. [SWS_Rte_06774]
4. [SWS_Rte_06775] or [SWS_Rte_06776] or [SWS_Rte_06777]

⌋*(SRS_Rte_00143, SRS_Rte_00144)*

If the partition of the mode users is capable to restart (PartitionCanBeRestarted == true) the mode manager shall be able to enqueue new mode switch requests during the restart of the partition. This shall support a dedicated error handling by the mode manager depending on other environmental conditions. In this case the mode manager may decide which transitions are appropriate to get the mode users either back in an operational mode or in a secure default mode. Therefore the errorReactionPolicy equals lastMode avoids any automatically forced mode transitions by the error handling of the RTE.

[SWS_Rte_06779] ⌈ RTE shall support the enqueueing of new mode switch requests during the restart of the mode user's partition by the mode manager after the call of Rte_PartitionRestarting. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

[SWS_Rte_06780] ⌈ When the partition with the mode users is restarted (after call of Rte_PartitionRestart), RTE shall dequeue queued mode switch notifications. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

When the first mode switch notification after a partition restart is dequeued the previous mode is defined as "last mode" or "on transition" depending on the modeManagerErrorBehavior.errorReactionPolicy. See [SWS_Rte_06783] and [SWS_Rte_06784].

Initialization of mode machine instance during mode user's partition restart

Depending on the modeManagerErrorBehavior the RTE has to re-initialize the mode machine instance during the restart of the mode user's partition. In case modeManagerErrorBehavior.errorReactionPolicy is set to defaultMode the behavior is similar as during the transition to the initial mode (see [SWS_Rte_02544]). During the initialization of the RTE resources for a restarting mode user partition only a subset of the single steps of a mode transition is applicable.

[SWS_Rte_06796] ⌈ During the transition to the default mode (next mode is default mode) of mode machine instances when the mode user's partition restarts, the steps defined in the following requirements have to be omitted as no previous mode is applicable:

- [SWS_Rte_02562],
- [SWS_Rte_07153],
- [SWS_Rte_02707],
- [SWS_Rte_02708],

- [SWS_Rte_02563],
- [SWS_Rte_02587]

If applicable, the steps described by the following requirements still have to be executed for entering the default mode:

- [SWS_Rte_02661],
- [SWS_Rte_02564]

⌋*(SRS_Rte_00143, SRS_Rte_00144)*

In case `modeManagerErrorBehavior.errorReactionPolicy` is set to `lastMode` the behavior indicates a stable mode during the re-initialization in order to provide the means to the `mode manager` to explicitly decide on the appropriate mode to handle the fault.

[SWS_Rte_06797] ⌈ If the attribute `modeManagerErrorBehavior.errorReactionPolicy` is set to `lastMode` the RTE / Basic Software Scheduler shall activate the `mode disablings` of the last mode during the partition restart, if any `mode disabling dependencys` for that mode are defined. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

4.4.9.2 Mode Manager gets terminated

When a `mode user` gets out of sync with the `mode manager` (because the partition of the `mode manager` has been terminated) a sequence of error reactions is defined.

Hereby the RTE offers the ability to automatically switch into a default mode. This feature can be used to ensure that the `mode users` are automatically switched into a defined mode which in turn may be used to ensure a secure behavior of the `mode users`, for instance switching off some actuators.

As an alternative the `mode machine instance` can stay in the last mode which can be used to keep the "status quo" until the `mode manager` is restarted.

[SWS_Rte_06795] ⌈ The RTE Generator shall take the `modeUserErrorBehavior` from the `ModeDeclarationGroup` typing the `ModeDeclarationGroupPrototype` in the `ModeSwitchInterface` of the `PPortPrototype`/`PRPortPrototype`. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

[SWS_Rte_06785] ⌈ If the partition of the `mode manager` gets terminated during an ongoing transition, the RTE shall complete the transition. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

[SWS_Rte_06786] ⌈ If the partition of the `mode manager` gets terminated during an ongoing transition, the RTE shall skip the mode switch acknowledgment. ⌋*(SRS_Rte_00143, SRS_Rte_00144)* For mode switch acknowledgment see [SWS_Rte_02587] and section 4.4.8

[SWS_Rte_06787] ⌈ The RTE shall clear all mode switch notifications in the queue when the partition of the mode manager gets terminated and after an ongoing transition is completed. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

[SWS_Rte_06788] ⌈ If the attribute modeUserErrorBehavior.errorReactionPolicy is set to lastMode the mode machine instance stays in the last mode before the termination of the mode manager. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

[SWS_Rte_06789] ⌈ If the attribute modeUserErrorBehavior.errorReactionPolicy is set to defaultMode the RTE shall enqueue the mode defined by modeUserErrorBehavior.defaultMode to the mode switch notification queue. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

[SWS_Rte_06790] ⌈ If the attribute modeUserErrorBehavior is not defined the RTE shall enqueue the mode defined by initialMode to the mode switch notification queue. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

[SWS_Rte_06791] ⌈ The RTE shall execute the error reactions in case the partition of the mode manager gets terminated in the following order:

1. [SWS_Rte_06785], [SWS_Rte_06786]
2. [SWS_Rte_06787]
3. [SWS_Rte_06788] or [SWS_Rte_06789] or [SWS_Rte_06790]

⌋*(SRS_Rte_00143, SRS_Rte_00144)*

[SWS_Rte_06792] ⌈ The RTE shall dequeue queued mode switch notifications and execute them regardless whether the partition with the mode manager is terminated, restarting or restarted. Thereby the restart of the mode manager's partition shall not abort the ongoing transition of a mode machine instance. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

This ensures that the defaultMode in the mode switch notification queue gets effective.

[SWS_Rte_06793] ⌈ The RTE shall activate RunnableEntitys triggered by a SwcModeManagerErrorEvent when the partition of the mode manager is restarted. ⌋*(SRS_Rte_00143, SRS_Rte_00144)*

4.4.10 Mapping of ModeDeclarations

There exist several use cases (especially if software is reused), where mode users are connected to mode managers providing ModeDeclarationGroups with different ModeDeclarations than the user.

Examples:

- A mode manager can be able to differentiate more fin grained sub states as it is required by the generic mode user. But due to the definition of the mode communication it is not possible to use two p-ports at the mode manager because this would lead to two independent and unsynchronized mode machine instances in the RTE.

- A generic mode user can support additionally modes which are not used by all mode managers.

This would normally lead to an error as incompatible ports are connected. To overcome this limitation the Software Component Template [2] provides a mapping between different ModeDeclarations so that the RTE can translated on mode to the other.

[SWS_Rte_08511] ⌈ If a ModeDeclaration of a mode user is mapped to a single ModeDeclaration of a mode manager the related mode of the mode user is entered or exit when the mapped mode of the mode manager is entered or exit. ⌋ *(SRS_Rte_00236)*

[SWS_Rte_08512] ⌈ If one ModeDeclaration of a mode user is mapped to several ModeDeclarations of a mode manager the related mode of the mode user is entered when any of the mapped modes of the mode manager mapped by one modeDeclarationMapping is entered. The related mode of the mode user is exit when any of the mapped modes of the mode manager mapped by one modeDeclarationMapping is exit and if the new mode is not mapped by the same modeDeclarationMapping to related mode of the mode user. ⌋*(SRS_Rte_00236)*

Note: If one ModeDeclaration of a mode user is mapped to several ModeDeclarations of a mode manager by the means of several modeDeclarationMappings the semantics is defined in a way that the individual mode transitions of the mode manager are getting visible as “exit” and “enter” events for the mode user. Further on the transition phase gets visible by the RTE_TRANSITION return value in the case that Rte_Mode-API is called during such a transition phase.

If one ModeDeclaration of a mode user is mapped to several ModeDeclarations of a mode manager by the means of a single modeDeclarationMapping the semantics is defined in a way that the individual mode transitions of the mode manager are **not** visible for the mode user.

Example:
The mode manager and the mode user have different ModeDeclarationGroups which are mapped by several modeDeclarationMappings. The ModeDeclarationGroup of the mode manager is more fine grained, so more than one of its ModeDeclarations has to be mapped onto the same ModeDeclaration of the mode user. The modeDeclarationMappings can be seen in table 4.13. The complete example is listed as ARXML in Appendix F.1.

modeDeclarationMapping	**ModeDeclarations of the mode manager**	**Mapped ModeDeclarations of the mode user**
StartUp_2_STARTUP	StartUp	STARTUP
Run_2_RUN	Run	RUN
PostRunX_2_POST_RUN	PostRun1 PostRun2	POST_RUN
ShutDown_2_SHUTDOWN	ShutDown	SHUTDOWN

Sleep_Hibernate_2_SHUTDOWN	Sleep Hibernate	SHUTDOWN

Table 4.13: Example of a modeDeclarationMapping which maps ModeDeclarations from mode manager to ModeDeclarations of the mode user

Table 4.14 shows a possible scenario how mode transitions of a mode manager will be seen from the point of view of a mode user when the modeDeclarationMapping maps more than one ModeDeclaration of the mode manager's ModeDeclarationGroup onto the same ModeDeclaration of the mode user's ModeDeclarationGroup.

Mode transitions of the mode manager	Mode transitions of the mode user resulting out of the mapping
Undefined → StartUp	Undefined → STARTUP
StartUp → Run	STARTUP → RUN
Run → PostRun1	RUN → POST_RUN
PostRun1 → PostRun2	— (no transition)
PostRun2 → ShutDown	POST_RUN → SHUTDOWN
ShutDown → Sleep	SHUTDOWN → SHUTDOWN
Sleep → Hibernate	— (no transition)

Table 4.14: Possible scenario of mode transitions by the mode manager and the resulting transitions from the point of view of the mode user

A configuration that maps several ModeDeclarations of a mode user to a single ModeDeclaration representing a mode of a mode manager shall be rejected (see also [constr_1209]). This is not valid as it violates the principle that modes are mutually exclusive.

[SWS_Rte_08513] ⌈ The RTE-Generator shall reject configurations violating [constr_1209]. ⌋ *(SRS_Rte_00236)*

If a modeDeclarationMapping exists that references a ModeDeclaration representing a mode of the mode manager then ModeDeclarationMappings shall exist that map all ModeDeclarations of the mode manager to ModeDeclarations of the mode user (see also [constr_1210]).

[SWS_Rte_08514] ⌈ The RTE-Generator shall reject configurations violating [constr_1210]. ⌋ *(SRS_Rte_00236)*

Note: It is only supported that modes of the mode user might not be mapped.

4.4.11 Distributed Shared Mode Queues

In case different mode state machines are switched via synchronous mode switches, the order of their execution is basically undefined. Limited possibilities exist by using separate tasks for the different mode state machines. But these would globally give switches of one mode machine instance a higher priority than switches of another mode machine instance. In some cases it is required to keep the strict order of the mode switches, independent to which mode state machine they belong. One example, could be the key state (ON, OFF) and the engine state (RUNNING, STOPPED) which are technically independent mode machine instances, but have a functional connection. If the mode switch from key ON to OFF occurs first, followed by the switch from engine RUNNING to STOPPED, it was obviously the user's intention to stop the engine. If the two transitions are executed in the reverse order, the system will see a switch from engine RUNNING to STOPPED while the key state is still ON which indicates a stalled engine which a start stop system might try to restart. This example shows how important it is for the application software to see the execution of the mode switches in the order they have been requested. As a result, it is required to have a mechanism to define a FIFO order for the mode switches of at least a subset of the mode machine machines in the ECU.

A similar issue occurs in multi core systems in which user components on multiple cores have to react directly or indirectly on a mode switch. On one side it is already clear that in case mode disabling dependencies exist on multiple cores, to fulfil the requirements about the synchronous switching of these disabling dependencies, it is necessary to have one mode switch task per partition having mode disabling dependencies. But also in case there are SwcModeSwitchEvents in components of different partitions which react on switches of the same mode machine instance there have to be multiple tasks performing these switches as it is not legal to execute RunnableEntitys of a software component assigned to one partition in tasks belonging to another partition. To avoid that one partition is already in the new state while the other one didn't even start the transition, it is also necessary to synchronize the mode switch tasks of multiple partitions, especially if they reside on different cores. This is important for the same reason as above. A component might expect a certain behavior of the system in a certain state. If now one partitions is still in the old state while another one is already in the new state, the expectation does not match reality with the consequence of functional misbehavior.

A distributed shared mode queue is characterized by a set of mode machine instances and a set of OsTasks in which the mode switches of the participating mode state machines will be executed.

[SWS_Rte_06832] ⌈The RTE Generator shall retrieve the set of mode machine instances belonging to one distributed shared mode queue from the set of RteDSMQModeMachineInstanceRef.⌋*(SRS_Rte_00143, SRS_Rte_00310)*

[SWS_Rte_06833] ⌈The RTE Generator shall retrieve the set of DSMQ transition OsTasks belonging to one distributed shared mode queue from the set of RteDSMQOsTaskRefs.⌋*(SRS_Rte_00143, SRS_Rte_00310)*

The OsTasks participating in a single distributed shared mode queue may or may not belong to a separate partition. If such OsTasks are belonging to OsApplications executed on the same micro controller core such DSMQ transition OsTasks have to be chained via the EcuC configuration. But not necessarily each partition will have an OsTask participating in a distributed shared mode queue.

The OsTasks participating in a single distributed shared mode queue will only contain ExecutableEntitys mapped to this OsTasks via SwcModeSwitchEvents, BswModeSwitchEvents, ModeSwitchedAckEvents or BswModeSwitchedAck-Events referencing one of the mode machine instance participating in this distributed shared mode queue.

[SWS_Rte_CONSTR_09102] Exclusive usage of OsTasks used for distributed shared mode queue ⌈ An OsTask belonging to a distributed shared mode queue shall have only mapped on-entry ExecutableEntitys, on-transition ExecutableEntitys, on-exit ExecutableEntitys, and ModeSwitchAck ExecutableEntitys to it which are triggered by mode machine instances belonging to the identical distributed shared mode queue. ⌋*()*

Thereby [SWS_Rte_06839] constraints the order of the event to task mappings.

Similar to the behavior defined in [SWS_Rte_02665] the execution of the mode switch may be triggered for each partition in parallel. If the partitions are executed on the same micro controller core the order depends on the priorities of the OsTask or on a configured task chaining. In case partitions are executed on different micro controller cores, execution of the on-entry ExecutableEntitys, on-transition ExecutableEntitys, and on-exit ExecutableEntitys may run concurrently.

[SWS_Rte_06834] ⌈ The RTE shall trigger all OsTasks belonging to a distributed shared mode queue simultaneously, except the ones which are chained after another OsTask belonging to this distributed shared mode queue. ⌋ *(SRS_Rte_00143, SRS_Rte_00310)*

[SWS_Rte_06835] ⌈ The RTE shall execute the mode switches of the mode machine instances participating in a distributed shared mode queue in the order of the calls of the related Rte_Switch or SchM_Switch APIs. ⌋*(SRS_Rte_00143, SRS_Rte_00310)*

Thereby the queued mode switches of the mode machine instances of the same distributed shared mode queue are processed one after the other according the FIFO principle.

[SWS_Rte_06838] ⌈ The RTE shall switch at most one mode machine instance of the set of mode machine instances participating in a distributed shared mode queue at the same time into transition. ⌋*(SRS_Rte_00143, SRS_Rte_00310)*

The implementation of the behavior defined in [SWS_Rte_06835] requires a single mode queue which handles the queuing of the mode switches for all mode machine instances. In opposite to the mode machine instance local queues such a shared queue has to memorize which transition in which mode machine instance was notified.

[SWS_Rte_06836] ⌈ The size of the mode queue of the distributed shared mode queue shall be the sum of the individual queue lengths of all mode machine instances participating in this distributed shared mode queue. ⌋ *(SRS_Rte_00143, SRS_Rte_00310)*

Nevertheless the RTE has still to check the individual queue sizes of each mode machine instances. This ensures, that each mode manager can always enqueue the maximum number of mode switch notifications reserved for this mode machine instances.

[SWS_Rte_06840] ⌈ If a new mode switch notification is received the RTE shall check if not more mode switch notifications of a particular mode machine instance are queued than the queue size of this particular mode machine instance supports. If the queue size would be exceeded, the RTE shall discard the received notification. ⌋ *(SRS_Rte_00143, SRS_Rte_00310)*

In this case, Rte_Switch will return an error, see [SWS_Rte_02675].

The behavior described in [SWS_Rte_02665] has the consequence, that RTE / Basic Software Scheduler deactivates the previous mode disablings asynchronous on each core. But one major use case of distributed shared mode queues is the synchronization of activities across partitions. Therefore previous mode disablings deactivated by RTE after all on-exit ExecutableEntitys are executed.

[SWS_Rte_06837] ⌈ During a transition of a mode machine instance belonging to one distributed shared mode queue following steps are applicable:

1. [SWS_Rte_02661],
2. [SWS_Rte_07152]
3. [SWS_Rte_02562],
4. [SWS_Rte_07153],
5. [SWS_Rte_02707],
6. [SWS_Rte_02708],
7. [SWS_Rte_02564],
8. [SWS_Rte_07154]
9. [SWS_Rte_02563] (The transition is completed with this step), and
10. immediately followed by [SWS_Rte_02587]

If a step is not applicable, the order of the remaining steps shall be unchanged.

Thereby:

- Step 1. - 2 shall be executed synchronously in each partition for the whole mode machine instance.
- Step 3. - 8. may be executed in parallel on the different cores and therefore are triggered in parallel for each partition.

- Step 9. shall be executed synchronously in each partition for the whole mode machine instance.

The step 10. is executed if the step 1. - 9. is finished for the whole mode machine instance. ⌋*(SRS_Rte_00143, SRS_Rte_00310)*

4.5 External and Internal Trigger

4.5.1 External Trigger Event Communication

4.5.1.1 Introduction

With the mechanism of the trigger event communication a software component or a *Basic Software Module* acting as a `trigger source` is able to request the activation of *Runnable Entities* respectively *Basic Software Schedulable Entities* of connected `trigger sinks`. Typically but not necessarily these *Runnable Entities* and *Basic Software Schedulable Entities* are executed in a sequential order.

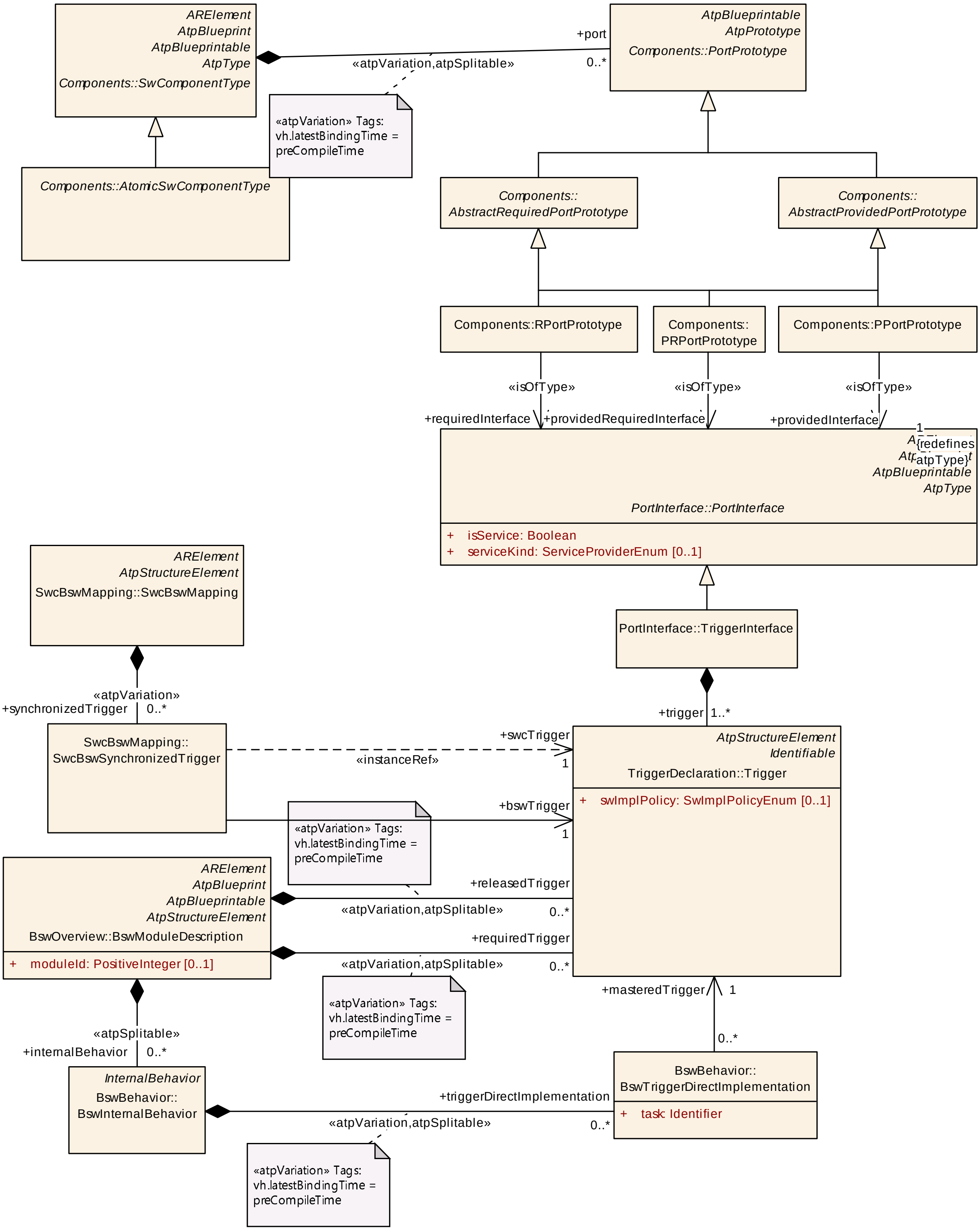


Figure 4.50: Summary of the use of Trigger by an AUTOSAR software-components and Basic Software Modules as defined in the *Software Component Template Specification*[2] and *Specification of BSW Module Description Template*[9].

[SWS_Rte_07212] ⌈ The RTE shall support *External Trigger Event Communication*. ⌋ *(SRS_Rte_00162)*

[SWS_Rte_07542] ⌈ The *Basic Software Scheduler* shall support the activation of *Basic Software Schedulable Entities* occurrence of External Trigger Events. ⌋ *(SRS_Rte_00216)*

4.5.1.2 Trigger Sink

A AUTOSAR software-component `trigger sink` has a dedicated require `trigger port`. The `trigger port` is typed by an *TriggerInterface* declaring one or more *Trigger*. See figure 4.50. The *Runnable Entities* of the software component are activated at the occurrence of the external event by the means of an `ExternalTriggerOccurredEvent`.

An *Basic Software Module* `trigger sink` has to define a *requiredTrigger Trigger*. The *Basic Software Schedulable Entities* of the *Basic Software Module* are activated at the occurrence of the external event by the means of a `BswExternalTriggerOccurredEvent`. See figure 4.50.

Basically there are two approaches to implement the activation of `triggered ExecutableEntitys`s. In one case the `triggered ExecutableEntitys`s of the `trigger sinks`s triggered by one `Trigger` of the `trigger source` are mapped in one or more tasks. In this case the event communication can be implemented by the means of activating an Operating System Task. Please note that the tasks may belong to different partitions.

[SWS_Rte_07213] ⌈ The RTE generator shall support invocation of `triggered ExecutableEntitys` via OS Task. ⌋ *(SRS_Rte_00162, SRS_Rte_00216)*

In the other case the Event Communication is mapped to a function call which means that the `triggered ExecutableEntitys` of the `trigger sinks` are executed in the `Rte_Trigger` API respectively `SchM_Trigger` API used to raise the trigger event in the `trigger sinks`.

[SWS_Rte_07214] ⌈ The RTE generator shall support invocation of `triggered ExecutableEntitys` via direct function call, if all of the follwing conditions are fulfilled:

- the `triggered ExecutableEntitys` do not define a 'minimum start distance'
- the `trigger sink` and `trigger source` are in the same Partition
- if no *BswTriggerDirectImplementation* is defined.
- if the preconditions of [constr_4086] are fulfilled
- no queuing for the `trigger source` is configured

⌋ *(SRS_Rte_00162, SRS_Rte_00216)*

4.5.1.3 Trigger Source

An AUTOSAR software-component trigger source has a dedicated provide trigger port. The trigger port is typed by an *TriggerInterface* declaring one or more *Trigger*. See figure 4.50. To be able to connect a provide trigger port and a require trigger port, both ports must be categorized by the same or by compatible *TriggerInterface*(s).

An *Basic Software Module* trigger source has to define a *releasedTrigger Trigger*. See figure 4.50. The connection of *releasedTrigger* and *requiredTrigger Trigger* is defined by the ECU configuration of the *Basic Software Scheduler*.

To inform the RTE about an occurrence of the external trigger event the RTE provides the Rte_Trigger to an AUTOSAR software-component trigger source.

[SWS_Rte_07543] ⌈ The call of the Rte_Trigger API shall activate all *Runnable Entities* that are activated by *ExternalTriggerOccurredEvent*s associated to a connected *Trigger* of the trigger source if either no queuing for the Trigger is configured or if queuing for the Trigger is configured and the trigger queue is empty. ⌋ *(SRS_Rte_00162)*

For Basic Software Module trigger source are two options defined to interfaces with *Basic Software Scheduler*.

The first option is that the *Basic Software Module* trigger source inform the *Basic Software Scheduler* about an occurrence of the external trigger event by the call of the SchM_Trigger API.

[SWS_Rte_07544] ⌈ The call of the SchM_Trigger API shall activate all ExecutableEntitys that are activated by *ExternalTriggerOccurredEvent*s associated to a connected *Trigger* of the trigger source if either no queuing for the Trigger is configured or if queuing for the Trigger is configured and the trigger queue is empty. ⌋*(SRS_Rte_00216)*

The second option is that the *Basic Software Module* trigger source directly takes care about the activation of the particular OS task to which the *ExternalTriggerOccurredEvent*s of the triggered ExecutableEntitys are mapped. In this case the trigger source has to define a *BswTriggerDirectImplementation*. The name of the used OS tasks is annotated by the *task* attribute. If an *BswTriggerDirectImplementation* is defined no SchM_Trigger API is generated by the RTE generator. see [SWS_Rte_07548] and [SWS_Rte_07264].

[SWS_Rte_07545] ⌈ The RTE generator shall reject configurations where a *BswTriggerDirectImplementation* is specified and an ExecutableEntity that is activated by an *ExternalTriggerOccurredEvent* associated to a connected *Trigger* of the trigger source is mapped to an OS task different from the one defined by the task attribute of the *BswTriggerDirectImplementation*. ⌋*(SRS_Rte_00216, SRS_Rte_00018)*

[SWS_Rte_07548] ⌈ The RTE generator shall reject configurations where a *issuedTrigger* association and a *BswTriggerDirectImplementation* is defined for the same *releasedTrigger Trigger*. ⌋*(SRS_Rte_00216, SRS_Rte_00018)*

[SWS_Rte_CONSTR_09007] *issuedTrigger* and *BswTriggerDirectImplementation* are mutually exclusive ⌈ A *releasedTrigger Trigger* shall not be referenced by both a *issuedTrigger* and a *BswTriggerDirectImplementation*. ⌋*()*

Note: This shall ensure in the combination with the existence conditions ([SWS_Rte_07264]) of the `SchM_Trigger` that either the Trigger API or the direct task activation is offered to the implementation of the `trigger source`.

Note also that several OS tasks might be used to implement a `Trigger` (several `BswTriggerDirectImplementation` can be defined for a *releasedTrigger*).

If the `BswTriggerDirectImplementation` is defined for a *releasedTrigger* which `swImplPolicy` attribute is set to `queued` it is part of the `trigger source` to implement the queue or to use the means of the OS (OsTaskActivation > 1) to queue the number of raised triggers. (OsTaskActivation > 1). Further details about queuing of triggers is described in 4.5.5.

4.5.1.4 Multiplicity

4.5.1.4.1 Multiple Trigger

A trigger interface contains one or more `Trigger`. A port of an AUTOSAR software-component that provides an AUTOSAR trigger interface to the component can independently raise events related to each `Trigger` defined in the interface .

[SWS_Rte_07215] ⌈ The RTE API shall support independent event raising for each `Trigger` in a trigger interface. ⌋*(SRS_Rte_00162)*

Further on a *Basic Software Module* `trigger source` can define several *releasedTrigger Trigger* which can be independently raised.

[SWS_Rte_07546] ⌈ The *Basic Software Scheduler* API shall support independent event raising for each *releasedTrigger* `Trigger`. ⌋*(SRS_Rte_00216)*

4.5.1.4.2 Multiple Trigger Sinks Single Trigger Source

The concept of external event communication supports, that a `trigger source` activates one or more `triggered ExecutableEntitys` in one or more `trigger sinks`.

[SWS_Rte_07216] ⌈ The RTE generator shall support `triggered ExecutableEntitys` triggered by the same `Trigger` of a `trigger source` ('$1 : n$' communication where $n \geq 1$). ⌋*(SRS_Rte_00162, SRS_Rte_00216)*

The execution order of the triggered ExecutableEntitys in the trigger sinks depends from the RteEventToTaskMapping described in chapter 8.5.1 and the configured priorities of the operating system.

4.5.1.4.3 Multiple Trigger Sources Single Trigger Sink

The RTE generator does not support multiple trigger sources communicating events to the same Trigger in a trigger sink ('$n:1$' communication where $n>1$).

[SWS_Rte_07039] ⌈ The RTE generator shall reject configurations where multiple trigger sources communicating events to the same Trigger in a trigger sink ('$n:1$' communication where $n>1$). ⌋*(SRS_Rte_00018)*

[SWS_Rte_CONSTR_09008] The same Trigger in a *trigger sink* must not be connected to multiple *trigger sources* ⌈ The same Trigger in a *trigger sink* must not be connected to multiple *trigger source*s. ⌋*()*

4.5.1.5 Synchronized Trigger

If two Triggers are synchronized by the definition of a SwcBswSynchronizedTrigger then the Trigger in the referenced provide trigger port and the referenced releasedTrigger Trigger are treated as one common Trigger. This means that all ExecutableEntitys activated by an ExternalTriggerOccurredEvent associated to one of the connected *Trigger*s are activated together.

[SWS_Rte_07218] ⌈ The RTE and *Basic Software Scheduler* shall activate together all ExecutableEntitys that are activated by ExternalTriggerOccurredEvents associated to a synchronized connected *Trigger*. ⌋*(SRS_Rte_00162, SRS_Rte_00216, SRS_Rte_00217)*

[SWS_Rte_07549] ⌈ The RTE generator shall reject configurations where a synchronized Trigger is referenced by more than one type of access method, where the type is one of the following:

1. ExternalTriggeringPoint
2. issuedTrigger
3. BswTriggerDirectImplementation

⌋*(SRS_Rte_00216, SRS_Rte_00217, SRS_Rte_00018)*

[SWS_Rte_CONSTR_09009] Synchronized Trigger shall not be referenced by more than one type of access method ⌈ A synchronized Trigger shall only be referenced by either ExternalTriggeringPoints, issuedTriggers or BswTriggerDirectImplementations. ⌋*()*

Note: This shall ensure in the combination with the existence conditions of the Rte_Trigger and SchM_Trigger that only one kind of Trigger API ([SWS_Rte_07201] and [SWS_Rte_07264]) or the direct task activation is offered to the implementation of the trigger source.

4.5.2 Inter Runnable Triggering

With the mechanism of *Inter Runnable Triggering* one *Runnable Entity* is able to request the activation of *Runnable Entities* of the same software-component instance.

[SWS_Rte_07220] ⌈ The RTE shall support Inter Runnable Triggering. ⌋ *(SRS_Rte_00163)*

Similar to External Trigger Event Communication (described in chapter 4.5.1) the activation of triggered runnables can be implemented by means of activating an Operating System Task or by direct function call.

[SWS_Rte_07555] ⌈ The call of the Rte_IrTrigger API shall activate all triggered runnables which *InternalTriggerOccurredEvent*s are associated with the related *InternalTriggeringPoint* of the same software-component instance if either no queuing for the InternalTriggeringPoint is configured or if queuing for the InternalTriggeringPoint is configured and the trigger queue is empty. ⌋ *(SRS_Rte_00163)*

[SWS_Rte_07221] ⌈ The RTE shall support for Inter Runnable Triggering that triggered runnables entities are invoked via OS Task activation. ⌋ *(SRS_Rte_00163)*

[SWS_Rte_07224] ⌈ The RTE shall support for *Inter Runnable Triggering* that triggered runnables are invoked via direct function call if all of the following conditions are fulfilled:

- none of the triggered BswSchedulableEntitys activated by this InternalTriggeringPoint define a ‘minimum start distance’
- no queuing for the InternalTriggeringPointis configured

⌋ *(SRS_Rte_00163)*

4.5.2.1 Multiplicity

An InternalTriggeringPoint might be referenced by more than one InternalTriggerOccurredEvent. Therefore one RunnableEntity is able to request the activation of several RunnableEntity’s with the mechanism of Inter Runnable Triggering contemporaneously.

[SWS_Rte_07223] ⌈ The RTE shall support multiple RunnableEntity’s triggered by the same InternalTriggeringPoint (‘$1 : n$’ Inter Runnable Triggering where $n \geq 1$). ⌋ *(SRS_Rte_00163)*

The execution order of the runnable entities in the trigger sinks depends from the Runnable Entity to task mapping described in chapter 8.5.1 and the configured priorities of the operating system.

4.5.3 Inter Basic Software Module Entity Triggering

The *Inter Basic Software Module Entity Triggering* is similar to the mechanism of *Inter Runnable Triggering* (see chapter 4.5.2) with the exception that it is used inside a Basic Software Module. It can be used to request the activation of a `BswSchedulableEntity` by a *Basic Software Entity* of the same a *Basic Software Module* instance.

[SWS_Rte_07551] ⌈ The *Basic Software Scheduler* shall support *Inter Basic Software Module Entity Triggering*. ⌋*(SRS_Rte_00230)*

Similar to External Trigger Event Communication (described in chapter 4.5.1) the activation of triggered `BswSchedulableEntity` can be implemented by means of activating an Operating System Task or by direct function call.

[SWS_Rte_07552] ⌈ The call of the `SchM_ActMainFunction` API shall activate all `triggered BswSchedulableEntitys` which *BswInternalTriggerOccurredEvent*s are associated by the related *activationPoint* of the same a *Basic Software Module* instance if either no queuing for the `BswInternalTriggeringPoint` is configured or if queuing for the `BswInternalTriggeringPoint` is configured and the trigger queue is empty.. ⌋*(SRS_Rte_00230)*

[SWS_Rte_07553] ⌈ The *Basic Software Scheduler* shall support for *Inter Basic Software Module Entity Triggering* that `triggered BswSchedulableEntitys` are invoked via OS Task activation. ⌋*(SRS_Rte_00230)*

[SWS_Rte_07554] ⌈ The *Basic Software Scheduler* shall support for *Inter Basic Software Module Entity Triggering* that `triggered BswSchedulableEntitys` are invoked via direct function call if

- the `triggered BswSchedulableEntitys` do not define a 'minimum start distance'
- if the preconditions of constraint [constr_4086] are fulfilled
- no queuing for the `BswInternalTriggeringPoint`is configured

⌋*(SRS_Rte_00230)*

Note: Typically the feature of *Inter Basic Software Module Entity Triggering* is used to decouple the execution context of *Basic Software Entities*. But if this decoupling is really required depends from the particular scheduling concept and microcontroller performance.

4.5.4 Inter ECU Trigger Communication

The trigger communication is also possible in case of inter-ECU communication. In this case, a software component on an ECU can act as a trigger source for a software component on another ECU, so requesting the activation of software components on the other ECU.

[SWS_Rte_08409] ⌈ The RTE shall support inter-ECU Trigger Communication. ⌋ *()*

[SWS_Rte_08410] ⌈ The RTE shall support the activation of RunnableEntitys occurence of Trigger Events coming from another ECU. ⌋*()*

[SWS_Rte_08411] ⌈ In case of an issued Trigger the RTE shall send the ISignal associated with that Trigger to the Com stack. ⌋*()*

In case no data transformation is used, the API call argument of Com_SendSignal has no meaning. In case of data transformation, the first transformer is executed without input data.

[SWS_Rte_08412] ⌈ In case of a received Trigger without data transformation the RTE shall only care about the COM Notification which indicates a reception of the zero size signal. The value of such signal shall not be read (Com_ReceiveSignal shall not be called). ⌋*()*

In case of a received Trigger with data transformation the RTE executes the inverse data transformation on the received data from Com Stack. (See [SWS_Rte_08597]). This is necessary to recognize transformation errors.

[SWS_Rte_08072] ⌈ The RTE generator shall reject configurations violating the [constr_3065]. ⌋*(SRS_Rte_00018)*

4.5.5 Queuing of Triggers

The queuing of triggers ensures that the number of executions of triggered ExecutableEntitys is equal to the number of released triggers. Further on it ensures that the number of activations of triggered ExecutableEntitys is equal for all associated triggered ExecutableEntitys of a trigger emitter if the associated triggered ExecutableEntitys are not activated by other RTEEvents. Therefore the trigger queue is rather a counter than a real queue.

[SWS_Rte_07087] ⌈ The RTE shall support the queuing of triggers for

- *External Trigger Event Communication*
- *Inter Runnable Triggering*
- *Inter Basic Software Module Entity Triggering*

if the RteTriggerSourceQueueLength / RteBswTriggerSourceQueueLength is configured > 0, regardless of the value of the attribute swImplPolicy of the trigger entity. ⌋(*SRS_Rte_00235*)

The attribute swImplPolicy specifies a queued or non queued processing of the trigger emitter. Since the setup of a queue might have other side effects on the dynamic behavior of the ECU its still an design decision of the ECU integrator to configure a trigger queue.
Therefore it is possible to configure a trigger queue regardless on the value of the attribute swImplPolicy of the trigger emitter.

[SWS_Rte_07088] ⌈ The RTE shall enqueue a trigger when the RTE gets informed about the occurrence of a trigger by the call of the related API (Rte_IrTrigger, Rte_Trigger, SchM_Trigger, SchM_ActMainFunction) if queuing for this trigger emitter is configured and if the maximum queue length (RteTrigger-SourceQueueLength / RteBswTriggerSourceQueueLength) is not exceeded. ⌋ (*SRS_Rte_00235*)

[SWS_Rte_07089] ⌈ The RTE shall dequeue a trigger when the trigger emitter is informed about the end of execution of all triggered ExecutableEntitys which are triggered by this trigger emitter. In the case of triggered ExecutableEntitys whose execution is disabled by a mode disabling dependency then the trigger is dequeued as if the entities ran. This behaviour prevents the dequeue operation from being blocked indefinitely ⌋(*SRS_Rte_00235*)

[SWS_Rte_07090] ⌈ The RTE shall activate all triggered ExecutableEntitys associated to a trigger emitter when it has successfully dequeued a trigger from the trigger queue of the trigger emitter except for the last dequeued trigger. ⌋ (*SRS_Rte_00235*)

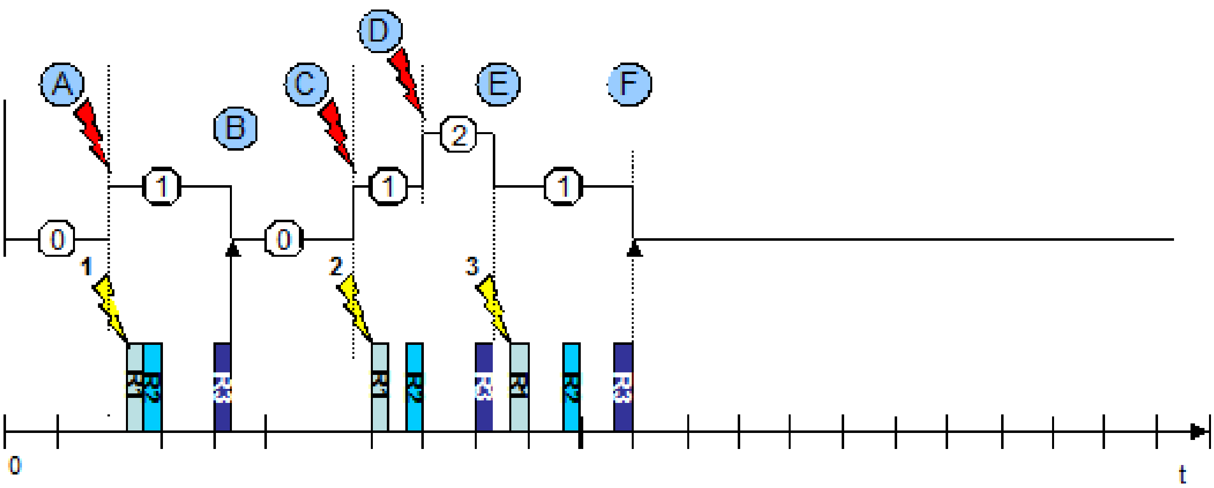


Figure 4.51: Queued activation of ExecutableEntitys

The figure 4.51 illustrates the basic behavior of a trigger queue.

- At "‘A"’ the RTE gets informed by the call of the API about the occurrence of a Trigger. Since no trigger is in the queue all associated triggered

ExecutableEntitys are activated ([SWS_Rte_07544], [SWS_Rte_07555], [SWS_Rte_07552]) and the trigger is enqueued ([SWS_Rte_07088]).

- At "'B"' all triggered ExecutableEntitys which are triggered by this trigger emitter have terminated. The RTE dequeues the trigger but since it is the last dequeued trigger the associated triggered ExecutableEntitys are not activated again.
- At "'C"' the RTE gets informed by the call of the API about the occurrence of a Trigger. Enqueuing of triggers and activating of triggered ExecutableEntitys is done as in "'A"'
- At "'D"' the RTE gets informed again by occurrence of a trigger. Since a trigger is already in the queue the associated triggered ExecutableEntitys are not activated ([SWS_Rte_07544], [SWS_Rte_07555], [SWS_Rte_07552]). Nevertheless the trigger is enqueued ([SWS_Rte_07088]).
- At "'E"' all triggered ExecutableEntitys which are triggered by this trigger emitter have terminated. The RTE dequeues the trigger ([SWS_Rte_07089]) and activates all associated triggered ExecutableEntitys ([SWS_Rte_07090]).
- At "'E"' all triggered ExecutableEntitys which are triggered by this trigger emitter have terminated. Dequeuing of triggers is done as in "'B"'

Implementation hint:
One possible solution to implement the queue for the number of released triggers is to use the means of the operation systems which already can queue the activation requests for a OS task (OsTaskActivation > 1). This for sure is only possible if all ExternalTriggerOccurredEvents, InternalTriggerOccurredEvents, BswExternalTriggerOccurredEvent and BswInternalTriggerOccurredEvent connected to the same trigger emitter with configured queuing are mapped exclusively to one OS task.

4.5.6 Activation of triggered ExecutableEntities

The activation of triggered ExecutableEntitys is done like described in chapter 4.2.3. See also Fig. 4.17.

If the triggered ExecutableEntitys are activated synchronous or asynchronous depends how the *RTEEvents* and *BswEvents* are mapped to OS tasks.

If all *ExternalTriggerOccurredEvents* of the trigger sinks which are associated to connected *Trigger* of the trigger source

- either are mapped to OS task(s) with higher priority as the OS task where the *Executable Entity* calling the Rte_Trigger respectively the SchM_Trigger API is mapped

- or are activated by direct function call

the triggering behaves synchronous. This means that all "triggered" *Executable Entities* of the trigger sinks are executed before the Rte_Trigger or SchM_Trigger API returns.

If any *ExternalTriggerOccurredEvent* of the trigger sinks which are associated to connected *Trigger* of the trigger source

are mapped to an OS task with lower priority as the OS task where the *Executable Entity* calling the Rte_Trigger respectively the SchM_Trigger API is mapped the triggering behaves asynchronous. This means that **not** all triggered ExecutableEntitys of the trigger sinks are executed before the Rte_Trigger or SchM_Trigger API returns.

4.6 Initialization and Finalization

4.6.1 Initialization and Finalization of the RTE

RTE and *Basic Software Scheduler* have a nested life cycle. It is only permitted to initialize the RTE if the *Basic Software Scheduler* is initialized ([SWS_Rte_CONSTR_09036]). Further on it is only supported to finalize the *Basic Software Scheduler* after the RTE is finalized ([SWS_Rte_CONSTR_09056]).

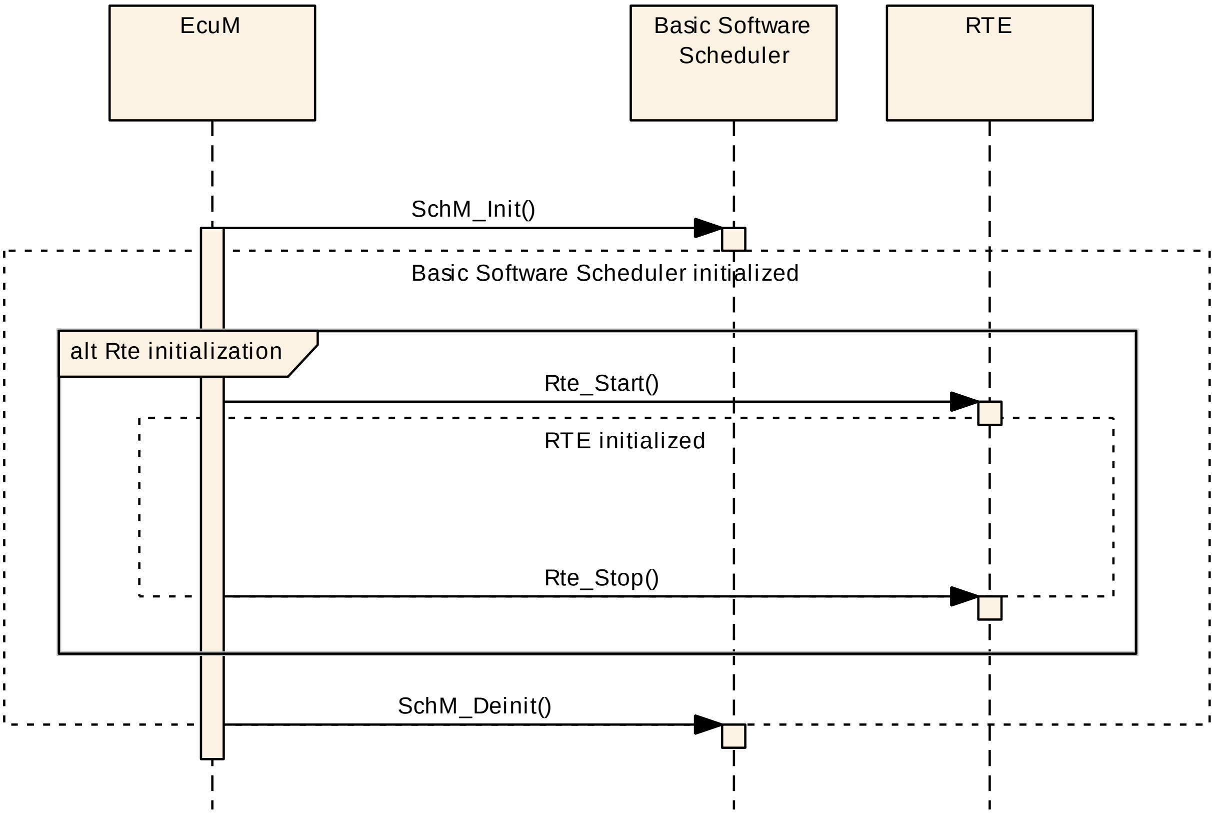


Figure 4.52: Nested life cycle of RTE and *Basic Software Scheduler*

4.6.1.1 Initialization of the Basic Software Scheduler

Before the *Basic Software Scheduler* is initialized only the API calls SchM_Enter and SchM_Exit are available ([SWS_Rte_07578]).

The ECU state manager calls the startup routine SchM_Init of the *Basic Software Scheduler* before any *Basic Software Module* needs to be scheduled.

The initialization routine of the *Basic Software Scheduler* will return within finite execution time (see [SWS_Rte_07273]).

The *Basic Software Scheduler* will initialize the mode machine instances ([SWS_Rte_02544])assigned to the *Basic Software Scheduler*. This will activate the mode disablings of all initial modes during SchM_Init and trigger the execution of the on-entry ExecutableEntitys of the initial modes. After initialization of the *Basic Software Scheduler* internal data structure and mode machine instances the activation of *Basic Software Schedulable Entities* triggered by BswTimingEvents starts.

[SWS_Rte_07574] ⌈ The call of SchM_StartTiming shall start the activation of BswSchedulableEntitys triggered by BswTimingEvents. ⌋*(SRS_Rte_00211)*

[SWS_Rte_07584] ⌈ The call of SchM_Init shall start the activation of BswSchedulableEntitys triggered by BswBackgroundEvents. ⌋*(SRS_Rte_00211)*

Note: In case of OS task where BswEvents and RTEEvents are mapped to the RTE Generator has to ensure, that RunnableEntitys are not activated before the RTE is initialized or after the RTE is finalized. See [SWS_Rte_07580] and [SWS_Rte_02538].

[SWS_Rte_07580] ⌈ The *Basic Software Scheduler* has to prevent the activation of RunnableEntitys before the RTE is initialized. ⌋*(SRS_Rte_00220)*

4.6.1.2 Initialization of the RTE

The ECU state manager calls the startup routine Rte_Start of the RTE at the end of startup phase II when the OS is available and all basic software modules are initialized.

The initialization routine of the RTE will return within finite execution time (see [SWS_Rte_02585]).

Before the RTE is initialized completely, there is only a limited capability of RTE to handle incoming data from COM:

The RTE will initialize the mode machine instances ([SWS_Rte_02544]) assigned to the RTE. This will activate the mode disablings of all initial modes during Rte_Start and trigger the execution of the on-entry ExecutableEntitys of the initial modes. Further on for common mode machine instances the *on-entry Runnable Entities* of the current active mode are executed during the initialization of the RTE ([SWS_Rte_07582]). common mode machine instances can not enter the transition phase during RTE initialization ([SWS_Rte_07583]).

[SWS_Rte_07575] ⌈ The call of Rte_Start shall start the activation of RunnableEntitys triggered by TimingEvents if the Rte_StartTiming API does not exist. ⌋ *(SRS_Rte_00072)*

[SWS_Rte_07178] ⌈ The call of Rte_Start shall start the activation of RunnableEntitys triggered by BackgroundEvents if the Rte_StartTiming API does not exist. ⌋ *(SRS_Rte_00072)*

[SWS_Rte_06759] ⌈ The call of Rte_StartTiming shall start the activation of RunnableEntitys triggered by TimingEvents if the Rte_StartTiming API does exist. ⌋ *(SRS_Rte_00072, SRS_Rte_00240)*

[SWS_Rte_06760] ⌈ The call of Rte_StartTiming shall start the activation of RunnableEntitys triggered by BackgroundEvents if the Rte_StartTiming API does exist. ⌋ *(SRS_Rte_00072, SRS_Rte_00240)*

[SWS_Rte_07615] ⌈ The call of Rte_Start shall be executed on every core independently. ⌋ *()*

[SWS_Rte_07616] ⌈ The Rte_Start includes the partition specific startup activities of RTE for all partitions that are mapped to the core, from which the Rte_Start is called. ⌋ *()*

4.6.1.3 Stop and restart of the RTE

Partitions of the ECU can be stopped and restarted. In a stopped or restarting partition, the OS has killed all running tasks. RTE has to react to stopping and restarting partitions.

The RTE does not execute ExecutableEntitys of a terminated or restarting partition.

[SWS_Rte_07604] ⌈ The RTE shall not activate, start or release ExecutableEntity execution-instances of a terminated or restarting partition. ⌋ *(SRS_Rte_00195)*

The RTE is notified of the termination (respectively, the beginning of restart) of a partition by the Rte_PartitionTerminated (respectively, Rte_PartitionRestarting) API. At this point in time, the tasks containing the runnables of this partition are already killed by the OS. In case of restart, RTE is notified by the Rte_RestartPartition API when the communication can be re-initialized and re-enabled.

[SWS_Rte_07604] also applies to ExecutableEntitys whose execution started before the notification to the RTE. RTE can rely on the OS functionality to stop or restart an OS application and all related OS objects.

When a partition is restarted, the RTE will restore an initial environment for its SW-Cs.

[SWS_Rte_02735] ⌈ When the Rte_RestartPartition API for a partition is called, the RTE shall restore an initial environment for its SW-Cs on this partition. ⌋ *()*

The SW-Cs themselves are responsible to restore their internal initial environment and should not rely on any initialization performed by the compiler. This should be done in initialization runnables.

[SWS_Rte_07610] ⌈ The RTE Generator shall reject configurations where the handleTerminationAndRestart attribute of a SW-C is not set to canBeTerminatedAndRestarted and this SW-C is mapped on a Partition with the PartitionCanBeRestarted parameter set to TRUE. ⌋*(SRS_Rte_00018, SRS_Rte_00196)*

When a partition is terminated or is being restarted, it is important that the runnable entities of this partition are not activated before the partition returns to the ACTIVE state.

In case of partition restart or termination, event sent to this partition or activation of tasks of this partition are discarded. The RTE can use these mechanism to ensure that ExecutableEntitys are not activated.

4.6.1.4 Finalization of the RTE

The finalization routine Rte_Stop of the RTE is called by the ECU state manager at the beginning of shutdown phase I when the OS is still available. (For details of the ECU state manager, see [7]. For details of Rte_Start and Rte_Stop see section 5.8.)

[SWS_Rte_02538] ⌈ The RTE shall not activate, start or release RunnableEntitys on a core after Rte_Stop has been called on this core. ⌋*(SRS_Rte_00116, SRS_Rte_00220)*

Note: RTE does not kill the tasks during the ‘running’ state of the runnables.

[SWS_Rte_02535] ⌈ RTE shall ignore incoming client server communication requests, before RTE is initialized completely and when it is stopped. ⌋*(SRS_Rte_00116)*

[SWS_Rte_02536] ⌈ Incoming data and events from sender receiver communication shall be ignored, before RTE is initialized completely and when it is stopped. ⌋ *(SRS_Rte_00116)*

4.6.1.5 Finalization of the *Basic Software Scheduler*

The ECU state manager calls the finalization routine SchM_Deinit of the *Basic Software Scheduler* if the scheduling of *Basic Software Modules* has to be stopped.

[SWS_Rte_07586] ⌈ The BSW Scheduler shall neither activate nor start BswSchedulableEntitys on a core after SchM_Deinit has been called on this core. ⌋ *(SRS_Rte_00116)*

Note: The BSW Scheduler does not kill the tasks during the ‘running’ state of the BswSchedulableEntitys.

[SWS_Rte_04552] ⌈ The basic software scheduler shall ignore incoming client server communication requests, before the basic software scheduler is initialized completely or after it is stopped. ⌋*(SRS_Rte_00116)*

4.6.2 Initialization and Finalization of AUTOSAR Software-Components

For the initialization and finalization of AUTOSAR software components, RTE provides the mechanism of mode switches. A SwcModeSwitchEvent of an appropriate ModeDeclaration can be used to trigger a corresponding initialization or finalization runnable (see [SWS_Rte_02562]). Runnables that shall not run during initialization or finalization can be disabled in the corresponding modes with a mode disabling dependency (see [SWS_Rte_02503]).

Since category 2 runnables have no predictable execution time and can not be terminated using ModeDisablingDependencies, it is the responsibility of the implementer to set meaningful termination criteria for the cat 2 runnables. These criteria could include mode information. At latest, all runnables will be terminated by RTE during the shutdown of RTE, see [SWS_Rte_02538].

It is appropriate to use user defined modes that will be handled in a proprietary application mode manager.

All runnables that are triggered by entering an initial mode, are activated immediately after the initialization of RTE. They can be used for initialization. In many cases it might be preferable to have a multi step initialization supported by a sequence of different initialization modes.

In addition to the mode-based approach RunnableEntitys to be used for initialization purposes can be activated by InitEvents as well. More information is provided in section 4.2.2.11.

4.7 Variant Handling Support

4.7.1 Overview

The *AUTOSAR Templates* support the creation of *Variant*s in a subset of its model elements. The *Variant Handling* support in the in *AUTOSAR Templates* is driven by the purpose to describe variability in a *AUTOSAR System* on several aspects, e.g.

- Virtual Functional Bus
- Component `SwcInternalBehavior` and `SwcImplementation`
- Deployment of the software components to ECUs
- Communication Matrix
- Basic Software Modules

This approach requires that the RTE Generator is able to process the described Variability in input configurations and partially to implement described variability in the generated RTE and Basic Software Scheduler code.

In the meta-model all locations that may exhibit variability are marked with the stereotype ≪atpVariation≫. This allows the definition of possible variation points. Tagged Values are used to specify additional information.

There are four types of locations in the meta-model which may exhibit variability:

- Aggregations
- Associations
- Attribute Values
- Classes providing property sets

More details about the AUTOSAR Variant Handling Concept can be found in the AUTOSAR Generic Structure Template [10].

[SWS_Rte_06543] ⌈The RTE generator shall support the `VariationPoint`s defined in the *AUTOSAR Meta Model* ⌋*(SRS_Rte_00201, SRS_Rte_00202, SRS_Rte_00229, SRS_Rte_00191)*

The list of `VariationPoint`s shall provide an overview about the most prominent ones which impacting the generated RTE code. Further on tables will show which implementation of variability is standardized due to the relevance for contract phase. (see tables 4.17, 4.19, 4.20, 4.21, 4.22, 4.23, 4.27, 4.28, 4.30 and 4.31. But please note that these tables are not listing all possible variation of the input configuration. For that the related Template Specifications are relevant.

4.7.2 Choosing a Variant and Binding Variability

To understand the later definition it is required to clarify the difference between *Choosing a Variant* and *Resolving Variability*.

A particular *PreBuild Variant* in a variant rich input configuration is chosen by assigning particular values to the `SwSystemconst`s with the means of `PredefinedVariant`s and associated `SwSystemconstantValueSet`s. With this information `SwSystemconstDependentFormula`s can be evaluated which determines PreBuild conditions of `VariationPoint`s and attribute values. Nevertheless the input configuration contains still the information of all potential variants.

A particular *PostBuild Variant* in a variant rich input configuration is chosen by assigning particular values to the `PostBuildVariantCriterion` with the means of `PredefinedVariant`s and associated `PostBuildVariantCriterionValueSet`s. With this information `PostBuildVariantCondition`s can be evaluated for instance to check the consistency of chosen *PostBuild Variant*. Nevertheless the input configuration contains still the information of all potential variants.

From an RTE perspective this information is mainly used to generate the *RTE Post Build Variant Sets* which are used to bind the `post-build variability` during initialization of the RTE (call of `SchM_Init`).

The variability of an input configuration is bound if information related to other variants is removed and only the information of the bound variant is kept. Binding respectively resolving variability in the scope of this specification means that the generated code only implements the particular variant which results out of the chosen variant of the input configuration.

If the variability can not be resolved in a particular phase of the *RTE Generation Process* (see chapter 3) the generated RTE files have to be able to support the potential variants by implementing all potential variants.

If the variability is relevant for the software components contract the RTE Generator uses standardized *Condition Value Macros* to implement the `pre-build variability`. These *Condition Value Macros* are set in the *RTE PreBuild Data Set Contract Phase* and *RTE PreBuild Data Set Generation Phase* to the resulting value of the evaluated `ConditionByFormula` of the related `VariationPoint`.

For further definition see sections 4.7.2.3, 4.7.2.4, 4.7.2.5, 4.7.2.6 and 4.7.2.7.

4.7.2.1 General impact of Binding Times on RTE generation

In the AUTOSAR meta-model, each `VariationPoint` is associated with a tag named `vh.latestBindingTime`. The value of the tag yields the applicable latest binding time for the given `VariationPoint`.

Each `VariationPoint` with a `swSyscond` has an attribute `bindingTime` in its `ConditionByFormula`, which defines when the pre-build condition may be evaluated earliest for this VariationPoint. This controls the capability of the software implementation to bind the variant earliest at a certain point of time.

Even if the variability is chosen earlier (for instance by assigning SwSystemconstValues to the SwSystemconsts used by the VariationPoint's condition) the RTE generator has to respect potential later binding of the VariationPoints.

Please note that variability with the bindingTime PreCompileTime and postBuildVariantConditions has a particular semantic for the RTE generation and impacts the generated output.

For instance a conditional existence RTE API which is bound at PreCompileTime requires that the RTE generator inserts specific pre processor statements.

RTE Phase	System Designe Time	Code Generation Time	Pre Compile Time	Link Time	Post Build
RTE Contract Phase	R	R	I	n/a	n/a
Basic Software Scheduler Contract Phase	R	R	I	n/a	n/a
RTE PreBuild Data Set Contract Phase	n/a	n/a	RV	n/a	n/a
Basic Software Scheduler Generation Phase	R	R	I	n/a	I
RTE Generation Phase	R	R	I	n/a	I
RTE PreBuild Data Set Generation Phase	n/a	n/a	RV	n/a	n/a
RTE PostBuild Data Set Generation Phase	n/a	n/a	n/a	n/a	RV

Table 4.15: Overview impact of Binding Times on RTE generation

R	resolve variability, a particular variant is the output
I	implement variability, all possible variants in the output
RV	provide values to resolve implemented variability *PreBuild* or *PostBuild*
n/a	not applicable

Table 4.16: Key to table 4.15

4.7.2.2 Choosing a particular variant

A particular variant of the variant rich input configuration is chosen via the ECU configuration For that purpose a set of PredefinedVariants is configured to chosen a variant in the input configuration and to later on bind the variability in subsequent phases of the *RTE Generation Process* 3. For further information see document [10].

[SWS_Rte_06500] ⌈ For each pre-build variability in the input configuration the RTE Generator shall choose a particular variant according to the PredefinedVariants selected by the parameter EcucVariationResolver. ⌋ *(SRS_Rte_00201, SRS_Rte_00202, SRS_Rte_00229, SRS_Rte_00191)*

[SWS_Rte_06546] ⌈ For each post-build variability in the input configuration the RTE Generator shall choose a particular variant according to the PredefinedVariants selected by the parameter RtePostBuildVariantConfiguration. ⌋ *(SRS_Rte_00201, SRS_Rte_00202, SRS_Rte_00229, SRS_Rte_00191)*

Having variants chosen the RTE generator can apply further consistency checks on the particular variants.

4.7.2.3 SystemDesignTime

Variability with latest binding time SystemDesignTime (called SystemDesignTime variability) has to be bound before the *RTE Contract Phase* respectively *Basic Software Scheduler Contract Phase*. Such variability is resolved by RTE generator in all generation phases. Due to that such kind of variability results always in a particular variant and needs no special code generation rules for RTE generator.

[SWS_Rte_06501] ⌈ The RTE generator shall bind SystemDesignTime variability in the *RTE Contract Phase*, *Basic Software Scheduler Contract Phase*, *RTE Generation Phase* and *Basic Software Scheduler Generation Phase* (3). ⌋ *(SRS_Rte_00191)*

[SWS_Rte_06502] ⌈ The RTE Generator shall reject input configurations during the *RTE Contract Phase* where not a particular variant is chosen for each SystemDesignTime variability affecting the software components contract. ⌋ *(SRS_Rte_00201, SRS_Rte_00018)*

[SWS_Rte_06503] ⌈ The RTE Generator shall reject input configurations during the *Basic Software Scheduler Contract Phase* where not a particular variant is chosen for each SystemDesignTime variability affecting the *Basic Software Scheduler* contract. ⌋ *(SRS_Rte_00229, SRS_Rte_00018)*

[SWS_Rte_06504] ⌈ The RTE Generator shall reject input configurations during the *Basic Software Scheduler Generation Phase* where not a particular variant is chosen for each SystemDesignTime variability affecting the *Basic Software Scheduler* generation. ⌋ *(SRS_Rte_00229, SRS_Rte_00018)*

[SWS_Rte_06505] ⌈ The RTE Generator shall reject input configurations during the *RTE Generation Phase* where not a particular variant is chosen for each SystemDesignTime variability affecting the *RTE* generation. ⌋ *(SRS_Rte_00201, SRS_Rte_00202, SRS_Rte_00018)*

4.7.2.4 CodeGenerationTime

During *RTE Contract Phase*, *RTE Generation Phase* and *Basic Software Scheduler Generation Phase* the variability with latest binding time *CodeGenerationTime* (called `CodeGenerationTime variability`) has to be bound and the RTE generator resolves the variability. This denotes that the code is generated for a particular variant. To do this it is required that a particular variant for each `CodeGenerationTime variability` has to be chosen.

[SWS_Rte_06507] ⌈ The RTE generator shall bind `CodeGenerationTime variability` in the *RTE Contract Phase*, *Basic Software Scheduler Contract Phase*, *RTE Generation Phase* and *Basic Software Scheduler Generation Phase* (see sections 3.1.1, 3.1.2, 3.4.1 and 3.4.2). ⌋*(SRS_Rte_00229, SRS_Rte_00191)*

[SWS_Rte_06547] ⌈ The RTE Generator shall reject input configurations during the *RTE Contract Phase* where not a particular variant is chosen for each `CodeGenerationTime variability` affecting the software components contract. ⌋*(SRS_Rte_00191, SRS_Rte_00018)*

[SWS_Rte_06548] ⌈ The RTE Generator shall reject input configurations during the *Basic Software Scheduler Contract Phase* where not a particular variant is chosen for each `CodeGenerationTime variability` affecting the *Basic Software Scheduler* contract. ⌋*(SRS_Rte_00229, SRS_Rte_00018)*

[SWS_Rte_06508] ⌈ The RTE Generator shall reject input configurations during the *Basic Software Scheduler Generation Phase* where not a particular variant is chosen for each `CodeGenerationTime variability` affecting the *Basic Software Scheduler* generation. ⌋*(SRS_Rte_00229, SRS_Rte_00018)*

[SWS_Rte_06509] ⌈ The RTE Generator shall reject input configurations during the *RTE Generation Phase* where not a particular variant is chosen for each `CodeGenerationTime variability` affecting the *RTE* generation. ⌋*(SRS_Rte_00191, SRS_Rte_00018)*

4.7.2.5 PreCompileTime

Variability with latest binding time *PreCompileTime* (called `PreCompileTime variability`) is relevant for the *RTE Contract Phase* and *Basic Software Scheduler Contract Phase* as well as for the *RTE Generation Phase* and *Basic Software Scheduler Generation Phase*. The *Application Header File*, *Application Types Header File*, *Module Interlink Header* and *Module Interlink Types Header* and the generated RTE / *Basic Software Scheduler* has to support the potential variability of the software components and *Basic Software Modules*. The variability is resolved during the execution of the pre processor of the C-Complier.

[SWS_Rte_06510] ⌈ The RTE generator shall implement `PreCompileTime variability` in the *RTE Contract Phase*, *Basic Software Scheduler Contract Phase*, *RTE Generation Phase*, *Basic Software Scheduler Generation Phase* via pre processor statements in the generated RTE code (see sections 3.1.1, 3.1.2, 3.4.1 and 3.4.2). ⌋*(SRS_Rte_00191)*

[SWS_Rte_06553] ⌈ The RTE Generator shall use the defined *Attribute Value Macro* instead of immediate values if the value depends on an `AttributeValueVariationPoint` where the `bindingTime` is set to `preCompileTime`. ⌋*(SRS_Rte_00191)*

4.7.2.6 LinkTime

The latest Binding Time *LinkTime* will not be supported for *VariationPoint*s relevant for the RTE Generator.

[SWS_Rte_06511] ⌈ The RTE generator shall reject configuration which defines RTE or *Basic Software Scheduler* relevant `LinkTime variability`. ⌋*(SRS_Rte_00018)*

4.7.2.7 PostBuild

Variability with latest binding time *PostBuild* (called `post-build variability`) might be bound / rebound after the generated RTE is compiled and has been linked to the executable. The generated RTE binary code has to contain all variants. Which variant is executed during ECU runtime is decided by variant selectors.

[SWS_Rte_06512] ⌈ The RTE generator shall implement `post-build variability` in the *RTE Generation Phase* and *Basic Software Scheduler Generation Phase* via C statements in the generated RTE code (see 3.4.1 and 3.4.2). ⌋*(SRS_Rte_00191)*

Combining PreBuild and post-build variability

According document [10] it is supported that a `VariationPoint` defines a `pre-build variability` in conjunction with `post-build variability`. If the *Pre-Build condition* is false, it is not expected that the element which is subject to variability including the code evaluating the *PostBuild condition* gets implemented at all.

[SWS_Rte_06549] ⌈ In cases where a `VariationPoint` defines a `SystemDesignTime variability` or `CodeGenerationTime variability` in conjunction with `post-build variability` the `post-build variability` shall only be implemented by the RTE Generator in the generated RTE code if the condition of the `pre-build variability` evaluates to true. ⌋*(SRS_Rte_00191)*

[SWS_Rte_06550] ⌈ In cases where a `VariationPoint` defines a `PreCompileTime variability` in conjunction with `post-build variability` the `post-build variability` shall only be effective in the RTE executable if the condition of the `PreCompileTime variability` evaluates to true. ⌋*(SRS_Rte_00191)*

In this case the post-build variability implemented according [SWS_Rte_06512] depends from the PreCompileTime variability implemented according [SWS_Rte_06510].

4.7.3 Variability affecting the RTE generation

4.7.3.1 Software Composition

This section describes the affects of the existence of variation points with regards to compositions. Though the application software compositions have been flattened and effectively eliminated after allocation to an ECU there is still one composition to consider for the RTE (i.e. the RootSwCompositionPrototype). The RootSwCompositionPrototype contains the atomic software components allocated to the respective ECU, its assembly connections,its delegation connections and the connections of the delegation ports to system signals. Once the variability is resolved for a variation point it must adhere to the constraints and limitations that apply to a model that does not have any variations. For example dangling connectors are not allowed and as such their existence will lead to undefined behavior if such configurations still exist after resolving post-build variation points.

Also within this specification section the wording "'a variant is enabled or disabled"' refers to the variation point's *SwSystemconstDependentFormula* and/or *PostBuildVariantCondition* evaluating to "'true or false"' respectively.

4.7.3.1.1 Variant existence of SwComponentPrototypes

[SWS_Rte_06601] ⌈ If a variant is disabled for the aggregation of a SwComponentPrototype in a CompositionSwComponentType then all RTEEvents destined for Runnables in the respective SwComponentPrototype shall be blocked; No RTEEvent is allowed to reach any Runnable that is contained in a "'disabled"' SwComponentPrototype. ⌋*(SRS_Rte_00206, SRS_Rte_00207, SRS_Rte_00204)*

Potential misconfigurations of connectors connecting to ports of "'disabled"' SWC's will result in undefined behavior; It is the responsibility of the person considering the variability of the SwComponentPrototype to make the connections also variable and valid when a variant selection results in the elimination of a SwComponentPrototype from a composition. It is recommended to use predefined variants to ensure proper configurations are established.

4.7.3.1.2 Variant existence of SwConnectors

[SWS_Rte_06602] ⌈ If a variant is disabled for a SwConnector (i.e. AssemblySwConnector or DelegationSwConnector) aggregated in a CompositionSwComponentType then the PortPrototypes at each end of the connector shall behave as an unconnected port (see section 5.2.7 for the defined RTE behavior) **if** no other variant enables a SwConnector between these ports. ⌋*(SRS_Rte_00206, SRS_Rte_00207)*

4.7.3.1.3 COM related Variant existence

This section describes the impact on the RTE interaction with the COM layer as a result of variability of DataMappings (i.e. SenderReceiverToSignalMapping and SenderReceiverToSignalGroupMapping in the SystemMapping) as well as the existence of variants for ISignals The Meta Model allows for mapping the same data to different SystemSignals as well as associating a SystemSignal with 1 or more ISignals.

[SWS_Rte_06603] ⌈ If a variant is enabled for a SystemMapping aggregating a DataMapping then the RTE shall call the appropriate API's for the applicable mapping type. ⌋*(SRS_Rte_00206, SRS_Rte_00207)*

[SWS_Rte_06604] ⌈ The appropriate API shall be determined based on the existence of variants of ISignals to which a SystemSignal is associated to. For each enabled ISignal the RTE shall call the proper COM API to send and receive data SystemSignals ⌋*(SRS_Rte_00206, SRS_Rte_00207)*

For example for an instance mapping from a VariableDataPrototype to a SystemSignal the RTE shall call the corresponding Com_SendSignal with the proper *SignalId* and *SignalDataPtr* based on the selected variant DataMapping.

The existence of variants of ISignals is determined by the System element (see also [constr_3028]).

[SWS_Rte_06605] ⌈ Delegation ports on a RootSwCompositionPrototype for which no DataMapping exists (i.e. no variant DataMapping is enabled) shall be considered unconnected because no path exists to a designated SystemSignal. Since this is a delegation port all enabled delegation connectors linking SWC R-ports to the respective delegation port must be considered unconnected (see section 5.2.7). P-Ports shall behave as documented in section 4.7.3.1.2. ⌋*(SRS_Rte_00206, SRS_Rte_00207)*

4.7.3.1.4 Variant existence of *PortPrototype*s

[SWS_Rte_06606] ⌈ If no variant is enabled for a delegation port on a RootSwCompositionPrototype then all connected R-Ports using a DelegationSwConnector to this delegation port shall be considered unconnected (see section 5.2.7). The behavior of the P-ports shall be as defined in section 4.7.3.1.2. ⌋*(SRS_Rte_00206, SRS_Rte_00207)*

Note on variant disabling criteria: In a proper variant configuration the following should be followed: when a PortPrototype is eliminated from any SwComponentType then any associated SwConnector should also have a variation point removing the connection since the connection is illegal.

4.7.3.2 Atomic Software Component and its Internal Behavior

4.7.3.2.1 RTE API which is subject to variability

Following VariationPoints in the Meta Model do control the variant existence of RTE API for a software component. If a RTE API is variant existent, the API mapping and the related entries in the component data structure are 'variant' as well. This means, if a RTE API does not exist the API mapping does not exist as well. A part of the component data structure entries are related to the existences of the port. In these cases the *component data structure entry* depends from the existence of the PortPrototype.

Variation Point Condition Value Macro	RTE API which is subject to variability	form	kind infix
ExclusiveArea [SWS_Rte_06518]	Rte_Enter, Rte_Exit	component internal	ExAr
VariableDataPrototype in the role arTypedPerInstanceMemory [SWS_Rte_06518]	Rte_Pim	component internal	PIM
PerInstanceMemory [SWS_Rte_06518]	Rte_Pim	component internal	PIM
ParameterDataPrototype in the role perInstanceParameter [SWS_Rte_06518]	Rte_CData	component internal	Prm
ParameterDataPrototype in the role sharedParameter [SWS_Rte_06518]	Rte_CData	component internal	Prm
ServerCallPoint [SWS_Rte_06515]	Rte_Call	component port	
AsynchronousServerCallResultPoint [SWS_Rte_06515]	Rte_Result	component port	
InternalTriggeringPoint [SWS_Rte_06519]	Rte_IrTrigger	entity internal	IRT
ExternalTriggeringPoint [SWS_Rte_06515]	Rte_Trigger	component port	
ModeSwitchPoint [SWS_Rte_06515]	Rte_Switch, Rte_SwitchAck	component port	
ModeAccessPoint [SWS_Rte_06515]	Rte_Mode	component port	

VariableAccess in the role dataReadAccess [SWS_Rte_06515]	Rte_IRead , Rte_IStatus, Rte_IsUpdated	entity port	
VariableAccess in the role dataWriteAccess [SWS_Rte_06515]	Rte_IWrite, Rte_IWriteRef, Rte_IInvalidate, Rte_IFeedback	entity port	
VariableAccess in the role dataSendPoint [SWS_Rte_06515]	Rte_Write, Rte_Invalidate, Rte_Feedback	component port	
VariableAccess in the role dataReceivePointByArgument [SWS_Rte_06515]	Rte_Read	component port	
VariableAccess in the role dataReceivePointByValue [SWS_Rte_06515]	Rte_DRead	component port	
VariableAccess in the role readLocalVariable referring an explicitInterRunnableVariable [SWS_Rte_06518]	Rte_IrvRead	component internal	IRV
VariableAccess in the role writtenLocalVariable referring an explicitInterRunnableVariable [SWS_Rte_06518]	Rte_IrvWrite	component internal	IRV
VariableAccess in the role readLocalVariable referring an implicitInterRunnableVariable [SWS_Rte_06519]	Rte_IrvIRead	entity internal	IRV
VariableAccess in the role writtenLocalVariable referring an implicitInterRunnableVariable [SWS_Rte_06519]	Rte_IrvIWrite Rte_IrvIWriteRef	entity internal	IRV
PortPrototype referring a ParameterInterface [SWS_Rte_06515]	Rte_Prm	component port	
PortAPIOption with attribute indirectAPI [SWS_Rte_06520]	Rte_Port		

Table 4.17: variant existence of RTE API

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column	description
kind infix	The column kind infix defines infix strings to differentiate condition value macros belonging to variation points of different API sets
form	The column form specifies which names for the macro of the condition value are concatenated to ensure a unique name space of the macro.

form	description
component port	The related API is provide for the whole software component and belongs to a software components port
entity port	The related API is provide for a particular RunnableEntity and belongs to a software components port

component internal	The related API is provide for the whole software component and belongs to a software component internal functionality
entity internal	The related API is provide per RunnableEntity and belongs to a software component internal functionality

Table 4.18: Key to table 4.17

[SWS_Rte_06517] ⌈ The RTE generator shall treat RTE API as variant RTE API only if all elements (e.g. VariableAccess) in the input configuration controlling the existence of the same RTE API are subject to variability. ⌋*(SRS_Rte_00203)*

4.7.3.2.2 Conditional API options

Following variation points in the Meta Model do control the variant properties of RTE API or allocated Memory.

Variation Point Condition Value Macro	Subject to variability
PortAPIOption with attribute portArgValue not standardized	PortDefinedArgumentValue is passed to a RunnableEntity
PortAPIOption with attribute indirectAPI not standardized	Number of Ports which are supporting indirect API, see Rte_NPorts and Rte_Ports

Table 4.19: Conditional API options

4.7.3.2.3 Runnable Entity's and RTEEvents

Following variation points in the Meta Model do control the variant existence and activation of RunnableEntitys.

Variation Point Condition Value Macro	Subject to variability
RunnableEntity [SWS_Rte_06530]	Existence of the RunnableEntity prototype
RTEEvent not standardized	Activation of the RunnableEntity

Table 4.20: variation on Runnable Entity's and RTEEvents

4.7.3.2.4 Conditional Memory Allocation

Following variation points in the Meta Model do control the variant existence of RTE memory allocation for the software component instance.

Variation Point Condition Value Macro	Subject to variability
implicitInterRunnableVariable not standardized	variable definition implementing the implicitInterRunnableVariable
explicitInterRunnableVariable not standardized	variable definition implementing the explicitInterRunnableVariable
arTypedPerInstanceMemory not standardized	variable definition implementing the arTypedPerInstanceMemory
PerInstanceMemory not standardized	variable definition implementing the PerInstanceMemory
perInstanceParameter not standardized	constant definition implementing the perInstanceParameter
sharedParameter not standardized	variable definition implementing the sharedParameter
InstantiationDataDefProps, SwDataDefProps not standardized	Allocation of the memory objects described via swAddrMethod, accessibility for MCD systems described via swCalibrationAccess, displayFormat, mcFunction

Table 4.21: Conditional Memory Allocation

4.7.3.3 NvBlockComponent and its Internal Behavior

Variation Point Condition Value Macro	Subject to variability
PortPrototype of a NvBlockSwComponentType typed by NvDataInterface not standardized	Existence of the ability to access the memory objects of the ramBlock
NvBlockDataMapping of a NvBlockDescriptor not standardized	Existence of the ability to access the memory objects of the ramBlock

provide PortPrototype of a NvBlockSwComponentType typed by ClientServerInterface, RunnableEntity and referring OperationInvokedEvent not standardized	Existence of the *Block Management* port and the ability to access the *Block Management* API of the *NvRAM Manager*
require PortPrototype of a NvBlockSwComponentType typed by ClientServerInterface, RoleBasedPortAssignment and referring the PortPrototype not standardized	Existence of the *callback notification* port
NumericalValueSpecification or TextValueSpecification of the ramBlock or romBlocks initValue ValueSpecification (aggregated or referred one) not standardized	initialization values of the memory objects implementing the ramBlock or romBlock
InstantiationDataDefProps not standardized	Allocation of the memory objects implementing the ramBlock or romBlock described via swAddrMethod, accessibility for MCD systems described via swCalibrationAccess, displayFormat, mcFunction

Table 4.22: variation in NvBlockSwComponentTypes

4.7.3.4 Parameter Component

Variation Point Condition Value Macro	Subject to variability
PortPrototype of a ParameterSwComponentType not standardized	Existence of the memory objects / definitions related to the ParameterDataPrototypes in the PortInterface referred by the PortPrototype
NumericalValueSpecification or TextValueSpecification of the ParameterProvideComSpecs initValue ValueSpecification (aggregated or referred one) not standardized	initialization values of the memory objects / definitions related to the ParameterDataPrototypes

Table 4.23: variation in ParameterSwComponentTypes

4.7.3.5 Data Type

Following variation points in the Meta Model do control the variant generation of data types.

Variation Point Condition Value Macro	Subject to variability
ImplementationDataTypeElement [SWS_Rte_06542]	Existence of the structure or union element

arraySize [SWS_Rte_06541]	Number of elements in the array
CompuMethod upperLimit	Upper limit of the ImplementationDataType
CompuMethod lowerLimit	Lower limit of the ImplementationDataType
CompuMethod v attributes	Coefficients of nominator and denominator

Table 4.24: variation in ImplementationDataTypes

Variation Point Condition Value Macro	Subject to variability
DataConstr upperLimit [SWS_Rte_06551]	Upper limit of the ApplicationPrimitiveDataType
DataConstr lowerLimit [SWS_Rte_06552]	Lower limit of the ApplicationPrimitiveDataType
CompuMethod upperLimit	Upper limit of the ApplicationPrimitiveDataType
CompuMethod lowerLimit	Lower limit of the ApplicationPrimitiveDataType
CompuMethod v attributes	Coefficients of nominator and denominator

Table 4.25: variation in ApplicationDataTypes and related meta classes

4.7.3.6 Constants

Variation Point Condition Value Macro	Subject to variability
NumericalValueSpecification value	numerical value
ApplicationValueSpecification v (swArraysize)	size of compound primitives
ApplicationValueSpecification v (value) attributes	physical value

Table 4.26: variation in ValueSpecifications

4.7.3.7 Basic Software Modules and its Internal Behavior

4.7.3.7.1 Basic Software Interfaces

Variation Point Condition Value Macro	Subject to variability
providedEntry not standardized	Existence of the provided BswModuleEntry
outgoingCallback not standardized	Existence of the expected BswModuleEntry
ModeDeclarationGroupPrototype in role providedModeGroup not standardized	Existence of the provided ModeDeclarationGroupPrototype
ModeDeclarationGroupPrototype in role requiredModeGroup not standardized	Existence of the required ModeDeclarationGroupPrototype
Trigger in role releasedTrigger not standardized	Existence of the released Trigger
Trigger in role requiredTrigger not standardized	Existence of the required Trigger

Table 4.27: variability affecting *Basic Software Interfaces*

4.7.3.8 Flat Instance descriptor

It is possible to instruct the RTE Generator to provide various instances for a ParameterDataPrototype in the component description. Therefore one FlatInstanceDescriptor per expected parameter instance has to point to the ParameterDataPrototype. Thereby the FlatInstanceDescriptors needs to define post build variation points to resolve the access to the various parameter instances.

Further details are described in section 4.2.8.3.7.

4.7.4 Variability affecting the Basic Software Scheduler generation

4.7.4.1 Basic Software Scheduler API which is subject to variability

The VariationPoints listed in table 4.28 in the input configuration are controlling the variant existence of *Basic Software Scheduler* API.

Variation Point Condition Value Macro	Subject to variability	form	kind infix
ExclusiveArea	SchM_Enter, SchM_Exit	module internal	ExAr

[SWS_Rte_06535]			
managedModeGroup association to providedModeGroup ModeDeclarationGroupPrototype [SWS_Rte_06536]	SchM_Switch, SchM_SwitchAck	module external	MMod
accessedModeGroup association to providedModeGroup or requiredModeGroup ModeDeclarationGroupPrototype [SWS_Rte_06536]	SchM_Mode	module external	AMod
issuedTrigger association to releasedTrigger Trigger [SWS_Rte_06536]	SchM_Trigger	module external	Tr
BswModuleCallPoint [SWS_Rte_06536]	SchM_Call	module external	SrvCall
BswAsynchronousServerCallResultPoint [SWS_Rte_06536]	SchM_Result	module external	SrvRes
dataSendPoint association to providedData [SWS_Rte_06536]	SchM_Send	module external	DSP
dataReceivePoint association to requiredData [SWS_Rte_06536]	SchM_Receive	module external	DRP
BswInternalTriggeringPoint [SWS_Rte_06536]	SchM_ActMainFunction	entity internal	ITr
perInstanceParameter ParameterDataPrototype [SWS_Rte_06535]	SchM_CData	module internal	PIP

Table 4.28: variant existence of Basic Software Scheduler API

column	description
kind infix	The column kind infix defines infix strings to differentiate condition value macros belonging to variation points of different API sets
form	The column form specifies which names for the macro of the condition value are concatenated to ensure a unique name space of the macro.

form	description
module external	The related API is provide for the whole module and belongs to a module interface
module internal	The related API is provide for the whole module and belongs to a module internal functionality
entity internal	The related API is provide per ExecutableEntity and belongs to a module internal functionality

Table 4.29: Key to table 4.28

[SWS_Rte_06537] ⌈ The RTE generator shall treat the existence of *Basic Software Scheduler* API as subject to variability only if all elements (e.g. managedModeGroup association) in the input configuration controlling the existence of the same *Basic Software Scheduler* API are subject to variability. ⌋*(SRS_Rte_00229)*

4.7.4.2 Basic Software Entities

The VariationPoints listed in table 4.30 in the input configuration are controlling the variant existence of BswModuleEntitys and the variant activation of BswSchedulableEntitys.

Variation Point Condition Value Macro	Subject to variability
BswSchedulableEntity [SWS_Rte_06532]	Existence of the BswSchedulableEntity prototype
BswEvent not standardized	Activation of the BswSchedulableEntity

Table 4.30: variability affecting BswSchedulableEntitys

4.7.4.3 API behavior

The VariationPoints listed in table 4.31 in the input configuration are controlling the variant behavior of *Basic Software Scheduler* API.

Variation Point Condition Value Macro	Subject to variability
BswModeSenderPolicy not standardized	Queue length in the mode machine instance dependent from the attribute
BswModeReceiverPolicy not standardized	attribute supportsAsynchronousModeSwitch has to be considered according the bound variant

Table 4.31: variant existence of BswSchedulableEntity

4.7.5 Variability affecting SWC implementation

In this section some examples will be given in order to describe the affects of variability with regard to SWC implementation. The implemented variability in SWCs is described through VariationPointProxys and can be resolved by pre-build evaluation, by post-build evaluation or by the combination of them. Furthermore for each VariationPointProxy AUTOSAR defines the categorys VALUE and CONDITION (see Software Component Template [2]). In the following code examples one scenario for each category will be described. The first scenario addresses the post-build case and the second one the case of combination of pre-build and post-build.

Scenario for category VALUE

VariationPointProxy FRIDA
postBuildValueAccess Rte_PBCon_FRIDA = 3
might result for example in something like:

```
/* Generated RTE-Code */

const Rte_PBCon_FRIDA 3
```

```
/* SWC-Code */

if (Rte_PBCon_FRIDA == 3) {
     /* code depending on proxy FRIDA */
     }
else {
     /* functional alternative, if FRIDA is not selected */
     }
```

Scenario for category CONDITION

SystemConstant FRANZ = 10
VariationPointProxy HUGO
conditionAccess Rte_SysCon_HUGO = (FRANZ == 10)
postBuildVariantCondition A = 3, postBuildVariantCondition B = 5
might result for example in something like:

```
/* Generated RTE-Code */

#define Rte_SysCon_HUGO 1

#define Rte_PBCon_HUGO (
     Rte_SysCon_HUGO  &&
     RteInternal_EvalPostBuildVariantCondition_HUGO_A &&
     RteInternal_EvalPostBuildVariantCondition_HUGO_B
     )
```

```
/*SWC-Code*/

/* ensure that no code for HUGO remains in
   the binary, if HUGO is not selected */
#if Rte_SysCon_HUGO

/* check during run time, if HUGO is
   active due to post-build conditions */
if (Rte_PBCon_HUGO) {
     /* code depending on proxy HUGO */
     }
else {
     /* functional alternative, if HUGO is not selected */
     }

#else
```

```
/* functional alternative is always
   active since HUGO is not selected */
#endif
```

Since the post-build data structure is not standardized the algorithm for the evaluation of the expressions RteInternal_EvalPostBuildVariantCondition_HUGO_A and RteInternal_EvalPostBuildVariantCondition_HUGO_B is up to the implementer.

In contrast to Rte_SysCon the Rte_PBCon API has no guarantee, that it can be resolved in the pre-processor. It is subject to the optimization of the compiler to reduce code size. If one wants to be absolutely sure, that no superfluous code exists even with non optimizing compilers, he needs to implement a pre-processor directive in addition (see example).

4.8 Development error

Errors which can occur at runtime in the RTE are classified as development errors. The RTE uses a BSW module report these types of errors to the DET [25] (Default Error Tracer).

4.8.1 DET Report Identifiers

[SWS_Rte_06631] ⌈ The RTE shall use the OS Application Identifier as the Instance Id to enable the developer to identify in which runtime section of the RTE the error occurs. This Instance ID is even unique across multi cores and so implicitly allows the development error to be traced to a specific core. ⌋*(SRS_BSW_00337)*

[SWS_Rte_06632] ⌈ The RTE shall use the Service Id as identified in the table 4.33. Each RTE API template, RTE callback template and RTE API will have an Identifier. This ID Service ID must be used when running code in the context of the respective RTE call. ⌋*(SRS_BSW_00337)*

4.8.2 DET Error Identifiers

Only a limited set of development identifiers are currently recognized. Each of these need to be detected either at runtime or during initialization of the RTE. To report these errors extra development code must be generated by the RTE generator.

[SWS_Rte_06633] ⌈ An RTE_E_DET_ILLEGAL_SIGNAL_ID (0x01) shall be reported at runtime by the RTE when it receives a COM callback for a signal name (e.g. Rte_COMCbk_<sn>, Rte_COMCbkTAck_<sn>) which was not expected within the context of the currently-selected postBuild variant. See section 5.9.2.1 for the list of possible COM callback template API. ⌋*(SRS_BSW_00337)*

[SWS_Rte_06634] ⌈ An RTE_E_DET_ILLEGAL_VARIANT_CRITERION_VALUE (0x02) shall be reported by the RTE when it determines that a value is assigned to a variant criterion which is not in the list of possible values for that criterion. This error shall be detected during the RTE initialization phase. ⌋*(SRS_BSW_00337)*

[SWS_Rte_07684] ⌈ An RTE_E_DET_ILLEGAL_VARIANT_CRITERION_VALUE (0x02) shall be reported by the *Basic Software Scheduler* when the `SchM_Init` API is called with a `NULL` parameter. ⌋*(SRS_BSW_00337)*

[SWS_Rte_06635] ⌈ An RTE_E_DET_ILLEGAL_INVOCATION (0x03) shall be reported by the RTE when it determines that an RTE API is called by a Runnable which should not call that RTE API. The RTE can identify the active Runnable when it dispatches the RTE Event and if it subsequently receives a call from that Runnable to an API that is not part of its contract then this particular error ID must me logged. ⌋*(SRS_BSW_00337)*

[SWS_Rte_06637] ⌈ An RTE_E_DET_WAIT_IN_EXCLUSIVE_AREA (0x04) shall be reported by the RTE when an application has called an Rte_Enter API and subsequently asks the RTE to enter a wait state. This is illegal because it would lock the ECU. ⌋*(SRS_BSW_00337)*

[SWS_Rte_07675] ⌈ An RTE_E_DET_ILLEGAL_NESTED_EXCLUSIVE_AREA (0x05) shall be reported by the RTE when an application violates [SWS_Rte_CONSTR_09029]. ⌋*(SRS_BSW_00337)*

[SWS_Rte_07685] ⌈ An RTE_E_DET_SEG_FAULT (0x06) shall be reported by the RTE when the parameters of an RTE API call contain a direct or indirect reference to memory that is not accessible from the callers partition as defined in [SWS_Rte_02752] and [SWS_Rte_02753]. ⌋*(SRS_BSW_00337)*

[SWS_Rte_07682] ⌈ If `RteDevErrorDetectUninit` is enabled, an RTE_E_UNINIT (0x07) shall be reported by the RTE when one of the APIs :

- Specified in 5.6.
- `Rte_NvMNotifyInitBlock`.
- `Rte_PartitionTerminated`.
- `Rte_PartitionRestarting`.
- `Rte_RestartPartition`.

is called before `Rte_Start`, after `Rte_Stop` or After the partition to which the API belongs is terminated. ⌋*(SRS_BSW_00337)*

Note:

- In production mode, No checks are performed.
- In development mode, if an error is detected the API behaviour is undefined and it is left to the Rte implementer.

Rational: The introduction of this developpement check should not introduce big changes to production mode configuration.

[SWS_Rte_07683] ⌈ If RteDevErrorDetectUninit is enabled, an RTE_E_UNINIT (0x07) shall be reported by the *Basic Software Scheduler* / RTE when one of the APIs SchM_Switch, SchM_Mode, SchM_SwitchAck, SchM_Trigger, SchM_Send, SchM_Receive, SchM_Call, SchM_Result, SchM_ActMainFunction, SchM_Start, SchM_StartTiming, or Rte_Start is called before SchM_Init. ⌋ *(SRS_BSW_00337)*

4.8.3 DET Error Classification

The following abbreviations are used to identify the DET error in table 4.33.

Abbreviation	RTE DET Error
ISI	RTE_E_DET_ILLEGAL_SIGNAL_ID
IVCV	RTE_E_DET_ILLEGAL_VARIANT_CRITERION_VALUE
II	RTE_E_DET_ILLEGAL_INVOCATION
INEA	RTE_E_DET_ILLEGAL_NESTED_EXCLUSIVE_AREA
WIEA	RTE_E_DET_WAIT_IN_EXCLUSIVE_AREA
UNINIT	RTE_E_UNINIT

Table 4.32: Abbreviations of RTE DET Errors to APIs

The following table 4.33 indicates which DET errors are relevant for the various RTE APIs, and the service ID associated with the RTE APIs (see [SWS_Rte_06632]):

API name	Service ID	ISI	IVCV	II	INEA	WIEA	UNINIT
Rte_Ports APIs	0x10						X
Rte_NPorts APIs	0x11						X
Rte_Port APIs	0x12						X
Rte_Send APIs	0x13						X
Rte_Write APIs	0x14						X
Rte_Switch APIs	0x15						X
Rte_Invalidate APIs	0x16						X
Rte_Feedback APIs	0x17					X	X
Rte_SwitchAck APIs	0x18					X	X
Rte_Read APIs	0x19						X
Rte_DRead APIs	0x1A						X
Rte_Receive APIs	0x1B					X	X
Rte_Call APIs	0x1C					X	X
Rte_Result APIs	0x1D					X	X
Rte_Pim APIs	0x1E						X
Rte_CData APIs	0x1F						X
Rte_Prm APIs	0x20						X
Rte_IRead APIs	0x21						X
Rte_IWrite APIs	0x22						X
Rte_IWriteRef APIs	0x23						X

Rte_IInvalidate APIs	0x24						X
Rte_IStatus APIs	0x25						X
Rte_IrvIRead APIs	0x26						X
Rte_IrvIWrite APIs	0x27						X
Rte_IrvIWriteRef APIs	0x31						X
Rte_IrvRead APIs	0x28						X
Rte_IrvWrite APIs	0x29						X
Rte_Enter APIs	0x2A						X
Rte_Exit APIs	0x2B				X		X
Rte_Mode APIs	0x2C						
Rte_Trigger APIs	0x2D						X
Rte_IrTrigger APIs	0x2E						X
Rte_IFeedback APIs	0x2F						X
Rte_IsUpdated APIs	0x30						X
trigger by TimingEvent	0x50			X			
trigger by BackgroundEvent	0x51			X			
trigger by SwcModeSwitchEvent	0x52			X			
trigger by AsynchronousServerCallReturnsEvent	0x53			X			
trigger by DataReceiveErrorEvent	0x54			X			
trigger by OperationInvokedEvent	0x55			X			
trigger by DataReceivedEvent	0x56			X			
trigger by DataSendCompletedEvent	0x57			X			
trigger by ExternalTriggerOccurredEvent	0x58			X			
trigger by InternalTriggerOccurredEvent	0x59			X			
trigger by DataWriteCompletedEvent	0x5A			X			
Rte_Start API	0x70						X
Rte_Stop API	0x71						
Rte_PartitionTerminated APIs	0x72						
Rte_PartitionRestarting APIs	0x73						
Rte_RestartPartition APIs	0x74						
Rte_Init API	0x75						
Rte_StartTiming API	0x76						
Rte_COMCbkTAck_<sn> callbacks	0x90	X					
Rte_COMCbkTErr_<sn> callbacks	0x91	X					
Rte_COMCbkInv_<sn> callbacks	0x92	X					
Rte_COMCbkRxTOut_<sn> callbacks	0x93	X					
Rte_COMCbkTxTOut_<sn> callbacks	0x94	X					
Rte_COMCbk_<sg> callbacks	0x95	X					
Rte_COMCbkTAck_<sg> callbacks	0x96	X					
Rte_COMCbkTErr_<sg> callbacks	0x97	X					
Rte_COMCbkInv_<sg> callbacks	0x98	X					
Rte_COMCbkRxTOut_<sg> callbacks	0x99	X					
Rte_COMCbkTxTOut_<sg> callbacks	0x9A	X					
Rte_COMCbk_<sn> callbacks	0x9F	X					
Rte_LdComCbkRxIndication_<sn> callbacks	0xA0	X					X
Rte_LdComCbkStartOfReception_<sn> callbacks	0xA1	X					X
Rte_LdComCbkCopyRxData_<sn> callbacks	0xA2	X					X
Rte_LdComCbkTpRxIndication_<sn> callbacks	0xA3	X					X
Rte_LdComCbkCopyTxData_<sn> callbacks	0xA4	X					X
Rte_LdComCbkTpTxConfirmation_<sn> callbacks	0xA5	X					X
Rte_LdComCbkTriggerTransmit_<sn> callbacks	0xA6	X					X
Rte_LdComCbkTxConfirmation_<sn> callbacks	0xA7	X					X
Rte_SetMirror callbacks	0x9B						

Rte_GetMirror callbacks	0x9C						
Rte_NvMNotifyJobFinished callbacks	0x9D						
Rte_NvMNotifyInitBlock callbacks	0x9E						X
SchM_Init API	0x00		X				
SchM_Deinit API	0x01						
SchM_GetVersionInfo API	0x02						
SchM_Enter APIs	0x03						
SchM_Exit APIs	0x04				X		
SchM_ActMainFunction APIs	0x05						X
SchM_Switch APIs	0x06						X
SchM_Mode APIs	0x07						X
SchM_SwitchAck APIs	0x08						X
SchM_Trigger APIs	0x09						X
SchM_Send APIs	0x0A						X
SchM_Receive APIs	0x0B						X
SchM_Call APIs	0x0C						X
SchM_Result APIs	0x0D						X

Table 4.33: Applicability of RTE DET Errors to APIs

4.9 Bypass Support

Rapid prototyping can be used during electronic control unit development to evaluate and test new software control algorithms for various functions.

With Fullpass technology the original ECU is totally replaced by a Rapid Prototyping Unit (RPU).

With Bypass technology the original ECU and software stays in the control loop to supports the majority of the control algorithms and interface with sensors, actuators and communication buses: only the specific control algorithm that shall be prototyped is deported into the RPU (external bypass) or even directly executed in the original ECU (internal bypass). Bypass mainly consists in replacing at run time inputs and/or outputs of the original software algorithms by value computed by the prototype algorithm under test.

The RTE does not directly implement bypass but the RTE provides supports for the integration of such implementation by CDD and/or integration code.

4.9.1 Bypass description

In order to describe a rapid prototyping system as an Autosar Software Component a System Description with the category `RPT_SYSTEM` is used. This System Description is not relevant for the RTE itself but is only a support for the ECU integrator to setup the rapid prototyping solution.

[SWS_Rte_07833] ⌈ RTE shall ignore definitions in System Description of category `RPT_SYSTEM`. ⌋*(SRS_Rte_00244)*

4.9.2 Component wrapper method

The component wrapper method consists in wrapping the original software component implementation with a CDD that implements the bypass. With this method the CDD is able to take the control of the AUTOSAR interfaces of the software component because there is no more direct call between RTE and the SWC but everything go through the CDD.

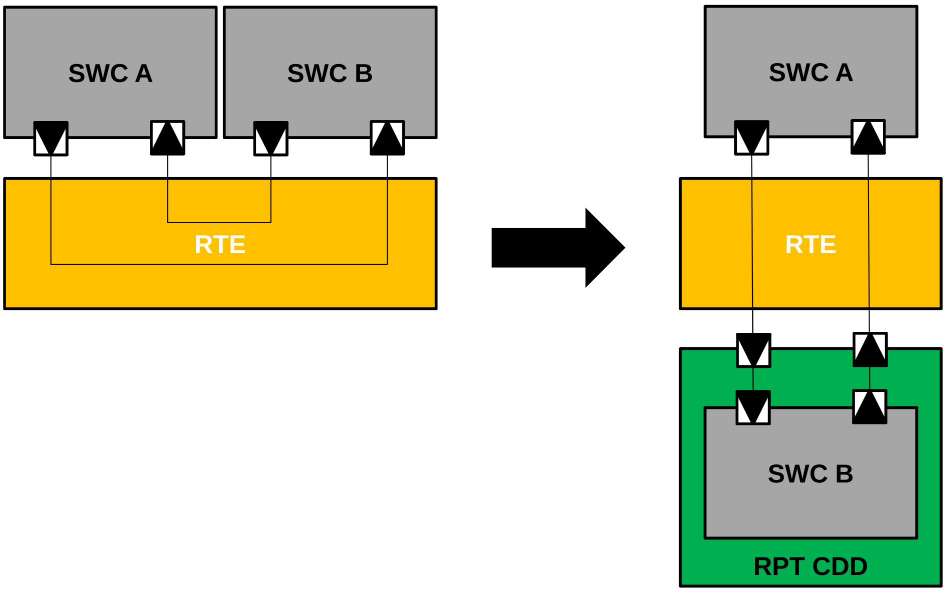

Figure 4.53: Component wrapper method

The RTE supports the component wrapper method by generating the SWC interfaces with a c-namespace including an additional [Byps_] infix for the bypassed SWC (i.e. `SWC B` in Figure 4.53). This includes:

- naming of Application Header File
- naming of the Application Type Header File
- naming of the RTE APIs (excepted life cycle APIs)
- naming of the runnables
- naming of the instance handle
- naming of the Component Data Structure type
- naming of the memory sections

The component wrapper method for bypass support is enabled per software component type.

[SWS_Rte_07840] ⌈ The component wrapper method for bypass support is enabled for a software component type if the general switch `RteBypassSupport` is set to `COMPONENT_WRAPPER` and the individual switch for this software component type `RteBypassSupportEnabled` is set to true. ⌋*(SRS_Rte_00244)*

[SWS_Rte_07841] ⌈ The component wrapper method for bypass support is disabled for a software component type if the general switch RteBypassSupport is set to value different from COMPONENT_WRAPPER or if the individual switch for this software component type RteBypassSupportEnabled is not configured or is set to false. ⌋ *(SRS_Rte_00244)*

[SWS_Rte_07834] ⌈ If the component wrapper method for bypass support is enabled for a software component type, the RTE generator shall include the optional infix [Byps_] to the name of all the elements generated for this software component type that are defined in this specification with the optional infix [Byps_]. ⌋ *(SRS_Rte_00244)*

[SWS_Rte_07835] ⌈ If the component wrapper method for bypass support is disabled for a software component type, the RTE generator shall remove the optional infix [Byps_] to the name of all the elements generated for this software component type that are defined in this specification with the optional infix [Byps_]. ⌋ *(SRS_Rte_00244)*

4.9.3 Direct buffer access method

The direct buffer access method provides runtime direct read and write access to the RTE buffers that implement the ECU communication infrastructure.

The RTE supports the direct buffer access method by generating the McSupportData for these buffers. This is already supported by the RTE measurement and calibration support but for the rapid prototyping purpose additional elements shall be generated.

The component wrapper method for bypass support is enabled per software component type.

The component wrapper method for bypass support is enabled for a software component type if the individual switch for this software component type RteBypassSupportEnabled is set to true.

[SWS_Rte_07836] ⌈ If the direct buffer access method for bypass support is enabled for a software component type, the RTE generator shall generate McSupportData with mcDataAccessDetails for each preemption area specific buffer that implements the implicit communication for this software component type. ⌋ *(SRS_Rte_00244)*

4.9.4 Extended buffer access method

The extended buffer access method enhances the support for rapid prototyping (RP) to support the bypass use case where the RTE cannot be regenerated by the bypass user. The goal is to ensure that all VariableDataPrototypes that are communicated via RTE APIs are written to and read back from a RP global buffer that can be modified by rapid prototyping tools (RPT). The method applies to all RTE APIs and not just those for implicit access and hence is termed the *extended* buffer access method.

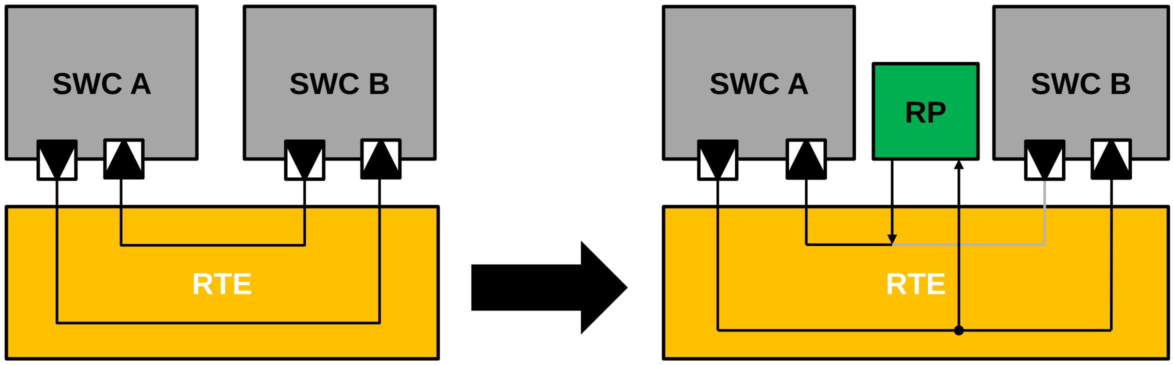

Figure 4.54: Extended Buffer Access method

Within the Extended buffer access method a VariableDataPrototype, an RTE-Event or a complete SwComponentPrototype can be flagged for rapid prototyping at one of three levels depending on whether or not post-build hooking is used. rptLevel1 is intended for use by post-build hooking tools and rptLevel2 and rptLevel3 by non post-build hooking. The mapping from RTE API class to supported level is defined by Table 4.34.

API Class	rptLevel1	rptLevel2	rptLevel3
Explicit S/R	Yes	Yes	Yes
Implicit S/R	Yes	Yes	Yes
C/S	Yes	Yes	Yes
Mode	Yes	Yes	Yes
Trigger	No	No	No
Explicit IRV	Yes	Yes	Yes
Implicit IRV	Yes	Yes	Yes

Table 4.34: Table of API classes and supported RPT level

4.9.4.1 Global Enable

[SWS_Rte_06086] ⌈ The Extended Buffer Access method is enabled if the general switch RteBypassSupport is set to EXTENDED_BUFFER_ACCESS ⌋ *(SRS_Rte_00244)*

When RteBypassSupport is set to a value other than EXTENDED_BUFFER_ACCESS then no bypass support, i.e. no use of RP memory interface, no RP service point, etc., is generated.

When RteBypassSupport is set to EXTENDED_BUFFER_ACCESS then the RteBypassSupportEnabled and/or RteServicePointSupportEnabled must also be set to `true` for Extended Buffer Access bypass support to be generated for a software component.

The configuration options are summarized in Table 4.35.

RteBypassSupport (global)	RteBypass-SupportEnabled (per-SWC)	RteServicePoint-SupportEnabled (per-SWC)	Effect
`NONE` or `COMPONENT_-WRAPPER`	Any	Any	No bypass support generated by RTE. No RP export generated by RTE
`EXTENDED_BUFFER_-ACCESS`	`FALSE`	`FALSE`	No bypass support for SWC type generated by RTE in code (i.e. No service points and no use of RP memory interface). RP export describes service points for SWC Internal service points only.
`EXTENDED_BUFFER_-ACCESS`	`FALSE`	`TRUE`	Service points generated for SWC. No use of RP memory interface. RP export describes resulting SWC Internal and RTE assigned service points.
`EXTENDED_BUFFER_-ACCESS`	`TRUE`	`FALSE`	Service points not generated for SWC. RP memory interface generated for RTE APIs. RP export describes SWC Internal service points and also the resulting RP buffers and enabler flags.
`EXTENDED_BUFFER_-ACCESS`	`TRUE`	`TRUE`	Service points generated for SWC. RP memory interface generated for RTE APIs. RP export describes resulting SWC Internal and RTE assigned service points, RP buffers and enabler flags.

Table 4.35: Summary of enable/disable options for Extended Buffer Access method

4.9.4.2 RPT Preparation

The `RptImplPolicy.rptPreparationLevel` supports three preparation levels:

- **Level 1** – When `RptImplPolicy.rptPreparationLevel` is set to `rptLevel1` then the generated RTE uses a specific memory access pattern (a write-read cycle within accessing code created by the RTE generator) suitable for access by post-build hooking tools patch writes to buffers.

- **Level 2** – When RptImplPolicy.rptPreparationLevel is set to rptLevel2 then in addition to the use of an RP global buffer (as for rptLevel1) the generated code also includes an RP enabler flag that is used to make update of the RP global buffer conditional.

  The RP enabler flag can be in either (calibratable) ROM or RAM based on RptContainer.rptEnablerImplType.

- **Level 3** – When RptImplPolicy.rptPreparationLevel is set to rptLevel3 then in addition to the requirements of rptLevel2, the generated code also records the original ECU-generated value as well as the RP replacement value.

When rptImplPolicy of a RptContainer is used the RptContainer can reference:

- VariableDataPrototype – the preparation level applies to a single data item (and hence, for example, related Sender-Receiver APIs).
- ArgumentDataPrototype – the preparation level applies to a single operation argument (and hence related Client-Server APIs).
- ModeDeclarationGroupPrototype – the preparation level applies to a single ModeDeclaration argument (and hence related Mode APIs).
- operation – the preparation level applies to all ClientServerOperation's ArgumentDataPrototypes (and hence related Client-Server APIs).
- RunnableEntity – the preparation level applies to a all data items / arguments accessed by the RunnableEntity.
- SwComponentPrototype – the preparation level applies to all RunnableEntitys (and hence all accessed data items and arguments) in the software component.

4.9.4.3 Level 1 - Post-Build Hooking

This level is intended to be used by post-build hooking tools that patch writes to buffers such that a bypass value is written into a buffer rather than the value calculated by the ECU.

Logically this means that a C statement like:

```
buffer = ecu_value;
```

is patched to be:

```
buffer = f(ecu_value);
```

where f() is a function calculated by the RP system, e.g. on external RP hardware. Note that the function call in the example may be, in reality, a simple access to a value calculated by the RP system rather than an actual function call.

4.9.4.3.1 Explicit Sender-Receiver and IRV APIs

As an example of the changes to generated RTE code when rptLevel1 of the Extended Buffer Access method is enabled, consider an Rte_Write API that sends VariableDataPrototype D via port P using explicit semantics. A "typical" implementation might look something like Example 4.13:

Example 4.13

```
Std_ReturnType Rte_Write_P_D(<type> data)
{
  <send> data;
  return <result of send>;
}
```

Where <type> is the implementation data type of the VariableDataPrototype, <send> represents the transmission process, e.g. via COM or direct access, and <result of send> represents the return value of the RTE API.

To support RP the implementation, Example 4.13 is modified as follows:

Example 4.14

```
/* RP global buffer */
volatile <type> SWCA_Bypass_P_D;

Std_ReturnType Rte_Write_P_D(<type> data)
{
  SWCA_Bypass_P_D = data;
  <send> SWCA_Bypass_P_D;
  return <result of send>;
}
```

The changes as a result of rptLevel1 support revolve around the reads/writes of the RP global buffer. These changes are summarized by the following two requirements:

[SWS_Rte_06033] ⌈ When rptLevel1 support is enabled for a VariableDataPrototype accessed using explicit semantics the RTE generator shall write each associated IN or INOUT API parameter to a RP global buffer. ⌋*(SRS_Rte_00244)*

Subsequent accesses to the actual parameter within the generated function are replaced by use of the RP global buffer instead.

[SWS_Rte_06034] ⌈ When rptLevel1 support is enabled for a VariableDataPrototype accessed using explicit semantics then within RTE APIs the RTE generator shall read the value of the associated IN and INOUT parameters from the RP global buffer rather than use the formal parameter. ⌋*(SRS_Rte_00244)*

These modifications ensure that if an RP tool patches the write to the `RP global buffer` `SWCA_Bypass_P_D` then the value that is written by the RP tool to `SWCA_Bypass_P_D` will be sent instead of the actual function parameter `data`.

The requirements inherently cause the `RP global buffer` to exist thus there is no explicit requirement to create the global buffer. However the characteristics of this buffer are constrained as follows.

[SWS_Rte_06035] ⌈ An `RP global buffer` used for `rptLevel1` data shall be marked as `volatile`. ⌋*(SRS_Rte_00244)*

The `volatile` keyword is essential to ensure that compiler optimization does not elide the read of `SWCA_Bypass_P_D` in `<send> SWCA_Bypass_P_D`.

[SWS_Rte_06036] ⌈ The `RP global buffer` contents shall be valid for at least the lifetime of the accessing RTE function (i.e. the lifetime of the runnable that calls the RTE function) and any related measurement and stimulation services. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06037] ⌈ The same `RP global buffer` shall always be used for the same SWCI/API-type/port/variable-data-prototype. ⌋*(SRS_Rte_00244)*

Requirement [SWS_Rte_06037] ensures stability for post-build hooking tools, e.g. if we have `Rte_Write_P_D` for `SWCA` then the same `RP global buffer` is used irrespective of when or how `SWCA` calls `Rte_Write_P_D`. Since the RTE API is created per-SWC instance then different instances will use different `RP global buffer`s.

Note that requirement [SWS_Rte_06036] indicates the minimum lifetime required; in an implementation the actual lifetime may be longer.

The above requirements are not intended to indicate that a dedicated `RP global buffer` must be created. In particular, if the generated RTE already contains a buffer whose characteristics satisfy those of an `RP global buffer` then an implementation is free to reuse the existing buffer.

As an additional example, consider an `Rte_Read` API that receives `VariableDataPrototype` `D` via port `P`. A "typical" implementation might look something like Example 4.15:

Example 4.15

```
Std_ReturnType Rte_Read_P_D(<type>* const data)
{
  *data = <receive>;
  <notifications>;
  return <result of receive>;
}
```

Where `<type>` is the implementation data type of the `VariableDataPrototype`, `<receive>` represents the reception process, e.g. from COM or direct access, `<notifications>` the steps required (if any) to notify that the reception has occurred and `<result of receive>` represents the return value of the RTE API.

When using the Extended buffer access method and the rptPreparationLevel is rptLevel1, the RptContainer references D and rptReadAccess is rptReadAccess the generated RTE API from Example 4.15 is modified to become Example 4.16:

Example 4.16

```
volatile <type> SWCB_Bypass_P_D;  /* RP global buffer */
Std_ReturnType Rte_Read_P_D(<type>* const data)
{
  SWCB_Bypass_P_D = <receive>;
  *data = SWCB_Bypass_P_D;
  <notifications>;
  return <result of receive>;
}
```

[SWS_Rte_06038] ⌈ When rptLevel1 support is enabled for a VariableDataPrototype accessed by explicit semantics the RTE generator shall substitute the write of received data to an associated OUT or INOUT API parameter with a write to an RP global buffer. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06039] ⌈ When rptLevel1 support is enabled for a VariableDataPrototype accessed by explicit semantics the RTE generator shall copy from the RP global buffer to OUT or INOUT API parameters before performing any AUTOSAR data reception notifications (and thus before the API returns if there are no notifications). ⌋*(SRS_Rte_00244)*

As with the explicit write, these requirements ensure that if an RP tool patches the write to SWCB_Bypass_P_D then the value that the tool writes will be returned to the API caller rather than the originally received value.

The characteristics of the RP global buffer are defined for the <send> process above. In particular the volatile keyword is essential to ensure that compiler optimization does not elide the read of the RP global buffer in *data = SWCB_Bypass_P_D.

Additional volatile RP global buffers are also used for IRV arguments in a similar way to the sender-receiver Rte_Read and Rte_Write APIs.

4.9.4.3.2 Interaction With Data Conversion

[SWS_Rte_06088] ⌈ Where a VariableDataPrototype is subject to data conversion before being transmitted the conversion shall occur before the write to the RP global buffer. ⌋*(SRS_Rte_00244)*

Assuming the data conversion if represented by the function f(x) then the example Rte_Write API would become Example 4.17:

Example 4.17

```
/* RP global buffer */
```

```
volatile <type2> SWCA_Bypass_P_D;

Std_ReturnType Rte_Write_P_D(<type> data)
{
  SWCA_Bypass_P_D = f(data);
  <send> SWCA_Bypass_P_D;
  return <result of send>;
}
```

Where `<type2>` is the data type after conversion.

4.9.4.3.3 Implicit Sender-Receiver and IRV

For implicit Sender-Receiver and IRV communication, RP global buffers are used when the context-local implicit communication buffers are initialized and written back. Consider an Rte_IWrite API that sends VariableDataPrototype D via port P and an Rte_IRead API that reads VariableDataPrototype E via port Q. A "typical" implementation might look like:

```
local_P_D = global_P_D;
local_Q_E = global_Q_E;
Runnable();
global_P_D = local_P_D;
```

Where `Runnable()` uses `Rte_IWrite_P_D()` and `Rte_IRead_Q_E()` which in turn access the context-local buffers `local_P_D` and `local_Q_E` to provide the required semantics.

When rptPreparationLevel is rptLevel1 and the container references the implicitly accessed VariableDataPrototype this is modified as follows:

```
volatile <type> Bypass_P_D;  /* RP global buffer */
volatile <type> Bypass_Q_E;  /* RP global buffer */
```

And inside the generated task body:

```
TASK(...)
{
  volatile <type> local_P_D;
  volatile <type> local_Q_E;

  /* ... */

  local_P_D = global_P_D;  /* Not changed */
  Bypass_Q_E = global_Q_E; /* Setup via RP global buffer */
  local_Q_E  = Bypass_Q_E;
  Runnable();
  Bypass_P_D = local_P_D;  /* Write-back via RP global buffer */
  global_P_D = Bypass_P_D;
}
```

To enable the RP tool to intercept the update of the context-local buffer used by the implicit APIs the Extended Buffer Access method uses an RP global buffer in a similar fashion to the explicit APIs.

[SWS_Rte_06040] ⌈ When rptLevel1 support is enabled for a VariableDataPrototype accessed by implicit semantics the RTE generator shall first update the RP global buffer from the RTE global variable / COM signal and then update the preemption area specific buffer from the RP global buffer before runnable invocation ⌋*(SRS_Rte_00244)*

[SWS_Rte_06087] ⌈ When rptLevel1 support is enabled for a VariableDataPrototype accessed by implicit semantics the RTE generator shall, after runnable termination, perform any write-back by first writing the preemption area specific buffer to the RP global buffer and then updating the RTE global variable / COM signal from the RP global buffer. ⌋*(SRS_Rte_00244)*

The Runnable() sequence can comprise of one or more calls to different runnables. Each runnable has a unique implicit API and therefore can, potentially, access different context-local buffers.

Finally, the write to the preemption area specific buffer and subsequent use could be used as the write-read cycle required for post-build hooking. A distinct RP global buffer may therefore be optimized away in some circumstances and the preemption area specific buffer used to enforce the requirement memory access pattern.

[SWS_Rte_06091] ⌈ When rptLevel1 support is enabled the RTE generator should avoid dedicated RP global buffer variables for implicit communication by implementing the preemption area specific buffers according to the (implementation) requirements on a RP global buffer ([SWS_Rte_06035],[SWS_Rte_06036]). ⌋*(SRS_Rte_00244)*

For instance in this case the preemption area specific buffers needs to be declared as volatile.

4.9.4.3.4 Mode APIs

Mode APIs are handled in a similar manner to explicit Sender-receiver APIs with the actual function parameters being written to an associated RP global buffer before use.

[SWS_Rte_06107] ⌈ When rptLevel1 support is enabled for a ModeDeclarationGroupPrototype the RTE generator shall write the API parameter to a RP global buffer. ⌋*(SRS_Rte_00244)*

Subsequent accesses to the actual parameter within the generated function are replaced by use of the RP global buffer instead.

[SWS_Rte_06108] ⌈ When rptLevel1 support is enabled for a ModeDeclarationGroupPrototype then within RTE APIs the RTE generator shall read the value of the associated parameter from the RP global buffer rather than use the formal parameter. ⌋(SRS_Rte_00244)

These modifications ensure that if an RP tool patches the write to the RP global buffer then the value that is written by the RP tool will be used as the new mode instead of the actual function parameter.

As an additional example, consider the typical implementation for an Rte_Switch API shown in Example 4.18 (error handling omitted for clarity):

Example 4.18

```
Std_ReturnType Rte_Switch_P_M( <type> newMode )
{
  if ( ! <in_transition> )
  {
     mode = newMode;
     <notifications>
  }
  else
  {
     <enQueue>( newMode );
  }
  return E_OK;
}
```

When using the Extended buffer access method and the rptPreparationLevel is rptLevel1 the generated RTE API from Example 4.18 is modified to become Example 4.19:

Example 4.19

```
/* RP global buffer */
volatile <type> SWCA_Bypass_P_M;

Std_ReturnType Rte_Switch_P_M( <type> newMode )
{
  SWCA_Bypass_P_M = newMode;

  if ( ! <in_transition> )
  {
     mode = SWCA_Bypass_P_M;
     <notifications>
  }
  else
  {
     <enQueue>( SWCA_Bypass_P_M );
  }
  return E_OK;
}
```

4.9.4.3.5 Client-Server APIs

rptLevel1 support can be enabled for individual parameters within an operation. The generated support differs based on the parameter direction.

4.9.4.3.5.1 IN Parameters

Client-Server parameters with direction of IN are copied to a dedicated RP global buffer variable before use to ensure the required write-read cycle. For IN parameters passed by reference a deep-copy is used.

[SWS_Rte_06092] ⌈ When rptLevel1 support is enabled for an ArgumentDataPrototype with direction of IN the generated RTE API shall write the parameter to a RP global buffer. ⌋*(SRS_Rte_00244)*

Subsequent accesses to the actual parameter within the generated RTE function are replaced by use of the RP global buffer instead.

[SWS_Rte_06093] ⌈ When rptLevel1 support is enabled for an ArgumentDataPrototype with direction of IN the RTE generator shall read the value of the associated parameter from the RP global buffer rather than use the formal parameter. ⌋*(SRS_Rte_00244)*

These modifications ensure that if an RP tool patches the write to the RP global buffer SWCA_Bypass_P_OP_a then the value that is written by the RP tool to SWCA_Bypass_P_OP_a will be see by the server instead of the actual function parameter a.

As an example of the changes to generated RTE code when rptLevel1 of the Extended Buffer Access method is enabled, consider an Rte_Call API that invokes ClientServerOperation OP via port P. A “typical” implementation might look something like Example 4.20:

Example 4.20

```
Std_ReturnType Rte_Call_P_OP([IN] <type> a)
{
  Server( a );
  return E_OK;
}
```

[SWS_Rte_06092] and [SWS_Rte_06093] modify Example 4.20 as follows:

Example 4.21

```
/* RP global buffer */
volatile <type> SWCA_Bypass_P_OP_a;

Std_ReturnType Rte_Call_P_OP([IN] <type> a)
{
```

```
  /* Copy to RP global buffer */
  SWCA_Bypass_P_OP_a = a;
  Server( SWCA_Bypass_P_OP_a );
  return E_OK;
}
```

The RP global buffer is volatile according to [SWS_Rte_06035].

4.9.4.3.5.2 OUT Parameters

When rptLevel1 support is enabled for Client-Server parameters with direction of OUT the server generated value can be replaced with a value generated by the RPT. In the generated code the value generated by the server is captured into a dedicated RP global buffer and then, after the server has completed, returned to the client via a copy that permits the RPT to affect the returned value.

[SWS_Rte_06094] ⌈ When rptLevel1 support is enabled for an ArgumentDataPrototype with direction of OUT the generated RTE API shall invoke the server with the OUT parameter replaced by a reference to an RP global buffer. ⌋ *(SRS_Rte_00244)*

After the server call the generated RTE API must return either the RPT generated result or the server generated result returned to the client.

[SWS_Rte_06095] ⌈ When rptLevel1 support is enabled for an ArgumentDataPrototype with direction of OUT the RTE generator shall copy the value of the associated parameter from the RP global buffer. ⌋*(SRS_Rte_00244)*

These modifications ensure that if an RP tool patches the write to the RP global buffer SWCA_Bypass_P_OP_a then the value that is written by the RP tool to SWCA_Bypass_P_OP_a will be see by the server instead of the actual function parameter a.

As an example of the changes to generated RTE code when rptLevel1 of the Extended Buffer Access method is enabled, consider an Rte_Call API that invokes ClientServerOperation OP via port P. A "typical" implementation might look something like Example 4.22:

Example 4.22

```
Std_ReturnType Rte_Call_P_OP([OUT] <type> a)
{
  Server( a );
  return E_OK;
}
```

[SWS_Rte_06094] and [SWS_Rte_06095] modify Example 4.22 as follows:

Example 4.23

```
/* RP global buffer */
volatile <type> SWCA_Bypass_P_OP_a;

Std_ReturnType Rte_Call_P_OP([OUT] <type> a)
{
  /* Pass reference to RP global buffer to server */
  Server( &SWCA_Bypass_P_OP_a );

  /* Copy server value (possible modified by RPT) to client */
  <deep-copy>( a, &SWCA_Bypass_P_OP_a );
  return E_OK;
}
```

4.9.4.3.5.3 IN-OUT Parameters

When `rptLevel1` support is enabled for Client-Server parameters with `direction` of `IN-OUT` the server generated value can be replaced with a value generated by the RPT as well as the value seen by the server being modified by RPT. Therefore in addition to the support for `OUT` parameters an initial copy before the server invocation is necessary.

[SWS_Rte_06096] ⌈ When `rptLevel1` support is enabled for an `ArgumentDataPrototype` with `direction` of `IN-OUT` the generated RTE API shall initialize the `RP global buffer` with the actual parameter before server invocation. ⌋ *(SRS_Rte_00244)*

After the server call the generated RTE API must return either the RPT generated result or the server generated result returned to the client.

[SWS_Rte_06097] ⌈ When `rptLevel1` support is enabled for an `ArgumentDataPrototype` with `direction` of `IN-OUT` the RTE generator shall copy the value of the associated parameter from the `RP global buffer`. ⌋*(SRS_Rte_00244)*

As an example of the changes to generated RTE code when `rptLevel1` of the Extended Buffer Access method is enabled, consider an `Rte_Call` API that invokes `ClientServerOperation` `OP` via port `P`. A “typical” implementation might look something like Example 4.24:

Example 4.24

```
Std_ReturnType Rte_Call_P_OP([IN-OUT] <type> a)
{
  Server( a );
  return E_OK;
}
```

[SWS_Rte_06094] and [SWS_Rte_06095] modify Example 4.22 as follows:

Example 4.25

```
/* RP global buffer */
volatile <type> SWCA_Bypass_P_OP_a;

Std_ReturnType Rte_Call_P_OP([IN-OUT] <type> a)
{
  /* Copy in value (possible modified by RPT) to RP global buffer */
  <deep-copy>( &SWCA_Bypass_P_OP_a, a );

  /* Pass reference to RP global buffer to server */
  Server( &SWCA_Bypass_P_OP_a );

  /* Copy server value (possible modified by RPT) to client */
  <deep-copy>( a, &SWCA_Bypass_P_OP_a );
  return E_OK;
}
```

4.9.4.4 Level 2 - Non Post-Build Hooking

This level is used for bypass scenarios where the binary code remains unchanged after RTE generation – in particular any code level requirements for bypass are inserted when the RTE is generated. For example, RP global buffers may be inserted as for rptLevel1 however run-time RP enabler flags are also added to allow control of how the buffers are used.

The typical Rte_Write Example 4.13 becomes Example 4.26:

Example 4.26

```
/* RP global buffer */
volatile <type> SWCA_Bypass_P_D;

/* RP enabler flag */
volatile <flag> SWCA_Bypass_P_D_Enable = FALSE;

Std_ReturnType Rte_Write_P_D(<type> data)
{
  if ( FALSE == SWCA_Bypass_P_D_Enable )
  {
      SWCA_Bypass_P_D = data;
  }
  <send> SWCA_Bypass_P_D;
  <notifications>;
  return <result of send>;
}
```

Where <type>, <send>, <notifications> and <result of send> are as before.

rptLevel2 is conceptually similar to rptLevel1 but with the additional constraint that the RP global buffer is only updated within the generated RTE function when the RP enabler flag is **disabled**[11]. Thus when the RP enabler flag is disabled, rptLevel2 has the same semantics as rptLevel1.

[SWS_Rte_06041] ⌈ When rptLevel2 support is enabled for a ModeDeclarationGroupPrototype or a VariableDataPrototype accessed using explicit semantics and the RP enabler flag is **disabled** the RTE generator shall write each associated IN or INOUT API parameter to a RP global buffer before the actual parameter is otherwise used within the generated function. ⌋*(SRS_Rte_00244)*

Subsequent accesses to the actual parameter within the generated function are replaced by use of the RP global buffer instead.

[SWS_Rte_06042] ⌈ When rptLevel2 support is enabled for a ModeDeclarationGroupPrototype or a VariableDataPrototype accessed using explicit semantics then within RTE APIs the RTE generator shall read the value of the associated IN and INOUT parameters from the RP global buffer rather than use the formal parameter. ⌋*(SRS_Rte_00244)*

The typical Rte_Read Example 4.15 becomes Example 4.27:

Example 4.27

```
/* RP global buffer */
volatile <type> SWCB_Bypass_P_D;

/* RP enabler flag */
volatile <flag> SWCB_Bypass_P_D_Enable = FALSE;

Std_ReturnType Rte_Read_P_D(<type>* const data)
{
  <type> temp = <receive>;
  if ( FALSE == SWCB_Bypass_P_D_Enable )
  {
      SWCB_Bypass_P_D = temp;
  }
  *data = SWCB_Bypass_P_D;
  <notifications>;
  return <result of receive>;
}
```

[11] The *RP enabler flag*s are described using inverted logic to reflect the requirements of bypass enable/disable. When rptLevel2/rptLevel3 bypass is **disabled** we want the API to use the value from the API's “data” argument whereas when rptLevel2/rptLevel3 bypass is **enabled** we do not want the API to use the value from the “data” argument because the RP service point will have written the bypass value into the *RP global buffer* before the runnable containing the API runs.

[SWS_Rte_06043] ⌈ When rptLevel2 support is enabled for a ModeDeclarationGroupPrototype or a VariableDataPrototype accessed using explicit semantics and the RP enabler flag is **disabled** the RTE generator shall write the value destined for each OUT or INOUT API parameter to an associated RP global buffer after the value is received within the generated function. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06044] ⌈ When rptLevel2 support is enabled for a VariableDataPrototype accessed using explicit semantics then within RTE APIs the RTE generator shall read the value of the associated OUT and INOUT parameters from the RP global buffers rather than directly using the values received in the generated function. ⌋*(SRS_Rte_00244)*

rptLevel2 support can be enabled for individual parameters within an operation. The generated RP enabler flags control the copies of the parameter before and/or after the server invocation within the generated RTE API.

For IN and IN-OUT parameters the generated code conditionally overwrites the value in the associated RP global buffer before server invocation. The overwrite occurs when the RP enabler flag is **disabled** and hence bypass – use of the RP generated value – is enabled.

[SWS_Rte_06098] ⌈ When rptLevel2 support is enabled for a ArgumentDataPrototype with direction IN or IN-OUT and the RP enabler flag is **disabled** the RTE generator shall write the actual parameter value destined for each IN or IN-OUT API parameter to an associated RP global buffer after the value is received within the generated function. ⌋*(SRS_Rte_00244)*

To enable replacement of the server generated value with one generated by the RPT a selection can be made based on the RP enabler flag.

[SWS_Rte_06099] ⌈ When rptLevel2 support is enabled for a ArgumentDataPrototype with direction IN-OUT or OUT and the RP enabler flag is **disabled** the RTE generator shall copy the server-generated value to the RP global buffer before copying the RP global buffer to the client's IN-OUT or OUT parameter . ⌋*(SRS_Rte_00244)*

[SWS_Rte_06100] ⌈ When rptLevel2 support is enabled for a ArgumentDataPrototype with direction IN-OUT or OUT and the RP enabler flag is **enabled** the RTE generator shall copy the RP global buffer to the client's IN-OUT or OUT parameter after the server invocation is complete. Note that in this case the server-generated value is ignored. ⌋*(SRS_Rte_00244)*

Requirements [SWS_Rte_06099] and [SWS_Rte_06100] require that the output comes from two different places; the server generated value when bypass is disabled and the RPT generate value when enabled. This implies the use of a temporary data store passed to the server to avoid overwriting the RPT value held in the RP global buffer.

[SWS_Rte_06101] ⌈ When rptLevel2 support is enabled for a ArgumentDataPrototype with direction IN-OUT the generated code shall use separate RP enabler flags for input-side and output-side bypass. ⌋ *(SRS_Rte_00244)*

The Rte_Call Example 4.24 is then modified as follows:

Example 4.28

```
/* Input-side bypass  */
volatile <type> SWCA_BypassIN_P_OP_a;
volatile <flag> SWCA_BypassIN_P_OP_Enable = FALSE;

/* Output-side bypass */
volatile <type> SWCA_BypassOUT_P_OP_a;
volatile <flag> SWCA_BypassOUT_P_OP_Enable = FALSE;

Std_ReturnType Rte_Call_P_OP([IN-OUT] <type> a)
{
  if ( FALSE == SWCA_BypassIN_P_OP_Enable )
  {
    /* RP disabled... use IN value */
    <deep-copy>( &SWCA_BypassIN_P_OP_a, a );
  }

  /* Pass reference to RP global buffer to server */
  Server( &SWCA_BypassIN_P_OP_a );

  if ( FALSE == SWCA_BypassOUT_P_OP_Enable )
  {
    /* Output-side bypass disabled: use server value */
    <deep-copy>( a, &SWCA_BypassIN_P_OP_a );
  }
  else
  {
    /* Copy RPT-initialized value to client */
    <deep-copy>( a, &SWCA_BypassOUT_P_OP_a );
  }

  return E_OK;
}
```

Note: The update of SWCA_BypassOUT_P_OP_a occurs in the background and is not shown in Example 4.28. The exact point that this occurs is not defined but will be before it is used in the generated function.

For IN and OUT parameters the generated code is similar to Example 4.28 but with either the input-side or output-side bypass omitted as appropriate.

4.9.4.4.1 RP Enabler Flag

The RP enabler flags control how the generated APIs interact with the RP global buffers (e.g. as updated by a post build hooking tool) depending on the flag state:

Disabled – When the RP enabler flag for a VariableDataPrototype is **disabled** the values received by the APIs are written to the RP global buffers and the APIs behave as normal.

Enabled – When the RP enabler flag for a VariableDataPrototype is **enabled** the write defined by [SWS_Rte_06043] does not occur and thus the API ignores data generated by runnables and uses bypass values written into the RP global buffers.

[SWS_Rte_06075] ⌈ When rptLevel2 support is enabled for a ModeDeclarationGroupPrototype or a VariableDataPrototype accessed using explicit semantics then within RTE APIs the RTE generator shall support RP enabler flags to permit the write to the RP global buffer to be disabled. ⌋*(SRS_Rte_00244)*

The RP enabler flags can be variables in RAM (as in the example), calibration characteristics or both - as specified in the input configuration. The <type> used for RP enabler flag is implementation dependent, e.g. an AUTOSAR Boolean or a bit-packed type, but is described in the generated RP description to enable access by RPT.

[SWS_Rte_06073] ⌈ The RTE generator shall create RP enabler flags in RAM when rptEnablerImplType is rptEnablerRam or rptEnablerRamAndRom. ⌋ *(SRS_Rte_00244)*

[SWS_Rte_06074] ⌈ The RTE generator shall create RP enabler flags as calibration characteristics when a rptEnablerImplType is rptEnablerRom. ⌋ *(SRS_Rte_00244)*

To enable the bypass to take effect the generated API must use the RP global buffers (as updated according to [SWS_Rte_06043], [SWS_Rte_06073] and [SWS_Rte_06074]) within the generated code rather than the values on input to the API.

[SWS_Rte_06079] ⌈ When the rptEnablerImplType is rptEnablerRamAndRom the two RP enabler flags are logically AND'd. ⌋*(SRS_Rte_00244)*

When both RAM and calibration characteristics are used the formulation would be something like:

Example 4.29

```
/* RP enabler flag (in RAM) */
volatile <flag> SWCA_Bypass_P_D_Enable = FALSE;

/* RP enabler flag (as a characteristic) */
volatile const <flag> SWCA_Bypass_P_D_Enable_Char = FALSE;
```

```

if ( ( FALSE == SWCA_Bypass_P_D_Enable ) &&
     ( FALSE == SWCA_Bypass_P_D_Enable_Char ) )
{
   SWCA_Bypass_P_D = data;
}
```

In the above examples `<flag>` represents the `RP enabler flag` data type. Implementations are at liberty to provide optimized implementations of the enablers, e.g. packing multiple enabler flags into a single variable, depending on known hardware characteristics.

4.9.4.5 Level 3 - Extended Non Post-Build Hooking

`rptLevel3` is an extension of `rptLevel2` but also records the value the ECU calculated. For example:

Example 4.30

```
/* RP global buffer */
volatile <type> SWCA_Bypass_P_D;

/* RP global measurement buffer */
volatile <type> SWCA_Bypass_P_D_Original;

/* RP enabler flag */
volatile <flag> SWCA_Bypass_P_D_Enable = FALSE;

Std_ReturnType Rte_Write_P_D(<type> data)
{
  SWCA_Bypass_P_D_Original = data;
  if ( FALSE == SWCA_Bypass_P_D_Enable )
  {
      SWCA_Bypass_P_D = data;
  }
  <send> SWCA_Bypass_P_D
  return <result of send>
}
```

[SWS_Rte_06045] ⌈ When `rptLevel3` support is enabled for a `ModeDeclarationGroupPrototype` or a `VariableDataPrototype` accessed using explicit semantics the RTE generator shall write the associated `IN` or `INOUT` API parameter to a `RP global measurement buffer` on entry to the generated function. ⌋ *(SRS_Rte_00244)*

[SWS_Rte_06046] ⌈ When `rptLevel3` support is enabled for a `ModeDeclarationGroupPrototype` or a `VariableDataPrototype` accessed using explicit semantics and the `RP enabler flag` is **disabled** the RTE generator shall write each associated `IN` or `INOUT` API parameter to a `RP global buffer` after the `RP` global measurement buffer is updated and before the RP global buffer is otherwise used within the generated function. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06102] ⌈When rptLevel3 support is enabled for a ArgumentDataPrototype the RTE generator shall write the associated IN or INOUT API parameter to a RP global measurement buffer on entry to the generated function. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06103] ⌈When rptLevel3 support is enabled for a ArgumentDataPrototype and the RP enabler flag is **disabled** the RTE generator shall write each associated IN or INOUT API parameter to a RP global buffer after the RP global measurement buffer is updated and before the RP global buffer is otherwise used within the generated function. ⌋*(SRS_Rte_00244)*

Subsequent accesses to the actual parameter within the generated function are replaced by use of the RP global buffer instead.

[SWS_Rte_06047] ⌈When rptLevel3 support is enabled for a ModeDeclarationGroupPrototype or a VariableDataPrototype accessed using explicit semantics then within RTE APIs the RTE generator shall read the value of the associated IN and INOUT parameters from the RP global buffer rather than use the formal parameter. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06104] ⌈When rptLevel3 support is enabled for a ArgumentDataPrototype then within RTE APIs the RTE generator shall read the value of the associated IN and INOUT parameters from the RP global buffer rather than use the formal parameter. ⌋*(SRS_Rte_00244)*

And likewise for the Rte_Read API:

Example 4.31

```
/* RP global buffer */
volatile <type> SWCB_Bypass_P_D;

/* RP global measurement buffer */
volatile <type> SWCB_Bypass_P_D_Original;

/* RP enabler flag */
volatile <flag> SWCB_Bypass_P_D_Enable = FALSE;

Std_ReturnType Rte_Read_P_D(<type>* const data)
{
  <type> temp = <receive>;
  SWCB_Bypass_P_D_Original = temp;
  if ( FALSE == SWCB_Bypass_P_D_Enable )
  {
       SWCB_Bypass_P_D = temp;
  }
  *data = SWCB_Bypass_P_D;
  return <result of receive>;
}
```

[SWS_Rte_06048] ⌈ When rptLevel3 support is enabled for a ModeDeclarationGroupPrototype or a VariableDataPrototype accessed using explicit semantics the RTE generator shall write the value destined for each OUT or INOUT API parameter to an associated RP global measurement buffer after the value is received within the generated function. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06105] ⌈ When rptLevel3 support is enabled for a ArgumentDataPrototype the RTE generator shall write the value destined for each OUT or INOUT API parameter to an associated RP global measurement buffer after the value is returned by the server within the generated function. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06049] ⌈ When rptLevel3 support is enabled for a ModeDeclarationGroupPrototype or a VariableDataPrototype accessed using explicit semantics and the RP enabler flag is **disabled** the RTE generator shall write the value destined for each OUT or INOUT API parameter to an associated RP global buffer after the RP global measurement buffer is updated. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06106] ⌈ When rptLevel3 support is enabled for a ArgumentDataPrototype and the RP enabler flag is **disabled** the RTE generator shall write the value destined for each OUT or INOUT API parameter to an associated RP global buffer after the RP global measurement buffer is updated. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06050] ⌈ When rptLevel3 support is enabled for a ModeDeclarationGroupPrototype or a VariableDataPrototype accessed using explicit semantics then within RTE APIs the RTE generator shall read the value of the associated OUT and INOUT parameters from the RP global buffers rather than directly using the values received in the generated function. ⌋*(SRS_Rte_00244)*

The Rte_Call Example 4.24 is then modified as follows:

Example 4.32

```
/* Input-side bypass  */
volatile <type> SWCA_BypassIN_P_OP_a;
volatile <type> SWCA_BypassINMeasurementBuf_P_OP_a;
volatile <flag> SWCA_BypassIN_P_OP_Enable = FALSE;

/* Output-side bypass */
volatile <type> SWCA_BypassOUT_P_OP_a;
volatile <type> SWCA_BypassOUTMeasurementBuf_P_OP_a;
volatile <flag> SWCA_BypassOUT_P_OP_Enable = FALSE;

Std_ReturnType Rte_Call_P_OP([IN-OUT] <type> a)
{
  /* rptLevel3: Retain input value */
  <deep-copy>( &SWCA_BypassINMeasurementBuf_P_OP_a, a );
  if ( FALSE == SWCA_BypassIN_P_OP_Enable )
  {
    /* RP disabled... use IN value */
    <deep-copy>( &SWCA_BypassIN_P_OP_a, a );
```

```
  }
  else
  {
    /* RP enabled... do nothing & use value from RPT */
  }

  /* Pass reference to RP global buffer to server */
  Server( &SWCA_BypassIN_P_OP_a );

  /* rptLevel3: Retain server generated value */
  <deep-copy>( &SWCA_BypassOUTMeasurementBuf_P_OP_a, &
      SWCA_BypassIN_P_OP_a );

  if ( FALSE == SWCA_BypassOUT_P_OP_Enable )
  {
    /* Output-side bypass disabled: use server value */
    <deep-copy>( a, &SWCA_BypassIN_P_OP_a );
  }
  else
  {
    /* Copy RPT-initialized value to client */
    <deep-copy>( a, &SWCA_BypassOUT_P_OP_a );
  }

  return E_OK;
}
```

For IN and OUT parameters the generated code is similar to Example 4.32 but with either the input-side or output-side bypass omitted as appropriate.

4.9.4.6 Level 2 and 3 - Non Post-Build Hooking and Implicit Communication

For implicit communication the context-local buffer is updated from the global master via an interception if the RP enabler flag is disabled. For rptLevel3 the original (master) data is also preserved in the RP global measurement buffer. A typical implementation for the initialization of the context-local buffer within a task (when rptLevel3 support is enabled) would therefore look like:

Example 4.33

```
/* RP global buffer */
volatile <type> SWCB_Bypass_P_D;

/* RP global measurement buffer */
volatile <type> SWCB_Bypass_P_D_Original;

/* RP enabler flag */
volatile <flag> SWCB_Bypass_P_D_Enable = FALSE;

TASK(X)
{
```

```
    /* RP global measurement buffer = global master data */
    SWCB_Bypass_P_D_Original = global_P_D;

    if ( FALSE == SWCB_Bypass_P_D_Enable )
    {
       /* RP global buffer = global master data */
       SWCB_Bypass_P_D = global_P_D;
    }

    /* context-local buffer */
    local_P_D = SWCB_Bypass_P_D;
    ...
}
```

When the RP enabler flag is **disabled** the global master data is used to update SWCB_Bypass_P_D and hence the RP generated value is not used. Conversely when bypass is **enabled** the value written by the RPT into SWCB_Bypass_P_D is used rather than overwriting with the global master.

[SWS_Rte_06051] ⌈ When rptLevel3 is enabled for a VariableDataPrototype accessed by implicit semantics the RTE generator shall update the RP global measurement buffer before the context-local buffer is updated (via the RP global buffer). ⌋*(SRS_Rte_00244)*

[SWS_Rte_06052] ⌈ When rptLevel2 or rptLevel3 is enabled for a VariableDataPrototype accessed by implicit semantics and the RP enabler flag is **disabled** the RTE generator shall write the value from the global master data to the RP global buffer. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06053] ⌈ When rptLevel2 or rptLevel3 is enabled for a VariableDataPrototype accessed by implicit semantics the RTE generator shall write the value from the RP global buffer to the context-local buffer after the RP global buffer is updated. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06054] ⌈ The RTE generator shall perform the above requirements in the sequence [SWS_Rte_06051] [SWS_Rte_06052] [SWS_Rte_06053]. ⌋*(SRS_Rte_00244)*

After runnable termination the value produced must be written back to the global master. The write-back occurs via an interception if the RP enabler flag is disabled. For rptLevel3 the original data produced by the runnable is also preserved in the RP global measurement buffer. A typical implementation for the initialization of the context-local buffer within a task (when rptLevel3 support is enabled) would therefore look like:

Example 4.34

```
/* RP global buffer */
volatile <type> SWCB_Bypass_P_D;

/* RP global measurement buffer */
```

```
volatile <type> SWCB_Bypass_P_D_Original;

/* RP enabler flag */
volatile <flag> SWCB_Bypass_P_D_Enable = FALSE;

TASK(X)
{
  ...

  /* RP global measurement buffer = context-local buffer */
  SWCB_Bypass_P_D_Original = local_P_D;

  if ( FALSE == SWCB_Bypass_P_D_Enable )
  {
    /* RP global buffer = context-local buffer */
    SWCB_Bypass_P_D = local_P_D;
  }

  global_P_D = SWCB_Bypass_P_D;
}
```

[SWS_Rte_06055] ⌈ When rptLevel3 is enabled for a VariableDataPrototype accessed by implicit semantics the RTE generator shall update the RP global measurement buffer using the context-local buffer. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06056] ⌈ When rptLevel2 or rptLevel3 is enabled for a VariableDataPrototype accessed by implicit semantics and the RP enabler flag is **disabled** the RTE generator shall write the value from the context-local buffer to the RP global buffer. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06057] ⌈ When rptLevel2 or rptLevel3 is enabled for a VariableDataPrototype accessed by implicit semantics the RTE generator shall write the value from the RP global buffer to the global master after the RP global buffer is updated. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06058] ⌈ The RTE generator shall perform the above requirements in the sequence [SWS_Rte_06055] [SWS_Rte_06056] [SWS_Rte_06057]. ⌋*(SRS_Rte_00244)*

4.9.4.7 Export

The RTE generator must describe the various buffers and flags created to support the configured RptImplPolicy.rptPreparationLevel for a VariableDataPrototype so that the information can be accessed by the RP system after RTE generation[12].

[12] To be fully used by an RPT system the information exported by the RTE generator may need subsequent augmentation to add details that are not known to the RTE generator, e.g. address information.

A generated RP buffer, flag, etc. is described by a separate McDataInstance with a particular role, e.g. RP-GLOBAL-BUFFER, that describe its usage. The role can describe the following:

1. RP global buffer.
2. RP enabler flag(s) (rptLevel2/rptLevel3).
3. RP global measurement buffer (rptLevel3).
4. RP stimulation enabler flag

The McDataInstance includes a reference to the relevant FlatInstanceDescriptor. This reference is the same one included in the McDataInstance for the RTEs buffer and therefore allows RP tools to make an association betwen the RTE managed buffers and the RP buffers/flags.

4.9.5 Service Based Prototyping

Access to the RP global buffers and RP global measurement buffers can be implemented by using a service based ECU interface in which an additional RP service component, such as an “XCP on CAN” or “XCP on Ethernet” service, is added to the ECU application.

The integration of the service can be performed pre-build by means of source code based integration, for example, by adding an XCP or custom BSW component, or post-build by patching the binary code of an already compiled ECU image.

In a service based scenario data is sampled and/or stimulated at RP service points. During either sampling or stimulation the data is read and/or written from the memory associated with the VariableDataPrototype to/from a local buffer during the execution of the RP service point and hence transferred to/from the RP tool. Within the context of the RTE the data stimulated by the RP service points are the RP global buffers and RP global measurement buffers however any data that is measurable is potentially subject to reading.

A RP service point is simply a call of a RP service function that is provided by the RP service component. The RP service function is responsible for sampling (reading) and stimulating (writing) the bypass data. The action of sampling may then trigger the RP system to perform the bypass (this may involve the communication of the sampled data to an external system for computation) ready for reading when the stimulation occurs.

4.9.5.1 Rapid Prototyping Scenarios

The Extended Buffer Access method augments the RapidPrototypingScenario to support service-based bypass. A RapidPrototypingScenario aggregates one or more RptContainers and one or more RptProfiles.

- RptProfile – Each profile defines an RP service profile consisting of:
  - The permitted range of RP service point id defined as minServicePointId to maxServicePointId.
  - The C-Symbols of the RP service functions invoked before and after the runnable entity.
- RptContainer – Each RptContainer defines the entity to be encapsulated by calls to the RP service function. A single RptContainer instance can reference a complete SW-C (in which case all invocations of its runnable entities are encapsulated by calls to RP service functions), a single RTEEvent or a single VariableDataPrototype.

  An RptContainer can optionally define one or more explicitRptProfileSelection references. When present the references provide a list of RptProfiles which needs to be applied when the RPT support is implemented. When no explicitRptProfileSelection references are defined then all RptProfiles defined in the RapidPrototypingScenario are applicable.

  The RptExecutableEntityProperties within an RptContainer aggregates information about the properties of the executable entity(s) to which the RP service points apply. This includes rptServicePoint which defines a switch for RP service point generation and thus permits profiles to define variable preparation and/or service point support.

For each applicable RptProfile (i.e. selected through explicitRptProfileSelection references or by the use of all profiles when no such references are present) the RTE generator inserts calls to the RP service function around the invocation of the runnable entity (or runnable entities) started by the RTEEvent referenced by each aggregated RptContainer.

Example 4.35

As an example of how RptProfile and RptContainer interact, consider the following scenario:

- A RapidPrototypingScenario instance that aggregates a single RptProfile instance.
- An RptProfile instance that aggregates two RP service functions:
  - servicePointSymbolPre defines ServiceFunc1_pre.
  - servicePointSymbolPost defines ServiceFunc1_post.

- A single RptContainer instance (with no explicitRptProfileSelection references) that:
  - Has zero explicitRptProfileSelection references.
  - References, using byPassPoint, a single RTEEvent Event1 that triggers runnable re1.

The RTE would then generate:

```
ServiceFunc1_pre(<rptEventId>, <spId1>, <stim>);
re1();
ServiceFunc1_post(<rptEventId>, <spId2>, <stim>);
```

Where:

- The RTE event identifier, <rptEventId>, identifies the RTE event and is within the range specified in the interval [minRptEventId. . .maxRptEventId) of the RptExecutableEntityProperties.
- The RP service point ids, <spId1> and <spId2>, identify the service point and are within the interval [minServicePointId. . .maxServicePointId) of the RptProfile.
- <stim> is the RP stimulation enabler flag to control RP stimulation.

To extend Example 4.35, an additional RptProfile referencing RP service function, ServiceFunc2 (both pre- and post) is added to the RapidPrototypingScenario.

Example 4.36

The RTE would then generate:

```
ServiceFunc1_pre(<rptEventId>, <spId1>, <stim>);
ServiceFunc2(<rptEventId>, <spId2>, <stim>);
re1();
ServiceFunc1_post(<rptEventId>, <spId3>, <stim>);
ServiceFunc2(<rptEventId>, <spId4>, <stim>);
```

Each RP service function use the same RTE event identifier, i.e. <rptEvendId>, since all four calls wrap the same runnable invocation however each uses a different RP service point id.

Multiple RptProfiles can lead to multiple RP service functions for the same RTEEvent. All such calls are ordered alphabetically ([SWS_Rte_06061]) and have the same RTE event identifier but different RP service point ids.

4.9.5.2 Service Functions

The RP service function is responsible for sampling the required data. The parameters of the RP service function do **not** include the data, instead, the parameters identify the RTE EVent and service point:

<rptEventId> – RTE event identifier indicating the associated RTE Event.

This parameter is defined by the RptContainer's RptExecutableEntityProperties and is therefore the same for all RptProfiles aggregated within the RptContainer.

<servicePointId> – The RP service point id is used by the RP service component to identify the particular service point.

This parameter is defined by the RptProfile and is therefore differentfor each profile.

<stimEnabler> – Calibratable value to control RP Stimulation. This parameter is optional, if not configured zero is passed to the RP service function.

This parameter is defined by the RptProfile and is therefore differentfor each profile.

[SWS_Rte_06059] ⌈ A RP service point id shall have the type uint16. ⌋ *(SRS_Rte_00244)*

[SWS_Rte_06060] ⌈ An invocation of a RP service function shall conform to the prototype:

```
void <RptServiceSymbol>( uint16 <rptEventId>,
                         uint16 <servicePointId>
                         uint8  <stimEnabler> );
```

Where <RptServiceSymbol> is specified as the RptProfile.servicePointSymbolPre or RptProfile.servicePointSymbolPost and <servicePointid> is the RP service point id. The <stimEnabler> provides run-time control of RP stimuation. ⌋*(SRS_Rte_00244)*

Note that given the defined type the range of RP service point id is [0 . . . 65535].

[SWS_Rte_06061] ⌈ For all RP service function defined by the input configuration the RTE generator shall invoke the RP service function in alphabetical order (ASCII / ISO 8859-1 code in ascending order). ⌋*(SRS_Rte_00244)*

To avoid ambiguity two RptProfiles are not permitted to declare identical <RptServiceSymbol>s.

[SWS_Rte_06076] ⌈ The RTE generator shall reject configurations where RptProfile.servicePointSymbolPre or RptProfile.servicePointSymbolPost are not globally unique. ⌋*(SRS_Rte_00244)*

The “pre” and “post” positions provide the ability to differentiate RP service points that are invoked before and after runnable invocation if this is required. The two calls will have a common RP event ids but different RP service point ids.

To permit one RptProfile to describe variable preparation and/or service points the rptServicePoint within the RptContainer defines an enable/disable switch:

[SWS_Rte_06120] ⌈ The RTE generator shall create calls to RP service functions defined by an RptProfile only when the RptContainer’s rptServicePoint parameter is enabled. ⌋*(SRS_Rte_00244)*

4.9.5.2.1 RP Stim Enabler

The RP stimulation enabler flag parameter provides runtime control of RP stimulation by the RP service function. Example 4.37 shows the same value passed as the <stimEnabler> parameter to both pre- and post RP service points.

Example 4.37

```
ServiceFunc1_pre(<rptEventId>, <spId1>, <stimEnabler>);
if (! <rp_disabler_flag>)
{
  re1();
}
ServiceFunc1_post(<rptEventId>, <spId2>, <stimEnabler>);
```

The <stimEnabler> parameter has a fixed datatype of uint8 and is, when configured, exported into RptSupportData as calibratable.

[SWS_Rte_06111] ⌈ When RptProfile.stimEnabler is rptEnablerRam or rptEnablerRom the value of the <stimEnabler> shall be passed as the third parameter of the RP service function invocation. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06112] ⌈ When RptProfile.stimEnabler is none the third parameter of the RP service function invocation shall be 0 (zero). ⌋*(SRS_Rte_00244)*

[SWS_Rte_06115] ⌈ The RTE generator shall reject configurations where the RptProfile.stimEnabler is rptEnablerRamAndRom. ⌋*(SRS_Rte_00244)*

Each RP service point has its own <stimEnabler> parameter. As a consequence, there are as many <stimEnabler> parameters as there are enabled RP service points, i.e. 1000 Service points with enabled RptProfile.stimEnabler will result in 1000 calibratable <stimEnabler> parameters.

As well as instantiating the <stimEnabler> parameter the RTE generate must output information in the generated RptSupportData to enable down-stream tools to locate the calibratable parameter.

[SWS_Rte_06110] ⌈ When RptProfile.stimEnabler is not none the <stimEnabler> description shall be exported in the RptSupportData. ⌋*(SRS_Rte_00244)*

The calibratable <stimEnabler> parameters are accessed by MC or RP tools. To enable the identification of different parameters the name of the generated calibratable value includes the name of the hooked RTE/BSW Event.

[SWS_Rte_06109] ⌈ The name of generated <stimEnabler> parameter shall include the name of hooked SwComponentPrototype and RTEEvent/BswEvent to be referenced. ⌋*(SRS_Rte_00244)*

4.9.5.3 Integration

There are two possibilities on how to integrate a RP service point pre-build; either as *SWC Internal* inserted by the SWC developer or as *RTE Assigned* created by the RTE generator.

SWC Internal In this scenario the RP service function signature of the BSW that provides the service is known by the SWC developer.

The SWC developer implements the RP service function calls at required positions within the RunnableEntity code, typically one right before and a second one right after every area to be prepared for bypassing. This mechanism is typically used in migration scenarios where a single RunnableEntity contains multiple functionality.

The SWC developer has to document the integrated RP service point, whether used for sampling or stimulating RP data, in the context of the RunnableEntity information of the AUTOSAR SWC description.

In this scenario there is no requirement for the RTE generator to insert RP service point calls within generated code. In addition, the RTE generator is not responsible for assignment of RP service point ids instead these are selected when the RP service functions invocations are created. However the RTE generator must ensure that the description of the SWC's service hooks is exported for subsequent tools.

RTE Assigned In this scenario the RTE generator evaluates the SWC descriptions for required SWC RP service points and adds them at dedicated positions before and after the invocation of a RunnableEntity.

In the following discussion the positions for the invocation of SWC RP service points is defined by the following pseudo-code for the invocation of a runnable entity:

Example 4.38

```
[Point A]
<update context-local buffers>
<VFB Runnable Start>();
```

```
[runnable invocation]
<VFB Runnable Return>();
[Point B]
<update global buffers>
<RTE notifications>
```

[SWS_Rte_06064] ⌈ When an RptContainer references a SwComponentPrototype, the RTE generator shall insert RP service points at both [Point A] and [Point B] for each RptProfile for all applicable RTEEvent/BswEvent(s). ⌋ *(SRS_Rte_00244)*

[SWS_Rte_06089] ⌈ When an RptContainer references an RTEEvent/BswEvent in a SwComponentPrototype, the RTE generator shall insert RP service points at both [Point A] and [Point B] for each applicable RptProfile. ⌋ *(SRS_Rte_00244)*

[SWS_Rte_06090] ⌈ When an RptContainer references an VariableDataPrototype, the RTE generator shall insert RP service points at both [Point A] and [Point B] for each applicable RptProfile for each RTEEvent/BswEvent that can read/write the VariableDataPrototype. ⌋ *(SRS_Rte_00244)*

The invocation of a RunnableEntity may be conditional, for example, as a result of an execution pre-scaling when multiple RTEEvents are mapped to the task. If so then the execution of the RP service points has the same conditionality.

[SWS_Rte_06065] ⌈ The RTE generator shall invoke the SWC RP service points at [Point A] and [Point B] only if the ExecutableEntity is subject to invocation at [runnable invocation]. ⌋ *(SRS_Rte_00244)*

Note that the invocation of the ExecutableEntity may still be subject to omission if the execution would conflict with the bypass functionality; see below.

4.9.5.4 Service Point IDs

The RTE input configuration may include SWCs from multiple suppliers that each contain SWC-Internal RP service point ids. The same RP service point id must never be used twice within the same ECU application and therefore the RTE generator is required to reject input configurations that result in duplications – it is not permitted to remap RP service point ids.

[SWS_Rte_06066] ⌈ The RTE generator shall reject configurations that contain SWCs with duplicate SWC-Internal RP service point ids. ⌋ *(SRS_Rte_00244)*

In addition to SWC-Internal RP service point ids the RTE generator is required to assign RP service point ids used for RTE hooks. To avoid conflicts with SWC-Internal RP service point ids the input configuration describes permitted range for IDs for such RP service points.

To enable Pre and Post RP service point invocations to be distinguished different RP service point id are used – a unique ID is used for each RP service point invocation.

[SWS_Rte_06067] ⌈ The RTE generator shall assign the next unused RP service point id for the RP service point invocations at [Point A] and [Point B] from the permitted range. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06068] ⌈ The permitted range is defined as minServicePointId to maxServicePointId inclusive. ⌋*(SRS_Rte_00244)*

The RP service point ids assigned by the RTE generator are documented in the generated configuration as part of the RptProfile. See Example 4.38 for locations of [Point A] and [Point B].

4.9.5.5 Conditional RunnableEntity Invocation

In addition to data bypass the invocation of the RP service function at [Point A] (see Example 4.38) may trigger computation that replaces the execution of the original RunnableEntity either because the execution would be redundant or have unwanted side effects. Thus it is possible to make the execution conditional and thus the [runnable invocation] element of the pseudo-code above is replaced by:

Example 4.39

```
if ( FALSE == <RPRunnableDisablerFlag> )
{
    [VFB Trace event - runnable start]
    symbol() /* runnable invocation */
    [VFB Trace event - runnable return]
}
```

The conditional execution of the original symbol is unrelated to the normal conditionality of the invocation, e.g. due to the presence of prescalers created by the RTE generator when multiple RTEEvents are mapped to the task. Mofication, e.g. increment, of the prescalers should occur even when the RP runnable disabler flag is TRUE. Example 4.40 shows the combination of RP runnable disabler flag with RTE generated conditional execution that invokes the runnable once every five task activations.

Example 4.40

```
if ( --Rte_RunnableDivide == 0 )
{
```

```
    Rte_RunnableDivide = 5u;
    if ( FALSE == <RPRunnableDisablerFlag> )
    {
       [VFB Trace event - runnable start]
       symbol() /* runnable invocation */
       [VFB Trace event - runnable return]
    }
 }
```

[SWS_Rte_06069] ⌈ When the RP `rptExecutionControl` is `conditional` the RTE generator shall invoke the `symbol` only if the runnable disabler flag is `FALSE`. ⌋ *(SRS_Rte_00244)*

Note that there is no ability to control the execution of `RTEEvent`s since the intent is to avoid the side effects of the runnable whatever the triggering event therefore the same conditionality applies to all uses of the runnable.

[SWS_Rte_06077] ⌈ For each `conditional` in the input `rptExecutionControl` the RTE generator shall document the generated `RP runnable disabler flag` in the exported `RptSupportData`. ⌋ *(SRS_Rte_00244)*

4.9.5.6 Interaction with RTE-Managed buffers

The `<update context-local buffers>` pseudo-code is responsible for manipulating the RTE-managed context-local buffers (i.e. those used for implicit communication) based on updates performed by the `RP service function` invocations – it must therefore happen after the invocations at `[Point A]` and `[Point B]` ((see Example 4.38 for locations of `[Point A]` and `[Point B]`).

The `<update context-local buffers>` pseudo-code uses the `RP global buffer`s to update the context-local buffers and thus, potentially, use values provided by the `RP service function` `[Point A]`.

As an example of `rptLevel3` bypass (which includes the ability to enable/disable bypass at run-time) the `<update context-local buffers>` pseudo-code could be implemented as follows:

Example 4.41

```
/* RP global measurement buffer = global master data */
SWCB_Bypass_P1_D_Original = global_P1_D;

if ( FALSE == SWCB_Bypass_P1_D_Enable )
{
     /* Bypass disabled */
     /* RP global buffer = global master data */
     SWCB_Bypass_P1_D = SWCB_Bypass_P1_D_Original;
}

/* context-local buffer */
```

```
local_P1_D = SWCB_Bypass_P1_D;
```

Similarly the <update global buffers> pseudo-code that follows [Point B] uses the RTE-managed context-local buffers to update the RTE-managed global buffers with either RP global buffer values or context-local values (if using rptLevel2 or rptLevel3 bypass which include run-time bypass enable/disable). Consequently the <update global buffers> must occur after RP service point [Point B] but before configured notifications have been made at <RTE notifications>.

Example 4.42

```
/* RP global measurement buffer = context-local buffer */
SWCB_Bypass_P2_D_Original = local_P2_D;

if ( FALSE == SWCB_Bypass_P2_D_Enable )
{
    /* Bypass disabled */
    /* RP global buffer = context-local buffer */
    SWCB_Bypass_P2_D = local_P2_D;
}

global_P2_D = SWCB_Bypass_P2_D;
```

4.9.5.7 Export

For both SWC-Internal and RTE-Assigned RP service point ids the RTE generator must describe the invoked RP service functions so that the information can be accessed by the RP system after RTE generation[13].

The exported RTE McSupportData is used to describe the generated configuration and consists of:

- RptSupportData describing RP execution contexts
- Invoked RP service points (whether SWC-Internal or RTE-Assigned).
- Relationship between RptExecutableEntityEvent and pre-functional RP service point.
- Relationship between RptExecutableEntityEvent and post-functional RP service point.
- Relationship between RptExecutableEntityEvent and RP runnable disabler flag.

[13] To be fully used by an RPT system the information exported by the RTE generator may need subsequent augmentation to add details that are not known to the RTE generator, e.g. address information.

In the following requirements [Point A] and [Point B] refer to locations defined in Example 4.38.

[SWS_Rte_06080] ⌈ When a RunnableEntity has implicit read access to a VariableDataPrototype for which RP service points are generated according to [SWS_Rte_06064] then the RTE generator shall export rptServicePointPre at the according RptExecutableEntityEvent documenting the RP service points generated at [Point A]. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06081] ⌈ When a RunnableEntity has implicit write access to a VariableDataPrototype for which RP service points are generated according to [SWS_Rte_06064] then the RTE generator shall export rptServicePointPost at the according RptExecutableEntityEvent documenting the RP service points generated at [Point B]. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06082] ⌈ When a RunnableEntity has explicit read access to a VariableDataPrototype for which RP service points are generated according to [SWS_Rte_06064] then the RTE generator shall export rptServicePointPost at the according RptExecutableEntityEvent documenting the RP service points generated at [Point B]. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06083] ⌈ When a RunnableEntity has explicit write access to a VariableDataPrototype for which service points are generated according to [SWS_Rte_06064], [SWS_Rte_06089] or [SWS_Rte_06090] then the RTE generator shall export rptServicePointPre at the according RptExecutableEntityEvent documenting the RP service points generated at [Point A]. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06084] ⌈ When a RunnableEntity has explicit read or write access to a VariableDataPrototype for which service points are generated according to [SWS_Rte_06064], [SWS_Rte_06089] or [SWS_Rte_06090] then the RTE generator shall export rptServicePointPre at the according RptExecutableEntityEvent documenting the RP service points generated at [Point A]. ⌋*(SRS_Rte_00244)*

[SWS_Rte_06085] ⌈ When a RunnableEntity has explicit read or write access to a VariableDataPrototype for which RP service points are generated according to [SWS_Rte_06064], [SWS_Rte_06089] or [SWS_Rte_06090] then the RTE generator shall export rptServicePointPost at the according RptExecutableEntityEvent documenting the RP service points generated at [Point B]. ⌋*(SRS_Rte_00244)*

4.10 Data Transformation

Transformers enable AUTOSAR systems to use a data transformation mechanism to linearize and transform data. They can be concatenated to transformer chains and are executed by the RTE for inter-ECU communication which is configured to be transformed. The input of the first transformer in the chain gets the data from the RTE. Each following transformer uses the output of the preceding transformer as input. All transformers following the first one then have a generic signature with just a byte array as IN and OUT parameter. Such an architecture could be used to design systems, where you can flexibly add functionality like safety or security protection to a serialized stream.

The transformers for inter-ECU communication are configured in the System Description.

Furthermore the RTE can execute transformers for intra-ECU communication to transform different representations of data structures between software components or basic software modules within one ECU. Transformers for intra-ECU communication are restricted to unqueued S/R communication. In addition no transformer chains are applicable. Those limitations are formulated since for the currently known use-cases there is no need for introducing this functionality.

The execution of the transformers and the necessary buffer handling is coordinated by the RTE.

4.10.1 Execution of Transformer

4.10.1.1 Transformer for inter-ECU communication

[SWS_Rte_08794] ⌈ The RTE shall execute data transformation for inter-ecu communication if a `DataTransformation` is referenced by an `ISignal` that references a `SystemSignal` which

1. is referenced by a `SenderReceiverToSignalMapping`, `ClientServerToSignalMapping` or `TriggerToSignalMapping`
2. **or** is referenced by a `SystemSignalGroup` in the role `transformingSystemSignal` if the `SystemSignalGroup` is referenced by a `SenderReceiverToSignalGroupMapping`

⌋*(SRS_Rte_00247)*

Note:
In case of fan-in of inter-ECU communication where the `ISignal`s use different data transformations, the RTE has to ensure that it executes the correct transformer chain that belongs to exactly that `ISignal`. This could be achieved for example by remembering within the Com callback which `DataTransformation` belongs to the received data.

[SWS_Rte_08795] ⌈ The RTE shall execute all transformers of a transformer chain in their execution order for queued (event semantics) sender-receiver communication even when the queue is empty (because no data are available) if `executeDespiteDataUnavailability` of `DataTransformation` is enabled and the `Rte_Receive`

API has non-blocking characteristics according to [SWS_Rte_01288]. The input to all the transformers in the chain shall be NULL with a dataLength equal to 0. ⌋ *(SRS_Rte_00247)*

Please note: This functionality is only available on the receiving side of queued Sender/Receiver communication. Furthermore, if Signal fan-in is used, no signal shall have the attribute executeDespiteDataUnavailability set to true (see [constr_3208]).

There are two main cases considered when executeDespiteDataUnavailability is important: an empty queue in case of queued S/R communication and errors in the COM stack so that the RTE doesn't get data from Com or LdCom.

[SWS_Rte_08796] ⌈ For VariableAccesses in the roles dataReceivePointByArgument, dataReceivePointByValue or dataSendPoint the RTE shall execute data transformation from within the called RTE API. ⌋ *(SRS_Rte_00247)*

In case of explicit sender-receiver communication, the execution of the data transformation takes place inside the RTE API which is called by the SWC.

In case of implicit sender-receiver communication, the execution of the data transformation takes place on sender side between execution of the runnable and handover of the data to the Com stack and on receiver side between reception of the data from the Com stack and start of the runnable.

[SWS_Rte_08570] ⌈ For VariableAccesses in the dataReadAccess role the RTE shall execute data transformation after reception of the data from the Com stack and before start of the runnable/coherency group. ⌋ *(SRS_Rte_00247)*

[SWS_Rte_08571] ⌈ For VariableAccesses in the dataWriteAccess role the RTE shall execute data transformation after termination of the runnable/coherency group and before handing the data over to the Com stack. ⌋ *(SRS_Rte_00247)*

[SWS_Rte_08596] ⌈ For ExternalTriggeringPoints the RTE shall execute data transformation from within the called RTE API Rte_Trigger. ⌋ *(SRS_Rte_00247)*

In case of external trigger communication, the execution of the data transformation takes place inside the RTE API which is called by the SWC.

[SWS_Rte_08797] ⌈ If transformer is configured to have access to original data, the RTE shall ensure that these are unchanged until the end of the execution of the transformer chain. ⌋ *(SRS_Rte_00247)*

4.10.1.2 Transformer for intra-ECU communication

[SWS_Rte_08105] ⌈ The RTE shall execute data transformation for intra-ecu communication if a DataTransformation is referenced by a DataPrototypeMapping. ⌋ *(SRS_Rte_00253)*

[SWS_Rte_08107] ⌈ For VariableAccess in the roles dataReceivePointByArgument, dataReceivePointByValue or dataSendPoint the RTE shall execute data transformation from within the called RTE API. ⌋*(SRS_Rte_00253)*

In case of implicit sender-receiver communication, the execution of the data transformation takes place on sender side after execution of the RunnableEntity/BswSchedulableEntity and on receiver side before the start of the RunnableEntity/BswSchedulableEntity.

[SWS_Rte_08108] ⌈ For VariableAccess in the dataReadAccess role the RTE shall execute data transformation before start of the RunnableEntity/BswSchedulableEntity. ⌋*(SRS_Rte_00253)*

[SWS_Rte_08109] ⌈ For VariableAccess in the dataWriteAccess role the RTE shall execute data transformation after termination of the RunnableEntity/BswSchedulableEntity. ⌋*(SRS_Rte_00253)*

4.10.2 Transformer Chains

[SWS_Rte_08798] ⌈ The RTE shall support transformer chains (DataTransformation) with a length up to 255 transformers TransformationTechnology. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08110] ⌈ The RTE shall support transformer chains (DataTransformation) only for inter-ecu data transformation. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08799] ⌈ The RTE on sender side shall execute the transformers of the chain in order. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08588] ⌈ The RTE on receiver side shall execute the retransformers of the chain in reverse order. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08589] ⌈ The RTE on client side shall execute the transformers of the chain in order for all IN and IN/OUT arguments of the server call. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08590] ⌈ The RTE on server side shall execute the retransformers of the chain in reverse order for all IN and IN/INOUT arguments of the server call. ⌋*(SRS_Rte_00247)*

Both the IN and the IN/OUT arguments are transferred from the client to the server.

[SWS_Rte_08515] ⌈ The RTE on server side shall execute the transformers of the chain in order for all IN/OUT and OUT arguments and return code of the server operation. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08516] ⌈ The RTE on client side shall execute the retransformers of the chain in reverse order for all IN/OUT and OUT arguments and return code of the server operation. ⌋*(SRS_Rte_00247)*

All the IN/OUT arguments, OUT arguments and the return value are transferred from the server to the client. The IN/OUT arguments have to be included in both communication directions because these arguments represent bi-directional communication.

[SWS_Rte_08517] ⌈ If data conversion does not apply, the input of the first transformer (in execution order) on sender side for sender-receiver communication shall be the data from the `VariableDataPrototype` by the SWC. ⌋*(SRS_Rte_00247)*

[SWS_Rte_04540] ⌈ If data conversion applies, the input of the first transformer (in execution order) on sender side for sender-receiver communication shall be the converted data from the `VariableDataPrototype` by the SWC. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08518] ⌈ The input for the first transformer (in execution order) on receiver side for inter-ECU sender-receiver communication shall be the received data from the Com stack. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08519] ⌈ The input for the first transformer (in execution order) on client side for client-server communication shall be the data from the `ClientServerOperation` by the SWC. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08520] ⌈ The input for the first transformer (in execution order) on server side for the request of a client-server communication shall be the received data from the Com stack. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08521] ⌈ The input for the first transformer (in execution order) on server side for the response of a client-server communication shall be the data from the `ClientServerOperation` by the SWC. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08522] ⌈ The input for the first transformer (in execution order) on client side for the response of a client-server communication shall be the received data from the Com stack. ⌋*(SRS_Rte_00247)*

The input for the first transformer (in execution order) on the Trigger Source side for external trigger communication contains no payload data (See [SWS_Xfrm_00102] in [26, ASWS Transformer General]).

[SWS_Rte_08597] ⌈ The input for the first transformer (in execution order) on Trigger Sink side for external trigger communication shall be the received data from the Com stack. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08523] ⌈ The output of the last transformer (in execution order) on sender side for inter-ECU sender-receiver communication shall be transmitted to the Com stack. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08524] ⌈ If data conversion does not apply, the output of the last transformer (in execution order) on receiver side for sender-receiver communication shall be handed over to the SWC. ⌋*(SRS_Rte_00247)*

[SWS_Rte_04541] ⌈ If data conversion applies, the RTE shall convert the output of the last transformer (in execution order) on receiver side for sender-receiver communication before handing it over to the SWC. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08525] ⌈ The output of the last transformer (in execution order) on client side for the request of a client-server communication shall be transmitted to the COM or Com stack. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08598] ⌈ The output of the last transformer (in execution order) on Trigger Source side for external trigger communication shall be transmitted to the Com stack. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08599] ⌈ On Trigger Sink side for external trigger communication, the RTE shall trigger the execution of the triggered `RunnableEntity` if no transformer in the transformer chain returns a hard error. ⌋*(SRS_Rte_00247)*

This means that only the `RunnableEntity` for the `TransformerHardErrorEvent`s but not the `RunnableEntity`s for `ExternalTriggerOccurredEvent`s shall be triggered if a hard transformer error occurred.

[SWS_Rte_08526] ⌈ On server side for client/server communication, the RTE shall trigger the execution of the triggered `RunnableEntity` and hand the output of the last transformer over to the triggered `RunnableEntity` if and only if no transformer in the transformer chain returns a hard error. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08527] ⌈ The output of the last transformer (in execution order) on server side for the response of a client-server communication shall be transmitted to the Com stack. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08528] ⌈ The output of the last transformer (in execution order) on client side for the response of a client-server communication shall be handed over to the SWC. ⌋*(SRS_Rte_00247)*

[SWS_Rte_08529] ⌈ The output of a non-last transformer (in execution order) in a transformer chain shall be the input for the next transformer in the execution order of the chain. ⌋*(SRS_Rte_00247)*

If there is a signal fanout, it is possible to optimize the execution of the transformers. If multiple transformer chains in case of a signal fanout have the same set of transformers at the beginning of the transformer chain, the RTE optimizes and executes those transformers only once for all transformer chains together. The result can be shared between all transformers chains. This is only possible if no `ComBasedTransformer` is involved.

[SWS_Rte_08530] ⌈ If the `XfrmImplementationMapping` (see [ECUC_Xf_00001]) maps multiple transformers (which are used to transform different `ISignal`s) to the same `BswModuleEntry`, the RTE shall execute those first transformers only once using the mapped `BswModuleEntry` and take the result as input for the further transformers for those `ISignal`s. ⌋*(SRS_Rte_00247)*

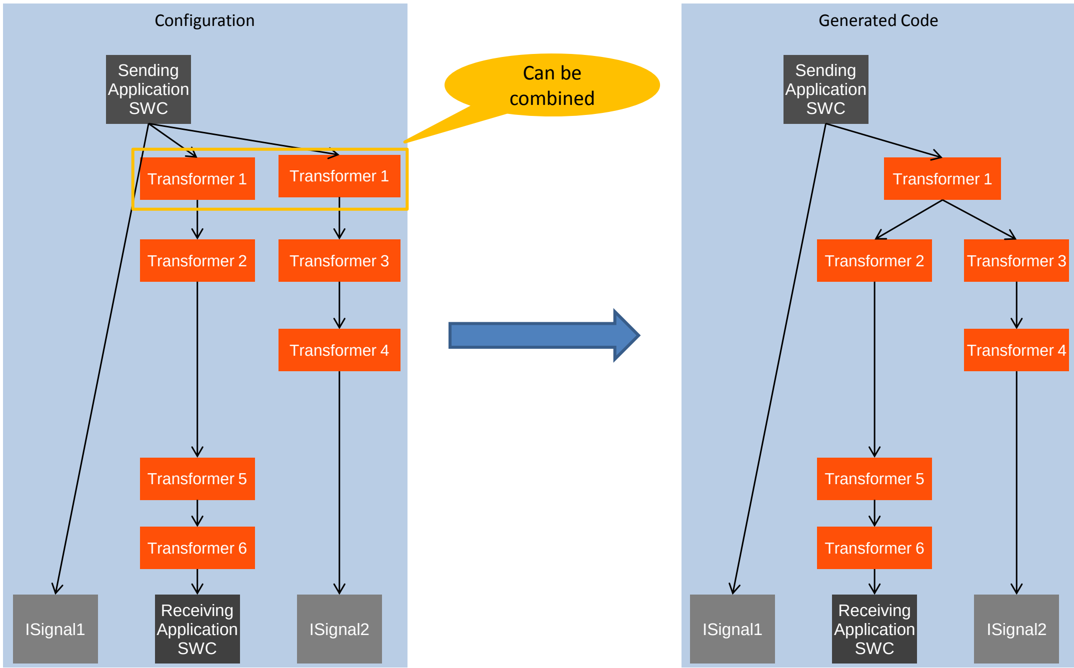

Figure 4.55: Example of a transformer optimization

4.10.3 Buffer Handling

[SWS_Rte_08531] ⌈ If the attribute inPlace in the BufferProperties of a TransformationTechnology is set to FALSE, the RTE shall provide a separate buffer to the transformers in which they can write their output. ⌋ *(SRS_Rte_00248)*

[SWS_Rte_08532] ⌈ If the attribute inPlace in the BufferProperties of a TransformationTechnology is set to TRUE, the RTE shall provide one buffer to the transformer. ⌋ *(SRS_Rte_00248)*

Rationale: With inplace buffer handling the transformer will read the input data from a buffer and writes its output into the same buffer. For this, the RTE hands over to the transformer a pointer and a length which represents the buffer both for input and output.

[SWS_Rte_08534] ⌈ The RTE shall calculate the needed buffer size for the output buffer size using the formula specified in bufferComputation. ⌋ *(SRS_Rte_00248)*

[SWS_Rte_08535] ⌈ The RTE shall interprete the formula specified in the CompuScale in the role bufferComputation as a function: $OutputBufferLength = CompuScale(InputBufferLength)$ ⌋ *(SRS_Rte_00248)*

[SWS_Rte_03867] ⌈ The RTE shall calculate the $InputBufferLength$ (used for output buffer calculation; see [SWS_Rte_08535]) the following way:

- For External Triggers:
  The $InputBufferLength$ shall be 0.
- For Sender/Receiver communication:
  The $InputBufferLength$ shall be equal to the size needed for VariableDataPrototype of the dataElement of the SenderReceiverInterface that shall be transformed.
- For Client/Server communication:
  The $InputBufferLength$ shall be the sum of
  - the size of the TransactionHandle
  - for the request: the sizes of the VariableDataPrototypes of all IN and INOUT arguments of the ClientServerOperation of the ClientServerInterface
  - or for the response:
    * the sizes of the VariableDataPrototypes of all INOUT and OUT arguments of the ClientServerOperation of the ClientServerInterface
    * 1 Byte for the return code of the ClientServerOperation of the ClientServerInterface if at least one possibleError is defined for the ClientServerInterface.

⌋*(SRS_Rte_00248)*

The BufferProperties contain a CompuScale in the role bufferComputation which describes the computation formula how to create the size of the output buffer depending of the size of the input buffer. Because transformer chains are modeled for the sending side, the formula has to be inversed for the receiving side.

The input of this formula is the size of the AUTOSAR data type of the interface.

[SWS_Rte_08536] ⌈ The RTE shall consider the headerLength information in the BufferProperties if inPlace in the BufferProperties is set:

- On the sending side (transformation) the RTE shall increase the buffer from the beginning by the size given in headerLength.
- On the receiving side (retransformation) the RTE shall decrease the buffer from the beginning by the size given in headerLength.

⌋*(SRS_Rte_00248)*

If a transformer with in-place buffering on the sending side for example is configured to add a header, the RTE is responsible for handing over a buffer which is large enough. So the buffer grows beween two transformers if the second of those adds a header with in-place buffering. To realize this, the RTE can have a buffer which stays the same size and is large enough to hold the output of the last transformer but only subsets of the buffer are handed over to the transformers depending on the buffer size needs of the specific transformers in the chain. This can be achieved by pointers. A free space in front of the existing data to insert the header there can be provided by the RTE by descreasing the pointer address which is handed over to the transformer. This adds a free space to the beginning of the buffer. It can be determined how long the header shall be by `headerLength` of `BufferProperties`.

The corresponding retransformer on the receiving side (which implements the inverse operation) has to remove the header. For this, the transformer simply has to make sure that no part of its output is inside the place of the header which shall be removed. From this transformer to the next one, the RTE increases the pointer address by the length of the header and hence removes the header using that mechanism.

[SWS_Rte_08537] ⌈ If the attribute `inPlace` in the `BufferProperties` of a `TransformationTechnology` is set and a fanout in the transformer optimization is directly done before this transformer, the RTE shall duplicate the buffer beforehand. ⌋ *(SRS_Rte_00248)*

[SWS_Rte_08550] ⌈ The RTE shall hand over the original data provided by a software component to a transformer on the sender side if the attribute `needsOriginalData` is set to `true`. ⌋*(SRS_Rte_00248)*

4.10.4 Interfaces to Transformer

The interfaces of the transformers depend on the transformer chain in which the transformer is placed and the transformed data. They are specified in [26, ASWS Transformer General].

Also see chapter 5.10.4.

[SWS_Rte_08538] ⌈ The RTE shall determine which data are passed up from a transformer to the SWC by using the `PortInterfaceMapping` or `ISignal.transformationISignalProps. DataPrototypeTransformationProps.networkRepresentationProps` (See Chapter 4.3.6.2. ⌋*(SRS_Rte_00247)*

4.10.5 Error Handling

[SWS_Rte_08539] ⌈ The RTE shall evaluate the return codes of transformers. ⌋ *(SRS_Rte_00249)*

Transformers have a fixed set of errors depending on their transformer class. Each transformer of a transformer class can only produce those errors.

Errors can be soft errors and hard errors. Soft errors correspond to warnings and hard errors stop the execution of the transformer chain. For client server communication it is possible on the server side to trigger an autonomous error reaction which generates the response of the client server communication automatically without involvement of any runnable.

[SWS_Rte_03608] ⌈ If there is a PortAPIOption with the attribute errorHandling set to transformerErrorHandling referencing a PortPrototype to which no data transformation applies, the Rte_TransformerClass shall be set to RTE_TRANSFORMER_UNSPECIFIED and Rte_TransformerErrorCode to E_OK. ⌋ *(SRS_Rte_00249)*

Rationale: The generation condition of the optional OUT parameter transformerError only depends on the attribute errorHandling. Nevertheless it is possible to integrate such SW-Cs supporting transformerErrorHandling without any transformers. And in this case the data transformation is always logically assumed to be successful.

[SWS_Rte_08540] ⌈ The RTE shall continue with the execution of a transformer chain if a transformer returns a soft error. ⌋ *(SRS_Rte_00249)*

[SWS_Rte_08541] ⌈ The RTE shall abort the execution of a transformer chain if a transformer returns a hard error and executeDespiteDataUnavailability of the DataTransformation is set to false. ⌋ *(SRS_Rte_00249)*

[SWS_Rte_08424] ⌈ The RTE shall continue with the execution of a transformer chain if a transformer returns a hard error and executeDespiteDataUnavailability of the DataTransformation is set to true. ⌋ *(SRS_Rte_00249)*

A transformer shall not modify its output buffer, when it returns a hard error to the RTE (see [SWS_Xfrm_00051]).

To return the transformer errors to the runnables, the RTE APIs which can trigger transformer executions have a parameter which is written by the RTE and read by the SWC if the attribute errorHandling of PortAPIOption is set to transformerErrorHandling.

[SWS_Rte_08558] ⌈ If a transformer which doesn't transform the request of a client server communication on the server side (i.e., a transformer that either transforms the request of a client server communication on the client side or transforms the response of a client server communication or transforms an sender receiver communication) returns a hard error, the Rte shall notify this hard error to the runnable which called the RTE API that triggered the transformer execution. ⌋ *(SRS_Rte_00249)*

[SWS_Rte_07417] ⌈ If a transformer which transforms the request of a client server communication on the server side returns a hard error, the Rte shall not trigger the assigned OperationInvokedEvents for the server runnables. ⌋ *(SRS_Rte_00249)*

[SWS_Rte_07418] ⌈ If a transformer which transforms the request of a client server communication on the server side returns a hard error, the Rte shall trigger the assigned TransformerHardErrorEvents. ⌋ *(SRS_Rte_00249)*

[SWS_Rte_07419] ⌈ If a transformer which transforms the request of a client server communication on the server side returns a hard error, the `transformerClass` is equal to `serializer` and `csErrorReaction` is set to `autonomous`, the Rte shall trigger an autonomous error reaction. ⌋*(SRS_Rte_00249)*

[SWS_Rte_07420] ⌈ For an autonomous error reaction the Rte shall execute the transformer chain of the response of the client server communication on the server side with the following arguments:

- `TransactionHandle` shall be handed over in an unaltered fashion
- As return value the error code of the transformer which issued the hard error shall be used
- All parameters passed by value shall be equal to 0
- All parameters passed by reference shall be equal to `NULL_PTR`

⌋*(SRS_Rte_00249)*

Note: The result of this executed transformer chain can be treated by the Rte like a regular response.

[SWS_Rte_08559] ⌈ If no transformer in the transformer chain returned a hard error and at least one transformer returned a soft error, the Rte shall notify the first soft error (in transformer execution order) to the SWC. ⌋*(SRS_Rte_00249)*

[SWS_Rte_08584] ⌈ If multiple custom transformers in a transformer chain (`TransformationTechnology` with `transformerClass` set to `custom`) produce more than one error and all errors are soft errors, the RTE shall hand over to the SWC the first soft error of all custom transformers (in execution order). ⌋*(SRS_Rte_00249)*

[SWS_Rte_08585] ⌈ If multiple custom transformers in a transformer chain (`TransformationTechnology` with `transformerClass` set to `custom`) produce more than one error and on of those is a hard error, the RTE shall hand over to the SWC this hard error (which caused the abortion of the execution of the transformer chain). ⌋*(SRS_Rte_00249)*

4.10.6 COM Based Transformer

The COM Based Transformer approach is an alternative transformation handling which has several aspects:

- the first transformer is the 'COM Based Transformer' [23] for the 'serialization' of data,
- the further transformers are invoked normally and enhance the array representation of the data element,
- the handling of the transformed data towards the COM Module [3] is done via a specific array based signal group API.

The 'COM Based Transformer' [23] serializes the data elements into the array representation exactly as the COM module would have done it.

The System Template [8] provides means to define which data elements shall be handled by the 'COM Based Transformer' and - via the communication matrix section - also how the data shall be serialized. This is the basis for the COM module's configuration and 'COM Based Transformer' behavior.

The RTE interacts with the COM module via dedicated array based signal group APIs for sending and receiving the transformed data.

5 RTE Reference

"Everything should be as simple as possible, but no simpler."
– *Albert Einstein*

5.1 Scope

This chapter presents the RTE API from the perspective of AUTOSAR applications and basic software – the same API applies to all software whether they are AUTOSAR software-components or basic software.

Section 5.2 presents basic principles of the API including naming conventions and supported programming languages. Section 5.3 describes the header files used by the RTE and the files created by an RTE generator. The data types used by the API are described in Section 5.5 and Sections 5.6 and 5.7 provide a reference to the RTE API itself including the definition of runnable entities. Section 5.11 defines the events that can be monitored during VFB tracing.

5.1.1 Programming Languages

The RTE is required to support components written using the C and C++ programming languages [SRS_Rte_00126] as well as legacy software modules. The ability for multiple languages to use the same generated RTE is an important step in reducing the complexity of RTE generation and therefore the scope for errors.

[SWS_Rte_01167] ⌈ The RTE shall be generated in C. ⌋*(SRS_Rte_00126)*

[SWS_Rte_01168] ⌈ All RTE code, whether generated or not, shall conform to the MISRA C standard [27]. In technically reasonable, exceptional cases MISRA violations are permissible. Except for MISRA rules #5.1 to #5.5 and and directive #1.1, such violations shall be clearly identified and documented. Specified MISRA violations are defined in Appendix C. In realistic use cases, the RTE will generate C identifiers (functions, types, variables, etc) whose name will be longer than the maximum size supported by the MISRA C standard (rules #5.1 to #5.5 and directive #1.1). Users should configure the RTE to indicate the maximum C identifiers' size supported by their tool chain to make sure that no issues will be caused by these MISRA violations. ⌋*(SRS_BSW_00007)*

Specified MISRA violations are defined in Appendix C.

In realistic use cases, the RTE will generate C identifiers (functions, types, variables, etc) whose name will be longer than the maximum size supported by the MISRA C standard. Users should configure the RTE to indicate the maximum C identifiers' size supported by their tool chain to make sure that no issues will be caused by these MISRA violation.

[SWS_Rte_07300] ⌈ If a RteToolChainSignificantCharacters limit has been configured, the RTE generator shall provide the list of C RTE identifiers whose name is not unique when only the first RteToolChainSignificantCharacters characters are considered. ⌋ *(SRS_BSW_00007)*

The RTE API presented in Section 5.6 is described using C. The API is also directly accessible from an AUTOSAR software-component written using C++ provided all API functions and instances of data structures are imported with C linkage.

[SWS_Rte_01011] ⌈ The RTE generator shall ensure that, for a component written in C++, all imported RTE symbols are declared using C linkage. ⌋ *(SRS_Rte_00138)*

For the RTE API for C and C++ components the import of symbols occurs within the application header file (Section 5.3.3).

5.1.2 Generator Principles

5.1.2.1 Operating Modes

An object-code component is compiled against an application header file that is created during the first “RTE Contract” phase of RTE generation. The object code is then linked against an RTE created during the second “RTE Generation” phase. To ensure that the object-code component and the RTE code are compatible the RTE generator supports *compatibility mode* that uses well-defined data structures and types for the component data structure. In addition, an RTE generator may support a *vendor* operating mode that removes compatibility between RTE generators from different vendors but permits implementation specific, and hence potentially more efficient, data structures and types.

[SWS_Rte_01195] ⌈ All RTE operating modes shall be source-code compatible at the SW-C level. ⌋ *(SRS_Rte_00024, SRS_Rte_00140)*

Requirement [SWS_Rte_01195] ensures that a SW-C can be used in any operating mode as long as the source is available. The converse is not true – for example, an object-code SW-C compiled after the “RTE Contract” phase must be linked against an RTE created by an RTE generator operating in the same operating mode. If the vendor mode is used in the “RTE Contract” phase, an RTE generator from the same vendor (or one compatible to the vendor-mode features of the RTE generator used in the “RTE Contract” phase) has to be used for the “RTE Generation” phase.

5.1.2.1.1 Compatibility Mode

Compatibility mode is either enabled in the default operating mode for an RTE generator or specific for a SW-C that is delivered as object code (i.e. object-code SW-C) and guarantees compatibility even between RTE generators from different vendors through the use of well-defined, “standardized”, data structures. The data structures that are used by the generated RTE in the compatibility mode are defined in Section 5.4.

Support for compatibility mode is required and therefore is guaranteed to be implemented by all RTE generators.

[SWS_Rte_01151] ⌈ The *compatibility mode* shall be the default operating mode and shall be supported by all RTE generators, whether they are for the “RTE Contract” or “RTE Generation” phases. ⌋*(SRS_Rte_00145)*

[SWS_Rte_03871] ⌈ The RTE generator shall enable the *compatibility mode* for all SW-Cs that are delivered as object code. ⌋*(SRS_Rte_00145)*

Note: Whether a SW-C is delivered as source code or object code can be determined from the `codeDescriptor` of the respective SW-C implementation.

The compatibility mode uses custom (generated) functions with standardized names and data structures that are defined during the “RTE Contract” phase and used when compiling object-code components.

[SWS_Rte_01216] ⌈ SW-Cs that are compiled against an “RTE Contract” phase application header file (i.e. object-code SW-Cs) generated in compatibility mode shall be compatible with an RTE that was generated in compatibility mode. ⌋*(SRS_Rte_00145)*

The use of well-defined data structures imposes tight constraints on the RTE implementation and therefore restricts the freedom of RTE vendors to optimize the solution of object-code components but have the advantage that RTE generators from different vendors can be used to compile a binary-component and to generate the RTE.

Note that even when an RTE generator is operating in compatibility mode the data structures used for *source-code* components are not defined thus permitting vendor-specific optimizations to be applied.

5.1.2.1.2 Vendor Mode

Vendor mode is an optional operating mode where the data structures defined in the “RTE Contract” phase and used in the “RTE Generation” phase are implementation specific rather than “standardized”.

[SWS_Rte_01152] ⌈ An RTE generator may optionally support *vendor mode*. ⌋ *(SRS_Rte_00083)*

The data structures defined and declared when an RTE generator operates in vendor mode are implementation specific and therefore *not* described in this document. This omission is deliberate and permits vendor-specific optimizations to be implemented for object-code components. It also means that RTE generators from different vendors are unlikely to be compatible when run in the vendor mode.

[SWS_Rte_01234] ⌈ An AUTOSAR software-component shall be assumed to be operating in "compatibility" mode unless "vendor mode" is explicitly requested. ⌋ *(SRS_Rte_00145, SRS_Rte_00146)*

The potential for more efficient implementations of object-code components offered by the vendor mode comes at the expense of requiring high cohesion between object-code components (compiled after the "RTE Contract" phase) and the generated RTE. However, this is not as restrictive as it may seem at first sight since the tight coupling is also reflected in many other aspects or the AUTOSAR methodology, not least of which is the requirement that the same compiler (and compatible options) is used when compiling both the object-code component and the RTE.

5.1.2.2 Optimization Modes

The actual RTE code is generated – based on the input information – for each ECU individually. To allow optimization during the RTE generation one of the two general optimization directions can be specified: `MEMORY` consumption or execution `RUNTIME`.

[SWS_Rte_05053] ⌈ The RTE Generator shall optimize the generated RTE code either for memory consumption or execution runtime depending on the provided input information `RteOptimizationMode`. ⌋ *(SRS_Rte_00023)*

5.1.2.3 Build support

The generated RTE code has to respect several rules in order to be integrated with other AUTOSAR software in the build process.

[SWS_Rte_05088] ⌈ All memory[1] allocated by the RTE shall be wrapped in the Memory Allocation Keyword as defined in the *Specification of Memory Mapping* [28] using `RTE_<SCOPE>` as the `<PREFIX>` where `<SCOPE>` is either

- the `shortName` of the `AtomicSwComponentType`

  or

- the `shortName` of the `EcucPartition` the allocated memory object belongs to

  or

- one of the defined `<SCOPE>`s in [SWS_Rte_07421], [SWS_Rte_07422], [SWS_Rte_07423], [SWS_Rte_07424], or [SWS_Rte_07425].

⌋ *(SRS_Rte_00148, SRS_Rte_00169)*

Due to the structure of the AUTOSAR Meta Model the input configuration might contain several `DataPrototype`s which are resulting only in one memory object. In this case

[1] *memory* refers to all elements in the generated RTE which will later occupy space in the ECU's memory and is directly associated with the RTE. This includes code, static data, parameters, etc.

it is required to define rules which SwAddrMethod is used to allocate the memory and to decide about its initialization. Therefore precedence rules for SwAddrMethods are defined by [SWS_Rte_07590] and [SWS_Rte_07591].

In order to ensure proper allocation of the variables and code instantiated by RTE, the RTE code utilizes the memory mapping mechanism described in document [28]. The requirements below follow the principles of the document [28], section "Requirements on implementations using memory mapping header files for BSW Modules and Software Components". However the basic granularity of constants and variables created due to DataPrototypes in the input configuration is driven by the properties of the applied data types and the applied SwAddrMethods.

[SWS_Rte_07421] ⌈ For component data structure (CDS) instances the <SCOPE> for the Memory Allocation Keyword shall be set to the shortName of the AtomicSwComponentType they belong to. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_07422] ⌈ For AutosarDataPrototype implementations the <SCOPE> for the Memory Allocation Keyword shall be set to the shortName of the AtomicSwComponentType they belong to. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_07423] ⌈ For mode machine instance implementations the <SCOPE> for the Memory Allocation Keyword shall be set to the shortName of the AtomicSwComponentType they belong to. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_07424] ⌈ For RTE APIs implemented as functions the <SCOPE> for the Memory Allocation Keyword shall be set to the shortName of the AtomicSwComponentType they belong to. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_07425] ⌈ For RTE Call-back implementations the <SCOPE> for the Memory Allocation Keyword shall be set according table 5.1 where:

<sn> is the name of the COM signal,

<sg> is the name of the COM signal group,

<sn> is the name of the LdCom signal/I-PDU,

<c> is the shortName of the NvBlockSwComponentType, and

<d> is the shortName of the NvBlockDescriptor

⌋*(SRS_Rte_00148, SRS_Rte_00169)*

Callback Function	*SCOPE*
Rte_PartitionTerminated	shortName of the EcucPartition
Rte_PartitionRestarting	shortName of the EcucPartition

▽

△

Callback Function	*SCOPE*
Rte_RestartPartition	shortName of the EcucPartition
Rte_COMCbkTAck_<sn>	SIG_<sn>
Rte_COMCbkTErr_<sn>	SIG_<sn>
Rte_COMCbkInv_<sn>	SIG_<sn>
Rte_COMCbkRxTOut_<sn>	SIG_<sn>
Rte_COMCbkTxTOut_<sn>	SIG_<sn>
Rte_COMCbk_<sg>	SIG_<sg>
Rte_COMCbkTAck_<sg>	SIG_<sg>
Rte_COMCbkTErr_<sg>	SIG_<sg>
Rte_COMCbkInv_<sg>	SIG_<sg>
Rte_COMCbkRxTOut_<sg>	SIG_<sg>
Rte_COMCbkTxTOut_<sg>	SIG_<sg>
Rte_COMCbk_<sn>	SIG_<sg>
Rte_LdComCbkRxIndication_<sn>	SIG_<sn>
Rte_LdComCbkStartOfReception_<sn>	SIG_<sn>
Rte_LdComCbkCopyRxData_<sn>	SIG_<sn>
Rte_LdComCbkTpRxIndication_<sn>	SIG_<sn>
Rte_LdComCbkCopyTxData_<sn>	SIG_<sn>
Rte_LdComCbkTpTxConfirmation_<sn>	SIG_<sn>
Rte_LdComCbkTriggerTransmit_<sn>	SIG_<sn>
Rte_LdComCbkTxConfirmation_<sn>	SIG_<sn>
Rte_SetMirror	<c>_<d>
Rte_GetMirror	NVM_<c>_<d>
Rte_NvMNotifyJobFinished	<c>_<d>
Rte_NvMNotifyInitBlock	<c>_<d>

Table 5.1: <SCOPE> for the Memory Allocation Keywords of RTE Call-back implementations

[SWS_Rte_07589] ⌈ For AutosarDataPrototype implementations the <SEGMENT> infix for the Memory Allocation Keyword shall be set to the shortName of the preceding SwAddrMethod if there is one defined and if [SWS_Rte_07592] is not applicable. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_07426] ⌈ For RTE APIs implemented as functions the <SEGMENT> infix for the Memory Allocation Keyword shall be set to CODE. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_07427] ⌈ For RTE Call-back implementations the <SEGMENT> infix for the Memory Allocation Keyword shall be set to CODE. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_07047] ⌈ If the memoryAllocationKeywordPolicy of the preceding SwAddrMethod is set to addrMethodShortName the <ALIGNMENT> suffix with leading underscore of the Memory Allocation Keyword used by the AutosarDataPrototype implementations and PerInstanceMemory implementations shall be omitted. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_07048] ⌈ If the memoryAllocationKeywordPolicy of the preceding SwAddrMethod is set to addrMethodShortNameAndAlignment the <ALIGNMENT> suffix with leading underscore of the Memory Allocation Keyword used by the AutosarDataPrototype implementations and PerInstanceMemory implementations shall be set to the resulting alignment as defined in [SWS_Rte_07049], [SWS_Rte_07050], [SWS_Rte_07051], [SWS_Rte_07052] and [SWS_Rte_07053]. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_08303] ⌈ The alignment of a PerInstanceMemory shall be set to UNSPECIFIED. ⌋*(SRS_Rte_00013, SRS_Rte_00077)*

[SWS_Rte_07049] ⌈ The alignment defined by the preceding (see [SWS_Rte_07196]) swAlignment attribute of a AutosarDataPrototype precedes the alignment defined by the ImplementationDataType related to the AutosarDataPrototype as defined in [SWS_Rte_07050], [SWS_Rte_07051], [SWS_Rte_07052] and [SWS_Rte_07053]. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_07050] ⌈ The alignment of a AutosarDataPrototype related to a Primitive Implementation Data Type or Array Implementation Data Type shall be set to the baseTypeSize of the referred SwBaseType. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

Note: Requirement [SWS_Rte_07050] uses "size" rather than "alignment" as it is considered to be the integrator's job to ensure via appropriate memory mapping configuration (i.e. using the proper alignment #pragmas or omitting them at all to let the compiler decide) that the platform specific alignment requirements of objects of the respective size are honored.

[SWS_Rte_07051] ⌈ The alignment of a AutosarDataPrototype related to a Structure Implementation Data Type or Union Implementation Data Type shall be set to to biggest baseTypeSize of the SwBaseTypes used by the elements. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

Note: According [SWS_Rte_07051] structures and unions are aligned according the size of the biggest primitive element in the structure.

[SWS_Rte_07052] ⌈ The alignment of a AutosarDataPrototype related to a Redefinition Implementation Data Type shall be determined from the redefined ImplementationDataType. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_07053] ⌈ The alignment of a AutosarDataPrototype related to a Pointer Implementation Data Type shall be set to PTR. ⌋*(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_03868] ⌈ The alignment of an AutosarDataPrototype typed by an Array Implementation Data Type, or Structure Implementation Data Type, or Union Implementation Data Type which solely contains elements typed by Pointer Implementation Data Type shall be set to PTR. ⌋ *(SRS_Rte_00148, SRS_Rte_00169)*

Note: If the RTE generator does not implement the memory objects related to VariableDataPrototypes and ParameterDataPrototypes for instance due to communication via IOC the assigned SwAddrMethods might have no effect on the generated RTE code.

[SWS_Rte_07592] ⌈ If the RTE Generator requires several non automatic memory objects per AutosarDataPrototypes (e.g. due to partitioning) the RTE Generator is permitted to select the <SEGMENT> infix for the auxiliary memory objects. ⌋ *(SRS_Rte_00148, SRS_Rte_00169)*

Note: For definitions and declarations for memory objects allocated by the RTE and implementing AutosarDataPrototypes without an assigned SwAddrMethod the RTE Generator is permitted to select the <SEGMENT> infix but still has to follow [SWS_Rte_05088].

[SWS_Rte_08787] ⌈ The <NAME> part of the memory allocation keyword shall adhere to the following pattern: <SEGMENT>[_<ALIGNMENT>] ⌋ *(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_07590] ⌈ The SwAddrMethod of a AutosarDataPrototype in the PPortPrototype precedes the assigned SwAddrMethod(s) of the AutosarDataPrototype in the RPortPrototype and PRPortPrototype. ⌋ *(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_06741] ⌈ The SwAddrMethod of a AutosarDataPrototype in the PRPortPrototype precedes the assigned SwAddrMethod(s) of the AutosarDataPrototype in the RPortPrototype. ⌋ *(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_07591] ⌈ The SwAddrMethod of the ramBlocks has always higher precedence as the assigned SwAddrMethods of the VariableDataPrototypes in the PortPrototypes. ⌋ *(SRS_Rte_00148, SRS_Rte_00169)*

[SWS_Rte_05089] ⌈ The RTE Generator shall provide information on the used memory segments and their attributes from [SWS_Rte_05088] in the generated *Basic Software Module Description*(see [SWS_Rte_05086]). The information shall be provided in the MemorySection elements of the *Basic Software Module Description* [9]. ⌋ *(SRS_Rte_00148, SRS_Rte_00169, SRS_Rte_00170)*

[SWS_Rte_05090] ⌈ The RTE Generator shall provide information about the generated artifacts which are produced during the RTE generation, using the generated *Basic Software Module Description*(see [SWS_Rte_05086]). The information shall be provided in the BswImplementation::generatedArtifact elements of the *Basic Software Module Description* [9]. ⌋ *()*

5.1.2.4 Software Component Namespace

The concept of RTE requires that objects and definitions which are related to one software component are generated in a global name space. Nevertheless in this global name space labels have to be unique for instance to support a correct linkage by C Linker Locater. To ensure unique labels such objects and definitions related to a specific software component are typically prefixed or infixed with the component type symbol.
When AtomicSwComponentTypes of several vendors are integrated in the same ECU name clashes might occur if the identical component type name is accidentally used twice. To ease the dissolving of name clashes the RTE supports the superseding of the AtomicSwComponentType.shortName with the SymbolProps.symbol attribute.

The resulting name related to an AtomicSwComponentType is called component type symbol in this document.

[SWS_Rte_06714] ⌈ The component type symbol shall be the value of the SymbolProps.symbol attribute of the AtomicSwComponentType if the symbol attribute is defined. ⌋ *()*

[SWS_Rte_06715] ⌈ The component type symbol shall be the shortName of the AtomicSwComponentType if no symbol attribute for this AtomicSwComponentTypeis defined. ⌋ *()*

Please note that the component type symbol is not applied for file names, e.g *Application Header File* or includes of Memory Mapping Header files. Its expected that a build environment can handle two equally named files.

5.1.3 Generator external configuration switches

There are use-cases where there is need to influence the behavior of the RTE Generator without changing the RTE Configuration description. In order to support such use-cases this section collects the *external configuration switches*.

Note: it is not specified how these switches shall be implemented in the actual RTE Generator implementation.

Unconnected R-Port check

[SWS_Rte_05099] ⌈ The RTE Generator shall support the *external configuration switch* strictUnconnectedRPortCheck which, when enabled, forces the RTE Generator to consider unconnected R-Ports as an error. ⌋ *(SRS_Rte_00139)*

Missing input configuration check

[SWS_Rte_05148] ⌈ The RTE Generator shall support the *external configuration switch* strictConfigurationCheck which, when enabled, forces the RTE Generator to consider missing input configuration information as an error. If the *external* *configuration switch* `strictConfigurationCheck` is not provided the value shall be considered as *true*. ⌋*()*

For Details on the use-cases please refer to section 3.7.

Missing initialization values

[SWS_Rte_07680] ⌈ The RTE Generator shall support the *external configuration switch* `strictInitialValuesCheck`. This switch, when enabled, forces the RTE Generator to check initial values against constraints defined in [TPS_SYST_02011], [SWS_Rte_07642] and [SWS_Rte_07681]. Not fulfilled constraints shall be considered as errors by the RTE Generator. ⌋*(SRS_Rte_00108)*

5.2 API Principles

[SWS_Rte_01316] ⌈ The RTE shall be configured and/or generated for each ECU. ⌋*(SRS_Rte_00021)*

Part of the process is the customization (i.e. configuration or generation) of the RTE API for each AUTOSAR software-component on the ECU. The customization of the API implementation for each AUTOSAR software-component, whether by generation anew or configuration of library code, permits improved run-time efficiency and reduces memory overheads.

The design of the RTE API has been guided by the following core principles:

- The API should be orthogonal – there should be only one way of performing a task.
- **[SWS_Rte_01314]** ⌈ The API shall be compiler independent. ⌋*(SRS_Rte_00100)*
- **[SWS_Rte_03787]** ⌈ The RTE implementation shall use the compiler abstraction. ⌋*(SRS_Rte_00149)*

  The consequence of [SWS_Rte_03787] is that no additional memory modifiers (e.g. volatile) are permitted in the signatures of the RTE APIs.
- **[SWS_Rte_01315]** ⌈ The API shall support components where the source-code is available [SRS_Rte_00024] and where only object-code is available [SRS_Rte_00140]. ⌋*(SRS_Rte_00024, SRS_Rte_00140)*
- The API shall support the multiple instantiation of AUTOSAR software-components [SRS_Rte_00011] that share code [SRS_Rte_00012].

Two forms of the RTE API are available to software-components; direct and indirect. The direct API has been designed with regard to efficient invocation and includes an API mapping that can be used by an RTE generator to optimize a component's API, for example, to permit the direct invocation of the generated API functions or even eliding the generated RTE completely. The indirect API cannot be optimized using the API mapping but has the advantage that the handle used to access the API can be stored in memory and accessed, via an iterator, to apply the same API to multiple ports.

5.2.1 RTE Namespace

All RTE symbols (e.g. function names, global variables, etc.) visible within the global namespace are required to use the “Rte” prefix.

[SWS_Rte_01171] ⌈ All externally visible symbols created by the RTE generator shall use the prefix `Rte_`.

This rule shall not be applied for the following symbols:

- type names representing AUTOSAR Data Types (specified in [SWS_Rte_07104], [SWS_Rte_07109], [SWS_Rte_07110], [SWS_Rte_07111], [SWS_Rte_07148])
- enumeration literals of implementation data types (specified in [SWS_Rte_03810])
- range limits of `ApplicationDataType`s (specified in [SWS_Rte_05052])

This rule shall be applied for RTE internal types to avoid name clashes with other modules and SWCs. ⌋*(SRS_BSW_00307, SRS_BSW_00300, SRS_Rte_00055)*

In order to maintain control over the RTE namespace the creation of symbols in the global namespace using the prefix `Rte_` is reserved for the RTE generator.

The generated RTE is required to work with components written in several source languages and therefore should not use language specific features, such as C++ namespaces, to ensure symbol name uniqueness.

5.2.2 Direct API

The direct invocation form is the form used to present the RTE API in Section 5.6. The RTE direct API mapping is designed to be optimizable so that the instance handle is elided (and therefore imposes zero run-time overhead) when the RTE generator can determine that exactly one instance of a component is mapped to an ECU.

All runnable entities for a AUTOSAR software-component type are passed the same instance handle type (as the first formal parameter) and can therefore use the same type definition from the component’s application header file.

The direct API can also be further optimized for source code components via the API mapping.

The direct API is typically implemented as macros that are modified by the RTE generator depending on configuration. This technique places certain restrictions on how the API can be used within a program, for example, it is not possible in C to take the address of a macro and therefore direct API functions cannot be placed within a function table or array. If it is required by the implementation of a software-component to derive a pointer to an object for the port API the PortAPIOption enableTakeAddress can be used. For instance in an implementation of an AUTOSAR Service this feature might be used to setup a constant function pointer table storing the configuration of callback functions per ID. Additionally the indirect API provides support for API addresses and iteration over ports.

[SWS_Rte_07100] ⌈ If a PortPrototype is referenced by PortAPIOption with enableTakeAddress = TRUE the RTE generator shall provide true/native C functions (as opposed to function-like preprocessor macros) for the API related to this port. ⌋*()*

The PortAPIOption enableTakeAddress = TRUE is not supported for software-components supporting multiple instantiation.

5.2.3 Indirect API

The indirect API is an optional form of API invocation that uses indirection through a port handle to invoke RTE API functions rather than direct invocation. This form is less efficient (the indirection cannot be optimized away) but supports a different programming style that may be more convenient. For example, when using the indirect API, an array of port handles of the same interface and provide/require direction is provided by RTE and the same RTE API can be invoked for multiple ports by iterating over the array.

Both direct and indirect forms of API call are equivalent and result in the same generated RTE function being invoked.

Whether the indirect API is generated or not can be specified for each software component and for each port prototype of the software component separately with the indirectAPI attribute.

The semantics of the port handle must be the same in both the “RTE Contract” and “RTE Generation” phases since the port handle accesses the standardized data structures of the RTE.

It is possible to mix the indirect and direct APIs within the same SW-C, if the indirect API is present for the SW-C.

The indirect API uses port handles during the invocation of RTE API calls. The type of the port handle is determined by the port interface that types the port which means that if a component declares multiple ports typed by the same port interface the port handle points to an array of port data structures and the same API invoked for each element.

The port handle type is defined in Section 5.4.2.5.

5.2.3.1 Accessing Port Handles

An AUTOSAR SW-C needs to obtain port handles using the instance handle before the indirect API can be used. The definition of the instance handle in Section 5.4.2 defines the “Port API” section of the component data structure and these entries can be used to access the port handles in either object-code or source-code components.

The API `Rte_Ports` and `Rte_NPorts` provides port data handles of a given interface. Example 5.1 shows how the indirect API can be used to apply the same operation to multiple ports in a component within a loop.

Example 5.1

The port handle points to an array that can be used within a loop to apply the same operation to each port. The following example sends the same data to each receiver:

```
void TT1(Rte_Instance instance)
{
  Rte_PortHandle_interface1_P my_array;
  my_array=Rte_Ports_interface1_P(instance);
  uint8 s;
  for(s = 0u; s < Rte_NPorts_interface1_P(instance); s++) {
    my_array[s].Send_a(23);
  }
}
```

Note that if `csInterface1` is a client/server interface with an operation `op`, the mechanism sketched in Example5.1 only works if `op` is invoked either by all clients synchronously or by all clients asynchronously, since the signature of `Rte_Call` and the existence of `Rte_Result` depend on the kind of invocation (see restriction [SWS_Rte_03605].

5.2.4 `VariableAccess` in the `dataReadAccess` and `dataWriteAccess` roles

The RTE is required to support access to data with implicit semantics. The required semantics are subject to two constraints:

- For `VariableAccess` in the `dataReadAccess` role, the data accessed by a runnable entity must not change during the lifetime of the runnable entity.
- For `VariableAccess` in the `dataWriteAccess` role, the data written by a runnable entity is only visible to other runnable entities after the accessing runnable entity has terminated.

The generated RTE satisfies both requirements through data copies that are created when the RTE is generated based on the known task and runnable mapping.

Example 5.2

Consider a data element, a, of port p which is accessed using a VariableAccess in the dataReadAccess role by runnable re1 and a VariableAccess in the dataWriteAccess role by runnable re2. Furthermore, consider that re1 and re2 are mapped to different tasks and that execution of re1 can pre-empt re2.

In this example, the RTE will create two different copies to contain a to prevent updates from re2 'corrupting' the value access by re1 since the latter must remain unchanged during the lifetime of re1.

The RTE API includes three API calls to support VariableAccesses in the dataReadAccess and dataWriteAccess roles for a software-component; Rte_IRead (see Section 5.6.18), Rte_IWrite, and Rte_IWriteRef (see Section 5.6.19 and 5.6.20). The API calls Rte_IRead and Rte_IWrite access the data copies (for read and write access respectively). The API call Rte_IWriteRef returns a reference to the data copy, thus enabling the runnable to write the data directly. This is especially useful for Structure Implementation Data Type and Array Implementation Data Type. The use of an API call for reading and writing enables the definition to be changed based on the task and runnable mapping without affecting the software-component code.

Example 5.3

Consider a data element, a, of port p which is declared as being accessed using VariableAccesses in the dataWriteAccess role by runnables re1 and re2 within component c. The RTE API for component c will then contain four API functions to write the data element;

```
void Rte_IWrite_re1_p_a(Rte_Instance instance, <type> val);
void Rte_IWrite_re2_p_a(Rte_Instance instance, <type> val);
<type> Rte_IWriteRef_re1_p_a(Rte_Instance instance);
<type> Rte_IWriteRef_re2_p_a(Rte_Instance instance);
```

The API calls are used by re1 and re2 as required. The definitions of the API depend on where the data copies are defined. If both re1 and re2 are mapped to the same task then each can access the same copy. However, if re1 and re2 are mapped to different (pre-emptable) tasks then the RTE will ensure that each API access a different copy.

The Rte_IRead and Rte_IWrite use the "data handles" defined in the component data structure (see Section 5.4.2).

5.2.5 Per Instance Memory

The RTE is required to support Per Instance Memory [SRS_Rte_00013].

The component's instance handle defines a particular instance of a component and is therefore used when accessing the *Per Instance Memory* using the Rte_Pim API.

The Rte_Pim API does not impose the RTE to apply a data consistency mechanism for the access to *Per Instance Memory*. An application is responsible for consistency of accessed data by itself. This design decision permits efficient (zero overhead) access when required. If a component possesses multiple runnable entities that require concurrent access to the same *Per Instance Memory*, an exclusive area can be used to ensure data consistency, either through explicit Rte_Enter and Rte_Exit API calls or by declaring that, implicitly, the runnable entities run inside an exclusive area.

Thus, the *Per Instance Memory* is exclusively used by a particular software-component instance and needs to be declared and allocated (statically).

In general there are two different kinds of *Per Instance Memory* available which are varying in the typing mechanisms. 'C' typed PerInstanceMemory is typed by the description of a 'C' typedef whereas arTypedPerInstanceMemory (*AUTOSAR Typed Per Instance Memory*) is typed by the means of an AutosarDataType. Nevertheless both kinds of *Per Instance Memory* are accessed via the Rte_Pim API.

[SWS_Rte_07161] ⌈ The generated RTE shall declare arTypedPerInstanceMemory in accordance to the associated ImplementationDataType of a particular arTypedPerInstanceMemory. ⌋*(SRS_Rte_00013, SRS_Rte_00077)*

Note: The related *AUTOSAR data type* will generated in the RTE Types Header File (see chapter 5.3.6).

[SWS_Rte_02303] ⌈ The generated RTE shall declare 'C' typed PerInstanceMemory in accordance to the attribute type of a particular PerInstanceMemory. ⌋ *(SRS_Rte_00013, SRS_Rte_00077)*

In addition, the attribute type needs to be defined in the corresponding software-component header. Therefore, the attribute typeDefinition of the PerInstanceMemory contains its definition as plain text string. It is assumed that this text is valid 'C' syntax, because it will be included verbatim in the application header file.

[SWS_Rte_02304] ⌈ The generated RTE shall define the type of a 'C' typed PerInstanceMemory by interpreting the text string of the attribute typeDefinition of a particular PerInstanceMemory as the 'C' definition. This type shall be named according to the attribute type of the PerInstanceMemory. ⌋*(SRS_Rte_00013, SRS_Rte_00077)*

[SWS_Rte_07133] ⌈ The type of a 'C' typed PerInstanceMemory shall be defined in the *RTE Types Header File* as

```
typedef <typedefinition> Rte_PimType_<cts>_<type>;
```

where <typedefinition> is the content of the typeDefinition attribute of the PerInstanceMemory,
<type> is the type name defined in the type attribute of the the PerInstanceMemory and
<cts> the component type symbol of the AtomicSwComponentType to which the PerInstanceMemory belongs.. ⌋*(SRS_Rte_00013, SRS_Rte_00077)*

[SWS_Rte_03782] ⌈ The type of a 'C' typed PerInstanceMemory shall be defined in the *Application Header File* as

```
typedef Rte_PimType_<cts>_<type> <type>;
```

where `<cts>` is the component type symbol of the AtomicSwComponentType to which the PerInstanceMemory belongs and
`<type>` is the type name defined in the type attribute of the PerInstanceMemory.
⌋*(SRS_Rte_00013, SRS_Rte_00077)*

[SWS_Rte_07134] ⌈ The RTE generator shall generate type definitions for 'C' typed PerInstanceMemory (see [SWS_Rte_07133] and [SWS_Rte_03782]) only once for all 'C' typed PerInstanceMemorys of same Software Component Type defining identical couples of type and typeDefinition attributes. ⌋*(SRS_Rte_00013, SRS_Rte_00165)*

Note: This shall support, that a Software Component Type can define several PerInstanceMemory's using the identical 'C' type.

[SWS_Rte_07135] ⌈ The RTE generator shall reject configurations, violating [constr_2007], where 'C' typed PerInstanceMemorys with identical type attributes but different typeDefinition attributes in the same Software Component Type are defined. ⌋*(SRS_Rte_00013, SRS_Rte_00018)*

Note: This would lead to an compiler error due to incompatible redefinition of a 'C' type.

[SWS_Rte_02305] ⌈ The generated RTE shall instantiate (or allocate) declared PerInstanceMemory. ⌋*(SRS_Rte_00013, SRS_Rte_00077)*

[SWS_Rte_07182] ⌈ The generated RTE shall initialize declared PerInstanceMemory according the initValue attribute if

- an initValue is defined

  AND

- no SwAddrMethod is defined for PerInstanceMemory.

⌋*(SRS_Rte_00013, SRS_Rte_00077)*

[SWS_Rte_08304] ⌈ Variables implementing PerInstanceMemory shall be initialized by RTE if

- an initValue is defined

  AND

- a SwAddrMethod is defined for PerInstanceMemory

  AND

- the RteInitializationStrategy for the sectionInitializationPolicy of the related SwAddrMethod is NOT configured to `RTE_INITIALIZATION_STRATEGY_NONE`.

⌋(SRS_Rte_00013, SRS_Rte_00077)

[SWS_Rte_07183] ⌈ The generated RTE shall instantiate (or allocate) declared arTypedPerInstanceMemory. ⌋(SRS_Rte_00013, SRS_Rte_00077)

[SWS_Rte_07184] ⌈ The generated RTE shall initialize declared arTypedPerInstanceMemory according the ValueSpecification of the VariableDataPrototype defining the arTypedPerInstanceMemory if the general initialization conditions in [SWS_Rte_07046] are fulfilled. ⌋(SRS_Rte_00013, SRS_Rte_00077)

[SWS_Rte_05062] ⌈ In case the PerInstanceMemory or arTypedPerInstanceMemory is used as a permanent RAM Block for the *NvRam manager* the name for the instantiated PerInstanceMemory or arTypedPerInstanceMemory shall be taken from the input information RteNvmRamBlockLocationSymbol. Otherwise the RTE generator is free to choose an arbitrary name. ⌋(SRS_Rte_00013, SRS_Rte_00077)

Note that, in cases where a PerInstanceMemory is not initialized due to [SWS_Rte_07182] or [SWS_Rte_07184], the memory allocated for a PerInstanceMemory is not initialized by the generated RTE, but by the corresponding software-component instances.

[SWS_Rte_07693] ⌈ In case a ParameterDataPrototype in the role perInstanceParameter is used as a ROM Block for the NVRam Manager, then the name for the instantiated ParameterDataPrototype shall be taken from the input information RteNvmRomBlockLocationSymbol. Otherwise the RTE generator is free to choose an arbitrary name. ⌋(SRS_Rte_00154)

Example 5.4

This description of a software component

```
<AR-PACKAGE>
  <SHORT-NAME>SWC</SHORT-NAME>
  <ELEMENTS>
    <APPLICATION-SW-COMPONENT-TYPE>
      <SHORT-NAME>TheSwc</SHORT-NAME>
      <INTERNAL-BEHAVIORS>
        <SWC-INTERNAL-BEHAVIOR>
          <SHORT-NAME>TheSwcInternalBehavior</SHORT-NAME>
          <PER-INSTANCE-MEMORYS>
            <PER-INSTANCE-MEMORY>
              <SHORT-NAME>MyPIM</SHORT-NAME>
              <TYPE>MyMemType</TYPE>
              <TYPE-DEFINITION>struct {uint16 val1; uint8 * val2;}</
                  TYPE-DEFINITION>
            </PER-INSTANCE-MEMORY>
          </PER-INSTANCE-MEMORYS>
        </SWC-INTERNAL-BEHAVIOR>
      </INTERNAL-BEHAVIORS>
    </APPLICATION-SW-COMPONENT-TYPE>
  </ELEMENTS>
</AR-PACKAGE>
```

will e. g. result in the following code:

In the *RTE Types Header File*:

```
/* typedef to ensure unique typename */
/* according to the attributes */
/* 'type' and 'typeDefinition' */
typedef struct{
    uint16 val1;
    uint8 * val2;
} Rte_PimType_TheSwc_MyMemType;
```

In the respective *Application Header File*:

```
/* typedef visible within the scope */
/* of the component according to the attributes */
/* 'type' and 'typeDefinition' */
typedef Rte_PimType_TheSwc_MyMemType MyMemType;
```

In Rte.c:

```
/* declare and instantiate mem1 */
/* "mem1" name may be taken from RteNvmRamBlockLocationSymbol */
Rte_PimType_TheSwc_MyMemType mem1;
```

Note that the name used for the definition of the `PerInstanceMemory` may be used outside of the RTE. One use-case is to support the definition of the link between the NvRam Manager's permanent blocks and the software-components. The name in `RteNvmRamBlockLocationSymbol` is used to configure the location at which the NvRam Manager shall store and retrieve the permanent block content. For a detailed description please refer to the AUTOSAR Software Component Template [2].

5.2.6 API Mapping

The RTE API is implemented by macros and generated API functions that are created (or configured, depending on the implementation) by the RTE generator during the "RTE Generation" phase. Typically one customized macro or function is created for each "end" of a communication though the RTE generator may elide or combine custom functions to improve run-time efficiency or memory overheads.

[SWS_Rte_01274] ⌈ The API mapping shall be implemented in the application header file. ⌋*(SRS_BSW_00330, SRS_Rte_00027, SRS_Rte_00051, SRS_Rte_00083, SRS_Rte_00087)*

The RTE generator is required to provide a mapping from the RTE API name to the generated function [SRS_Rte_00051]. The API mapping provides a level of indirection necessary to support binary components and multiple component instances. The indirection is necessary for two reasons. Firstly, some information may not be known when the component is created, for example, the component's instance name, but are necessary to ensure that the names of the generated functions are unique. Secondly, the names of the generated API functions should be unique (so that the ECU image can link correctly) and the steps taken to ensure this may make the names not “user-friendly”. Therefore, the primary rationale for the API mapping is to provide the required abstraction that means that a component does not need to concern itself with the preceding problems.

The requirements on the API mapping depend on the phase in which an RTE generator is operating. The requirements on the API mapping are only binding for RTE generators operating in compatibility mode.

5.2.6.1 “RTE Contract” Phase

Within the “RTE Contract” phase the API mapping is required to convert from the source API call (as defined in Section 5.6) to the runnable entity provided by a software-component or the implementation of the API function created by the RTE generator.

When compiled against a “RTE Contract” phase header file a software-component that can be multiple instantiated is required to use a general API mapping that uses the instance handle to access the function table defined in the component data structure.

[SWS_Rte_03706] ⌈ If a software-component `supportsMultipleInstantiation`, the “RTE Contract” phase API mapping shall access the generated RTE functions using the instance handle to indirect through the generated function table in the component data structure. ⌋ *(SRS_Rte_00051)*

Example 5.5

For a require client-server port ‘p1’ with operation ‘a’ with a single argument, the general form of the API mapping would be:

```
#define Rte_Call_p1_a(instance,v) ((instance)->p1.Call_a(v))
```

Where `s` is the instance handle.

[SWS_Rte_06516] ⌈ The RTE Generator shall wrap each API mapping and API function definition of a variant existent API according table 4.17 if the variability shall be implemented.

```
#if (<condition> [||<condition>])

<API Mapping>

#endif
```

where `condition` are the condition value macro(s) of the `VariationPoint`s relevant for the conditional existence of the RTE API (see table 4.17), `API Mapping` is the code according an invariant API Mapping (see also [SWS_Rte_01274], [SWS_Rte_03707], [SWS_Rte_03837], [SWS_Rte_01156]) ⌋ *(SRS_Rte_00201)*

Note: In case of explicit communication any existent access points in the meta model might result in the related API which results in a or condition for the pre processor.

Example 5.6

For a require client-server port 'p1' with operation 'a' with a single argument of the component 'c1' defining a ServerCallPoint which is subject of variability in runnable 'run1', the general form of the conditional API mapping would be:

```

#if (Rte_VPCon_c1_run1_p1_a==TRUE)

#define Rte_Call_p1_a(instance,v) ((instance)->p1.Call_a(v))

#endif
```

[SWS_Rte_03707] ⌈ If a software-component does not supportsMultipleInstantiation, the "RTE Contract" phase API mapping shall access the generated RTE functions directly. ⌋*(SRS_Rte_00051)*

[SWS_Rte_08073] ⌈ In compatibility mode or "RTE Contract" phase, the API mapping for Rte_PBCon shall access the generated RTE functions directly. ⌋*(SRS_Rte_00051)*

When accessed directly, the names of the generated functions are formed according to the following rule:

[SWS_Rte_03837] ⌈ The function generated for API calls Rte_<name>_<api_extension> that are intended to be called by the software component shall be

Rte_<name>_<cts>_<api_extension>,

where <name> is the API root (e.g. Receive),
<cts> the component type symbol of the AtomicSwComponentType,
and <api_extension> is the extension of the API dependent on <name> (e.g. <re>_<p>_<o>). ⌋*(SRS_Rte_00051)*

[SWS_Rte_01156] ⌈ In compatibility mode, the following API calls shall be implemented as macros:

- Rte_Pim
- Rte_IrvIRead
- Rte_IrvIWrite
- Rte_IrvIWriteRef

The generated macros for these API calls shall map to the relevant fields of the component data structure. ⌋*(SRS_Rte_00051)*

For APIs not mentioned in [SWS_Rte_01156], and not subject to enableTakeAddress, requirement [SWS_Rte_03707] means that in contract phase a function must be generated for single instantiated SWCs. Likewise for multiple instantiated SWCs a function must also be generated in contract phase as the relevant fields in the CDS are omitted and therefore macros cannot be used in the API mapping. In compatibility mode and RTE phase the same limitations apply due to the constraints of the CDS.

Note that the rule described in [SWS_Rte_03837] does not apply for the life cycle APIs, nor for the callback APIs, nor for the APIs that are implemented as macros (see [SWS_Rte_01156]).

[SWS_Rte_06831] ⌈ In compatibility mode, the following API calls shall be implemented either as macros (that map directly to the relevant field of the component data structure) or as a C function (that may use the fields of the component data structure) based on the state of the `enableTakeAddress` attribute [SWS_Rte_07100]:

- `Rte_IRead`
- `Rte_IWrite`
- `Rte_IWriteRef`
- `Rte_IStatus`
- `Rte_IFeedback`
- `Rte_IInvalidate`

⌋*(SRS_Rte_00051)*

Note: For [SWS_Rte_01156] and [SWS_Rte_06831] when the APIs are implemented as macros the API mapping in the application header file directly uses relevant fields of the component data structure. However the `enableTakeAddress` attribute only applies for single instantiated SWCs and therefore the body of the generated function can directly access the relevant data if required without indirection through the component data structure.

The functions generated that are the destination of the API mapping, which is created during the “RTE Contract” phase, are created by the RTE generator during the second “RTE Generation” phase.

[SWS_Rte_01153] ⌈ The generated function (or runnable) shall take the same parameters, in the same order, as the API mapping. ⌋*(SRS_Rte_00051)*

Example 5.7

For a require client-server port ‘p1’ with operation ‘a’ with a single argument for component type ‘c1’ for which multiple instantiation is forbidden, the following mapping would be generated:

```
#define Rte_Call_p1_a Rte_Call_c1_p1_a
```

5.2.6.2 “RTE Generation” Phase

There are no requirements on the *form* that the API mapping created during the “RTE Generation” phase should take. This is because the application header files defined during this phase are used by source-code components and therefore compatibility between the generated RTE and source-code components is automatic.

The RTE generator is required to produce the component data structure instances required by object-code components and multiple instantiated source-code components.

If multiple instantiation of a software-component is forbidden, then the API mapping specified for the “RTE Contract” phase (Section 5.2.6.1) defines the names of the generated functions. If multiple instantiation is possible, there are no corresponding requirements that define the name of the generated function since all accesses to the generated functions are performed via the component data structure which contains well-defined entries (Sections 5.4.2.5 and 5.4.2.5).

5.2.6.3 Function Elision

Using the “RTE Generation” phase API mapping, it is possible for the RTE generator to elide the use of generated RTE functions.

[SWS_Rte_01146] ⌈ If the API mapping elides an RTE function the “RTE Generation” phase API mapping mechanism shall ensure that the invoking component still receives a “return value” so that no changes to the AUTOSAR software-component are necessary. ⌋*(SRS_Rte_00051)*

In C, the elision of API calls can be achieved using a comma expression[2]

Example 5.8

As an example, consider the following component code:

```
Std_ReturnType s;
s = Rte_Send_p1_a(instance,23);
```

Furthermore, assume that the communication attributes are specified such that the sender-receiver communication can be performed as a direct assignment and therefore no RTE API call needs to be generated. However, the component source cannot be modified and expects to receive an `Std_ReturnType` as the return. The “RTE Generation” phase API mapping could then be rewritten as:

```
#define Rte_Send_p1_a(s,a) (<var> = (a), RTE_E_OK)
```

Where `<var>` is the implementation dependent name for an RTE created cache between sender and receiver.

[2] This is contrary to MISRA Rule 12.3 “*The comma operator should not be used* ”.However, a comma expression is valid, legal, C and the elision cannot be achieved without a comma expression and therefore the rule must be relaxed.

5.2.6.4 API Naming Conventions

An AUTOSAR software-component communicates with other components (including basic software) through ports and therefore the names that constitute the RTE API are formed from the combination of the API call's functionality (e.g. Call, Send) that defines the API root name and the access point through which the API operates.

For any API that operates through a port, the API's access point includes the port name.

A `SenderReceiverInterface` can support multiple data items and a `ClientServerInterface` can support multiple operations, any of which can be invoked through the requiring port by a client. The RTE API therefore needs a mechanism to indicate which data item/operation on the port to access and this is implemented by including the data item/operation name in the API's access point.

As described above, the RTE API mapping is responsible for mapping the RTE API name to the correct generated RTE function. The API mapping permits an RTE generator to include targeted optimization as well as removing the need to implement functions that act as routing functions from generic API calls to particular functions within the generated RTE.

For C and C++ the RTE API names introduce symbols into global scope and therefore the names are required to be prefixed with `Rte_` [SWS_Rte_01171].

5.2.6.5 API Parameters

All API parameters fall into one of two classes; parameters that are strictly read-only ("In" parameters) and parameters whose value may be modified by the API function ("In/Out" and "Out" parameters).

The type of these parameters is taken from the data element prototype or operation prototype in the interface that characterizes the port for which the API is being generated.

In the following, requirement [SWS_Rte_06806] reflects the standard defined by [29]. The remaining requirements are include to ensure the consistency between different RTE implementations. The rules described below regarding the default argument passing strategy may be overwritten by more specific requirements, e.g. `ServerArgumentImplPolicy`.

[SWS_Rte_06804] ⌈ All input parameters using the `P2CONST` macro shall use `memclass AUTOMATIC` and `ptrclass RTE_APPL_DATA`. ⌋*(SRS_Rte_00060, SRS_BSW_00007)*

[SWS_Rte_06805] ⌈ All parameters using the `VAR` macro shall use `memclass AUTOMATIC`. ⌋*(SRS_Rte_00059, SRS_BSW_00007)*

[SWS_Rte_06806] ⌈ All output and bi-directional parameters (i.e. both input and output) parameters shall use the P2VAR macro. ⌋*(SRS_Rte_00061, SRS_BSW_00007)*

[SWS_Rte_06807] ⌈ All parameters using the P2VAR macro shall use memclass AUTOMATIC and ptrclass RTE_APPL_DATA. ⌋*(SRS_Rte_00059, SRS_Rte_00060, SRS_BSW_00007)*

- **"In" Parameters**

  [SWS_Rte_01017] ⌈ All input parameters that are a Primitive Implementation Data Type shall be passed by value. ⌋*(SRS_Rte_00059, SRS_Rte_00061)*

  [SWS_Rte_01018] ⌈ All input parameters that are of type Structure Implementation Data Type or Union Implementation Data Type shall be passed by reference. ⌋*(SRS_Rte_00060, SRS_Rte_00061)*

  [SWS_Rte_05107] ⌈ All input parameters that are an Array Implementation Data Type shall be passed as an array expression (that is a pointer to the array base type). ⌋*(SRS_Rte_00060, SRS_Rte_00061)*

  [SWS_Rte_07661] ⌈ All input parameters that are a data type of category DATA_REFERENCE shall be passed as a pointer to the data type specified by the SwPointerTargetProps. ⌋*(SRS_Rte_00059, SRS_Rte_00061)*

  [SWS_Rte_07086] ⌈ All input parameters that are passed by reference ([SWS_Rte_01018]) or passed as an array expression ([SWS_Rte_05107]) shall be declared as pointer to const with the means of the P2CONST macro. ⌋*(SRS_Rte_00060, SRS_BSW_00007)*

  Please note that the description of the P2CONST macro can be found in [30].

- **"Out" Parameters**

  [SWS_Rte_01019] ⌈ All output parameters that are of type Primitive Implementation Data Type shall be passed by reference. ⌋*(SRS_Rte_00061)*

  [SWS_Rte_07082] ⌈ All output parameters that are of type Structure Implementation Data Type or Union Implementation Data Type shall be passed by reference. ⌋*(SRS_Rte_00060, SRS_Rte_00061)*

  [SWS_Rte_05108] ⌈ All output parameters that are an Array Implementation Data Type shall be passed as an array expression (that is a pointer to the array base type). ⌋*(SRS_Rte_00060, SRS_Rte_00061)*

  [SWS_Rte_07083] ⌈ All output parameters that are of type Pointer Implementation Data Type shall be passed as a pointer to the Pointer Implementation Data Type. ⌋*(SRS_Rte_00059, SRS_Rte_00061)*

- **"In/Out" Parameters**

[SWS_Rte_01020] ⌈ All bi-directional parameters (i.e. both input and output) that are of type `Primitive Implementation Data Type` or `Structure Implementation Data Type` or `Union Implementation Data Type` shall be passed by reference. ⌋*(SRS_Rte_00059, SRS_Rte_00061)*

[SWS_Rte_05109] ⌈ All bi-directional parameters (i.e. both input and output) that are an `Array Implementation Data Type` shall be passed as an array expression (that is a pointer to the array base type). ⌋*(SRS_Rte_00061)*

[SWS_Rte_07084] ⌈ All input, output and bi-directional parameters which related `DataPrototype` is typed or mapped to an `Redefinition Implementation Data Type` shall be treated according the kind of data type redefined by the `Redefinition Implementation Data Type`. The possible kinds of data types supported by RTE are listed in 5.3.4.2. ⌋*(SRS_Rte_00059, SRS_Rte_00060, SRS_Rte_00061)*

In order to indicate the direction of the individual API parameters, the descriptions of the API signatures in this API reference chapter use the direction qualifiers ”IN”, ”OUT”, and ”INOUT”. These direction qualifiers are not part of the actual API prototypes. Especially, the user cannot expect that these direction qualifiers are available for the application.

Example 5.9

This would be the `Rte_Write` API generated for the example 5.5 (example of a two dimension array typed by an `ImplementationDataType`):

```
FUNC(Std_ReturnType, RTE_CODE) Rte_Write_<p>_<o>(P2CONST(uint8,
    AUTOMATIC, AUTOMATIC) data)
```

Which can be used in the SWC code:

```
status = Rte_Write_<p>_<o> (&array[0][0]);
```

5.2.6.6 Return Values

A subset of the RTE API’s returning the values instead of using OUT Parameters. In the API section these API signatures defining a `<return>` value. In addition to the following rules some of the APIs might specify additionally const qualifiers.

[SWS_Rte_07069] ⌈ The RTE Generator shall determine the `<return>` type according the applicable `ImplementationDataType` of the `DataPrototype` for which the API provides access. ⌋*(SRS_Rte_00059)*

[SWS_Rte_08300] ⌈ A pointer return value of an RTE API shall be declared as pointer to const with the means of the `FUNC_P2CONST` macro or `P2CONST` if the pointer is not used to modify the addressed object. ⌋*(SRS_Rte_00059)*

Please note that the FUNC_P2CONST macro is applicable if the RTE API is implemented as an real function and the P2CONST might be used if the RTE API is implemented as a macro.

Requirement [SWS_Rte_08300] applies for instance for the RTE APIs Rte_Prm, Rte_CData, Rte_IrvRead, Rte_IrvIRead in the cases where the API grants access to composite data (arrays, structures, unions).

Please note, that the the implementation of the C data types are specified in section 5.3.4 "RTE Types Header File".

[SWS_Rte_07070] ⌈ If the DataPrototype is associated to a Primitive Implementation Data Type the RTE API shall return the value of the DataPrototype for which the API provides access. The type name shall be equal to the shortName of these ImplementationDataType. ⌋*(SRS_Rte_00059)*

Example 5.10

Consider an RTE API call return a primitive as defined in the example 5.2 for a singly instantiated SW-C. The signature of the API will be:

```
MyUint8 Rte_IRead_<re>_<p>_<o>(void);
```

Please note that the usage of Compiler Abstraction is not shown in the example.

[SWS_Rte_07071] ⌈ If the DataPrototype is associated to a Structure Implementation Data Type or Union Implementation Data Type, the RTE API shall return a pointer to a variable holding the DataPrototype value provided by the API. The type name shall be equal to the shortName of these ImplementationDataType. ⌋*(SRS_Rte_00059)*

Example 5.11

Consider an RTE API call return a structure as defined in the example 5.6 for a singly instantiated SW-C. The signature of the API will be:

```

FUNC_P2CONST(RecA, RTE_VAR_FAST_INIT, RTE_CODE)
                Rte_IRead_<re>_<p>_<o>(void);
```

Please note that the usage of Compiler Abstraction assumes that the SwAddrMethod of the accessed VariableDataPrototype is named "‘VAR_FAST_INIT"’. Further on the example does not respect the principles of API mapping.

[SWS_Rte_07072] ⌈ If the DataPrototype is associated to an Array Implementation Data Type the RTE API shall return an array expression (that is a pointer to the array base type) pointing to variable holding the value of the DataPrototype for which the API provides access. If the leaf ImplementationDataTypeElement is typed by a SwBaseType the array type name shall be equal to the nativeDeclaration attribute of the SwBaseType. If the leaf ImplementationDataTypeElement is typed by an ImplementationDataType the type name shall be equal to the shortName of this ImplementationDataType. If the leaf ImplementationDataTypeElement is of category STRUCTURE or UNION the type name shall be equal to the shortName of this ImplementationDataTypeElement. ⌋*(SRS_Rte_00059)*

Example 5.12

Consider an RTE API call return an array as defined in the example 5.4 for a singly instantiated SW-C. The signature of the API will be:

```
FUNC_P2CONST(unsigned char, RTE_VAR_POWER_ON_INIT, RTE_CODE)
                Rte_IRead_<re>_<p>_<o>(void);
```

Please note that the usage of Compiler Abstraction assumes that the SwAddrMethod of the accessed VariableDataPrototype is named "‘VAR_POWER_ON_INIT"’. Further on the example does not respect the principles of API mapping.

Example 5.13

Consider an RTE API call return an array as defined in the example 5.5 for a singly instantiated SW-C. The signature of the API will be:

```
FUNC_P2CONST(uint8, RTE_VAR_NO_INIT, RTE_CODE)
                Rte_IRead_<re>_<p>_<o>(void);
```

Please note that the usage of Compiler Abstraction assumes that the SwAddrMethod of the accessed VariableDataPrototype is named "‘VAR_NO_INIT"’. Further on the example does not respect the principles of API mapping.

[SWS_Rte_07073] ⌈ If the DataPrototype is associated to a Pointer Implementation Data Type the RTE API shall return the value of the DataPrototype for which the API provides access. The type name shall be equal to the shortName of these ImplementationDataType. ⌋*(SRS_Rte_00059)* Please not that in this case the value is a pointer.

[SWS_Rte_07074] ⌈ If the DataPrototype is associated to a Redefinition Implementation Data Type the RTE Generator shall determine the API return value behaviour as described in [SWS_Rte_07070], [SWS_Rte_07071], [SWS_Rte_07072], [SWS_Rte_07073], [SWS_Rte_07074] according the referenced ImplementationDataType. Nevertheless except for Array Implementation Data Type the type name shall be equal to the shortName of these ImplementationDataType. ⌋ *(SRS_Rte_00059)*

Please note that Redefinition Implementation Data Type might redefine an other Redefinition Implementation Data Type again.

5.2.6.7 Return References

A subset of the RTE API's returning a reference to the memory location where the data can be accessed instead of using IN/OUT Parameters. In the API section these API signatures defining a `<return reference>` value.

[SWS_Rte_06808] ⌈ A `<return reference>` shall use the `FUNC_P2VAR` or `P2VAR` macro. ⌋*(SRS_BSW_00007)*

[SWS_Rte_06809] ⌈ A `<return reference>` which uses either the `P2VAR` or the `FUNC_P2VAR` macro shall use `memclass AUTOMATIC` and `ptrclass RTE_DATA`. ⌋*(SRS_BSW_00007)*

[SWS_Rte_07076] ⌈ The RTE Generator shall determine the `<return reference>` type according the applicable `ImplementationDataType` of the `DataPrototype` for which the API provides access. ⌋*(SRS_Rte_00059)*

Please note, that the the implementation of the C data types are specified in section 5.3.4 "RTE Types Header File".

[SWS_Rte_07077] ⌈ If the `DataPrototype` is associated to a `Primitive Implementation Data Type` the RTE API shall return a pointer to variable holding the data of the value of the `DataPrototype` for which the API provides access. The type name shall be equal to the `shortName` of these `ImplementationDataType`. ⌋*(SRS_Rte_00059)*

Example 5.14

Consider an RTE API call return a reference to a primitive as defined in the example 5.2 for a singly instantiated SW-C. The signature of the API will be:

```
MyUint8 * Rte_IWriteRef_<re>_<p>_<o>(void);
```

Please note that the usage of Compiler Abstraction is not shown in the example.

[SWS_Rte_07078] ⌈ If the `DataPrototype` is associated to a `Structure Implementation Data Type` or `Union Implementation Data Type` the RTE API shall return a pointer to variable holding the value of the `DataPrototype` for which the API provides access. The type name shall be equal to the `shortName` of these `ImplementationDataType`. ⌋*(SRS_Rte_00059)*

Example 5.15

Consider an RTE API call return a reference to a structure as defined in the example 5.6 for a singly instantiated SW-C. The signature of the API will be:

```
RecA * Rte_IWriteRef_<re>_<p>_<o>(void);
```

Please note that the usage of Compiler Abstraction is not shown in the example.

[SWS_Rte_07079] ⌈ If the DataPrototype is associated to an Array Implementation Data Type the RTE API shall return an array expression (that is a pointer to the array base type) pointing to variable holding the value of the DataPrototype for which the API provides access. If the leaf ImplementationDataTypeElement is typed by a SwBaseType the array type name shall be equal to the nativeDeclaration attribute of the SwBaseType. If the leaf ImplementationDataTypeElement is typed by an ImplementationDataType the type name shall be equal to the shortName of these ImplementationDataType. ⌋*(SRS_Rte_00059)*

Example 5.16

Consider an RTE API call return a reference to an array as defined in the example 5.4 for a singly instantiated SW-C. The signature of the API will be:

```
unsigned char * Rte_IWriteRef_<re>_<p>_<o>(void);
```

Example 5.17

Consider an RTE API call return a reference to an array as defined in the example 5.5 for a singly instantiated SW-C. The signature of the API will be:

```
uint8 * Rte_IWriteRef_<re>_<p>_<o>(void);
```

Please note that the usage of Compiler Abstraction is not shown in the examples.

[SWS_Rte_07080] ⌈ If the DataPrototype is associated to a Pointer Implementation Data Type the RTE API shall return a pointer pointing to variable holding the value of the DataPrototype for which the API provides access. The type name shall be equal to the shortName of these ImplementationDataType. ⌋*(SRS_Rte_00059)* Please not that in this case the value is a pointer again.

[SWS_Rte_07081] ⌈ If the DataPrototype is associated to a Redefinition Implementation Data Type the RTE Generator shall determine the API return value behaviour as described in [SWS_Rte_07077], [SWS_Rte_07078], [SWS_Rte_07079], [SWS_Rte_07080], [SWS_Rte_07081] according the referenced ImplementationDataType. Nevertheless except for Array Implementation Data Type the type name shall be equal to the shortName of these ImplementationDataType. ⌋*(SRS_Rte_00059)*

Please note that Redefinition Implementation Data Type might redefine an other Redefinition Implementation Data Type again.

5.2.6.8 Error Handling

In RTE, error and status information is defined with the data type Std_ReturnType, see Section 5.5.1.

It is possible to distinguish between infrastructure errors and application errors. Infrastructure errors are caused by a resource failure or an invalid input parameter. Infrastructure errors usually occur in the basic software or hardware along the communication path of a data element. Application errors are reported by a SW-C or by AUTOSAR services. RTE has the capability to treat application errors that are forwarded

- by return value in client server communication or
- by signal invalidation in sender receiver communication with `data semantic`s.

Errors that are detected during an RTE API call are notified to the caller using the API's return value.

[SWS_Rte_01034] ⌈ Error states (including 'no error') shall only be passed as return value of the RTE API to the AUTOSAR SW-C. ⌋*(SRS_Rte_00094)*

Requirement [SWS_Rte_01034] ensures that, irrespective of whether the API is blocking or non-blocking, the error is collected at the same time the data is made available to the caller thus ensuring that both items are accessed consistently.

Certain RTE API calls operate asynchronously from the underlying communication mechanism. In this case, the return value from the API indicates only errors detected during that API call. Errors detected after the API has terminated are returned using a different mechanism [SWS_Rte_01111]. RTE also provides an 'implicit' API for direct access to virtually shared memory. This API does not return any errors. The underlying communication is decoupled. Instead, an API is provided to pick up the current status of the corresponding data element.

5.2.6.9 Success Feedback

The RTE supports the notification of results of transmission attempts to an AUTOSAR software-component.

The `Rte_Feedback` API [SWS_Rte_01083] or the `Rte_IFeedback` API [SWS_Rte_07367] can be configured to return the transmission result as either a blocking or non-blocking API or via activation of a runnable entity.

5.2.7 Unconnected Ports

[SWS_Rte_01329] ⌈ The RTE shall handle both require and provide ports that are not connected. ⌋*(SRS_Rte_00139)*

The handling of require ports as an error is described in requirement [SWS_Rte_05099].

[SWS_Rte_06030] ⌈ The RTE shall consider a `PRPortPrototype` as always connected. ⌋*(SRS_Rte_00139)*

Note: [SWS_Rte_06030] is the consequence of [TPS_SWCT_01573]. This is because a PRPortPrototype is logically an overlay of require and provide semantics hence the PRPortPrototype needs no further explicitly defined connection in the form of an SwConnector or signal mapping.

RTE event handling and the API calls for unconnected ports are specified to behave as if the port was connected but the remote communication point took no action.

Unconnected require ports are regarded by the RTE generator as an invalid configuration (see [SWS_Rte_03019]) if the strict handling has been enabled (see [SWS_Rte_05099]).

5.2.7.1 Data Elements

5.2.7.1.1 Explicit Communication

[SWS_Rte_01330] ⌈ A Rte_Read API for an unconnected require port typed by a SenderReceiverInterface or NvDataInterface shall return the RTE_E_UNCONNECTED code and provide the initValue as if a sender was connected but did not transmit anything. ⌋*(SRS_Rte_00094, SRS_Rte_00139, SRS_Rte_00200)*

[SWS_Rte_07663] ⌈ A Rte_DRead API for an unconnected require port typed by a SenderReceiverInterface or NvDataInterface shall return the initValue as if a sender was connected but did not transmit anything. ⌋*(SRS_Rte_00139, SRS_Rte_00200)*

Requirements [SWS_Rte_01330] and [SWS_Rte_07663] apply to elements with "'data"' semantics and therefore "last is best"' semantics. This means that the initial value will be returned.

[SWS_Rte_01331] ⌈ A blocking or non-blocking Rte_Receive API for an unconnected require port typed by a SenderReceiverInterface shall return RTE_E_UNCONNECTED immediately. ⌋*(SRS_Rte_00094, SRS_Rte_00107, SRS_Rte_00110, SRS_Rte_00139, SRS_Rte_00200)*

The existence of blocking and non-blocking Rte_Read, Rte_DRead and Rte_Receive API calls is controlled by the presence of VariableAccesses in the dataReceivePointByValue or dataReceivePointByArgument role, DataReceivedEvents and WaitPoints within the SW-C description [SWS_Rte_01288], [SWS_Rte_01289] and [SWS_Rte_01290].

[SWS_Rte_01344] ⌈ A blocking or non-blocking Rte_Feedback API for a VariableDataPrototype of an unconnected provide port shall return RTE_E_UNCONNECTED immediately. ⌋*(SRS_Rte_00094, SRS_Rte_00122, SRS_Rte_00139)*

The existence of blocking and non-blocking Rte_Feedback API is controlled by the presence of VariableAccesses in the dataSendPoint role, DataSendCompletedEvents and WaitPoints within the SW-C description for a VariableDataPrototype with acknowledgement enabled, see [SWS_Rte_01283], [SWS_Rte_01284], [SWS_Rte_01285] and [SWS_Rte_01286].

[SWS_Rte_01332] ⌈ The Rte_Send or Rte_Write API for an unconnected provide port typed by a SenderReceiverInterface or NvDataInterface shall discard the input parameters and return RTE_E_OK. ⌋*(SRS_Rte_00139)*

The existence of Rte_Send or Rte_Write is controlled by the presence of VariableAccesses in the dataSendPoint role within the SW/C description [SWS_Rte_01280] and [SWS_Rte_01281].

[SWS_Rte_03783] ⌈ The Rte_Invalidate API for an unconnected provide port typed by a SenderReceiverInterface shall return RTE_E_OK. ⌋*(SRS_Rte_00139)*

The existence of Rte_Invalidate is controlled by the presence of VariableAccesses in the dataSendPoint role within the SW/C description for a VariableDataPrototype which is marked as invalidatable by an associated InvalidationPolicy. The handleInvalid attribute of the InvalidationPolicy has to be set to keep, replace or externalReplacement to enable the invalidation support for this dataElement ([SWS_Rte_01282]).

5.2.7.1.2 Implicit Communication

[SWS_Rte_07378] ⌈ An Rte_IFeedback API for a VariableDataPrototype of an unconnected provide port shall return RTE_E_UNCONNECTED immediately. ⌋*(SRS_Rte_00139, SRS_Rte_00185)*

The existence of an Rte_IFeedback API is controlled by the presence of VariableAccesses in the dataWriteAccess role, and DataWriteCompletedEvents within the SWC description for a VariableDataPrototype with acknowledgement enabled, see [SWS_Rte_07646], [SWS_Rte_07647].

[SWS_Rte_01346] ⌈ An Rte_IRead API for an unconnected require port typed by a SenderReceiverInterface or NvDataInterface shall return the initial value. ⌋*(SRS_Rte_00139)*

The existence of Rte_IRead is controlled by the presence of a VariableAccess in the dataReadAccess role in the SW-C description [SWS_Rte_01301].

[SWS_Rte_01347] ⌈ An Rte_IWrite API for an unconnected provide port typed by a SenderReceiverInterface or NvDataInterface shall discard the written data. ⌋*(SRS_Rte_00139)*

The existence of Rte_IWrite is controlled by the presence of a VariableAccess in the dataWriteAccess role in the SW-C description [SWS_Rte_01302].

[SWS_Rte_03784] ⌈ An Rte_IInvalidate API for an unconnected provide port typed by a SenderReceiverInterface shall perform no action. ⌋*(SRS_Rte_00139)*

The existence of Rte_IInvalidate is controlled by the presence of a VariableAccess in the dataWriteAccess role in the SW-C description for a VariableDataPrototype which is marked as invalidatable by an associated InvalidationPolicy. The handleInvalid attribute of the InvalidationPolicy has to be set to keep, replace or externalReplacement to enable the invalidation support for this dataElement ([SWS_Rte_03801]).

[SWS_Rte_03785] ⌈ An Rte_IStatus API for an unconnected require port typed by a SenderReceiverInterface shall return RTE_E_UNCONNECTED. ⌋*(SRS_Rte_00094, SRS_Rte_00139, SRS_Rte_00200)*

The existence of Rte_IStatus is controlled by the presence of a VariableAccess in the dataReadAccess role in the SW-C description for a VariableDataPrototype with data element outdated notification or data element invalidation [SWS_Rte_02600].

5.2.7.2 Mode Switch Ports

For the mode user an unconnected mode switch port behaves as if it was connected to a mode manager that never sends a mode switch notification.

[SWS_Rte_02638] ⌈ A Rte_Mode API for an unconnected mode switch port of a mode user shall return the initial state. ⌋*(SRS_Rte_00139)*

[SWS_Rte_02639] ⌈ Regarding the modes of an unconnected mode switch port of a mode user, the mode disabling dependencies on the initial mode shall be permanently active and the mode disabling dependencies on all other modes shall be inactive. ⌋*(SRS_Rte_00139)*

[SWS_Rte_02640] ⌈ Regarding the modes of an unconnected mode switch port of a mode user, RTE will only generate a SwcModeSwitchEvent for entering the initial mode which occurs directly after startup. ⌋*(SRS_Rte_00139)*

[SWS_Rte_02641] ⌈ The Rte_Switch API for an unconnected mode switch port of the mode manager shall discard the input parameters and return RTE_E_OK. ⌋*(SRS_Rte_00139)*

[SWS_Rte_02642] ⌈ A blocking or non blocking Rte_SwitchAck API for an unconnected mode switch port of the mode manager shall return RTE_E_UNCONNECTED immediately. ⌋*(SRS_Rte_00139)*

[SWS_Rte_01375] ⌈ A provided mode switch port of a mode manager shall be considered unconnected only if there are no connections at the composition level and no ModeAccessPoint exists for the provided mode switch port and no *synchronizedModeGroup* refers to the provided mode switch port. ⌋*(SRS_Rte_00139)*

5.2.7.3 Client-Server

[SWS_Rte_01333] ⌈ The Rte_Result API for an unconnected asynchronous require port typed by a ClientServerInterface shall return RTE_E_UNCONNECTED immediately. ⌋*(SRS_Rte_00094, SRS_Rte_00139, SRS_Rte_00200)*

[SWS_Rte_01334] ⌈ The Rte_Call API for an unconnected require port typed by a ClientServerInterface shall return RTE_E_UNCONNECTED immediately. ⌋*(SRS_Rte_00094, SRS_Rte_00139, SRS_Rte_00200)*

[SWS_Rte_04530] ⌈ If a client/server communication is inter-ECU, then for each ClientServerOperation the DataMappings element shall contain a mapping to at least one COM signal or being referenced at least by a LdCom I-PDU, otherwise the ClientServerOperation shall be treated as if it is part of an unconnected port. ⌋*(SRS_Rte_00094, SRS_Rte_00139, SRS_Rte_00200)*

5.2.7.4 External Triggers

For unconnected RPortPrototypes the associated ExternalTriggerOccurredEvents will never get fired (i.e. it behaves as if the remote communication partner never triggers the event).

[SWS_Rte_06210] ⌈ The Rte_Trigger API for an unconnected PPortPrototypes typed by a TriggerInterface shall discard the trigger request and return RTE_E_OK. ⌋*(SRS_Rte_00094, SRS_Rte_00139, SRS_Rte_00162, SRS_Rte_00200)*

5.2.8 Non-identical port interfaces

Two ports are permitted to be connected provided that they are characterized by compatible, but not necessarily identical, interfaces. For the full definition of whether two interfaces are compatible, see the Software Component Template [2].

[SWS_Rte_01368] ⌈ The RTE generator shall report an error if the [constr_1036] and the [constr_1069] are violated so if two connected ports are connected by incompatible interfaces. ⌋*(SRS_Rte_00137)*

A significant issue in determining whether two interfaces are compatible is that the interface characterizing the require port may be a strict subset of the interface characterizing the provide port. This means that there may be provided data elements or operations for which there is no corresponding element in the require port. This can be imagined as a multi-strand wire between the two ports (the assembly connector) where each strand represents the connection between two data elements or operations, and where some of the strands from the ‘provide’ end are not connected to anything at the ‘require’ end.

Define, for the purposes of this section, an "unconnected element" as a data element or operation that occurs in the provide interface, but for which no corresponding data element or operation occurs in a particular R-Port's interface.

[SWS_Rte_01369] ⌈ For each data element or operation within the provide interface, every connected requirer with an "unconnected element" must be treated as if it were not connected. ⌋*(SRS_Rte_00137)*

Note that requirement [SWS_Rte_01369] means that in the case of a 1:n Sender-Receiver the `Rte_Write` call may transmit to some but not all receivers.

The extreme is if all connected requirers have an "unconnected element":

[SWS_Rte_01370] ⌈ For a data element or operation in a provide interface which is an unconnected element in every connected R-Port, the generated `Rte_Send`, `Rte_Write`, `Rte_IWrite`, or `Rte_IWriteRef` APIs must act as if the port were unconnected. ⌋*(SRS_Rte_00137)*

See Section 5.2.7 for the required behavior in this case.

5.3 RTE Modules

Figure 5.1 defines the relationship between header files and how those files are included by modules implementing AUTOSAR software-components and by general, non-component, code.

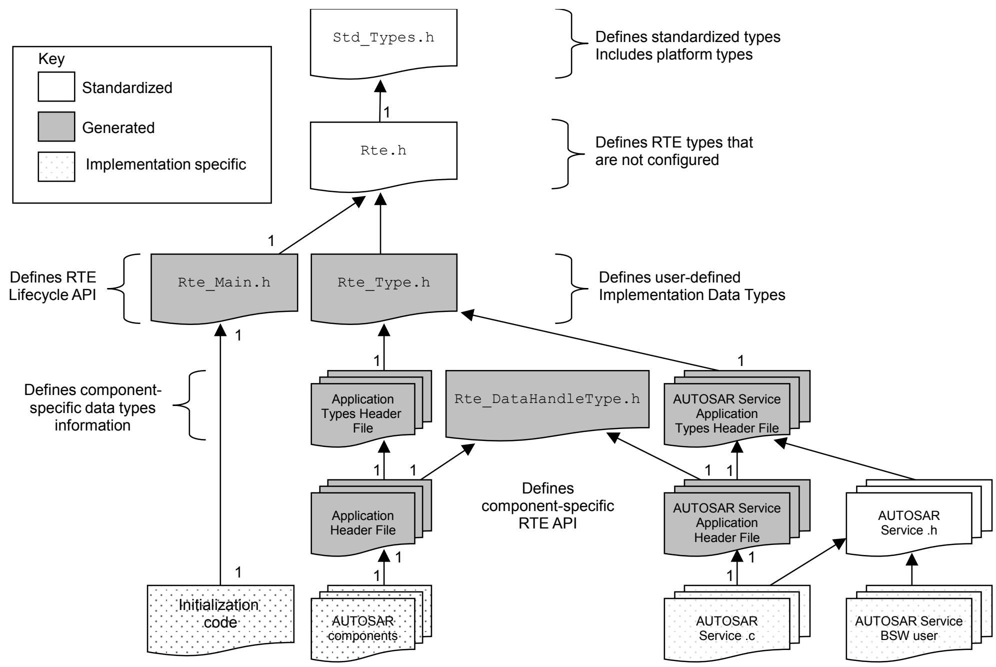

Figure 5.1: Relationships between RTE Header Files

The output of an RTE generator can consist of both generated code and configuration for "library" code that may be supplied as either object code or source code. Both configured and generated code reference standard definitions that are defined in the *RTE Header File*.

The relationship between the *RTE header file*, *Application Header File*s, the *Lifecycle Header File* and AUTOSAR software-components is illustrated in Figure 5.1.

In general a RTE can be partitioned in several files. The partitioning depends from the RTE vendors software design and generation strategy. Nevertheless it shall be possible to clearly identify code and header files which are part of the RTE module.

[SWS_Rte_07139] ⌈ Every file of the RTE beside Rte.h and Rte.c shall be named with the prefix `Rte_`. ⌋*(SRS_BSW_00300)*

5.3.1 RTE Header File

The RTE header file defines fixed elements of the RTE that do not need to be generated or configured for each ECU.

[SWS_Rte_01157] ⌈ For C/C++ AUTOSAR software-components, the name of the RTE header file shall be `Rte.h`. ⌋*(SRS_BSW_00300)*

Typically the contents of the RTE header file are fixed for any particular implementation and therefore it is not created by the RTE generator. However, customization for each generated RTE is not forbidden.

[SWS_Rte_01164] ⌈ The RTE header file shall include the file `Std_Types.h`. ⌋*(SRS_Rte_00149, SRS_Rte_00150, SRS_BSW_00353)*

The file `Std_Types.h` is the standard AUTOSAR file [31] that defines basic data types including platform specific definitions of unsigned and signed integers and provides access to the compiler abstraction.

The contents of the RTE header file are not restricted to standardized elements that are defined within this document – it can also contain definitions specific to a particular implementation.

5.3.2 Lifecycle Header File

[SWS_Rte_08309] ⌈ The RTE generator shall provide declarations for RTE and SchM Lifecycle APIs (see Section 5.8 and 6.7) through the Lifecycle header file. ⌋*(SRS_Rte_00051)*

[SWS_Rte_01158] ⌈ For C/C++ AUTOSAR software-components, the name of the lifecycle header file shall be `Rte_Main.h`. ⌋*(SRS_BSW_00300)*

[SWS_Rte_01159] ⌈ The lifecycle header file shall include the *RTE header file*. ⌋*(SRS_Rte_00051)*

5.3.3 Application Header File

The application header file [SRS_Rte_00087] is central to the definition of the RTE API. An application header file defines the RTE API and any associated data structures that are required by the SW-C to use the RTE implementation. But the application header file is not allowed to create objects in memory.

[SWS_Rte_01000] ⌈ The RTE generator shall create an application header file for each software-component type (excluding ParameterSwComponentTypes and NvBlock-SwComponentTypes) defined in the input. ⌋*(SRS_Rte_00087, SRS_Rte_00024, SRS_Rte_00140)*

[SWS_Rte_03786] ⌈ The application header file shall not contain code that creates objects in memory. ⌋*(SRS_Rte_00087, SRS_BSW_00308)*

RTE generation consists of two phases; an initial “RTE Contract” phase and a second “RTE Generation” phase (see Section 2.3). Object-code components are compiled after the first phase of RTE generation and therefore the application header file should conform to the form of definitions defined in Sections 5.4.1 and 5.5.2. In contrast, source-code components are compiled after the second phase of RTE generation and therefore the RTE generator produces an optimized application header file based on knowledge of component instantiation and deployment.

5.3.3.1 File Name

[SWS_Rte_01003] ⌈ The name of the *Application Header File* of an AUTOSAR software component shall be `Rte_[Byps_]<name>.h`. `<name>` is the AUTOSAR software component type name. `[Byps_]` is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00300)*

Example 5.18

The following declaration in the input XML:

```
<APPLICATION-SW-COMPONENT-TYPE>
    <SHORT-NAME>Source</SHORT-NAME>
</APPLICATION-SW-COMPONENT-TYPE>
```

should result in the application header file `Rte_Source.h` being generated when the component wrapper method for bypass support is disabled.

The component type name is used rather than the component instance name for two reasons; firstly the same component code is used for all component instances and, secondly, the component instance name is an internal identifier, and should not appear outside of generated code.

5.3.3.2 Scope

RTE supports two approaches for the scope of the application header file, a SW-C based, and a runnable based approach.

1. Always, the application header file provides only the API that is specific for one atomic SW-C, see [SWS_Rte_01004].
2. The scope of the application header file can be further reduced to one runnable by using the mechanism described in [SWS_Rte_02751].

Many of the RTE APIs are specific to runnables. The restrictions for the usage of the generated APIs are defined in the ‘Existence’ parts of each API subsection in 5.6. To prevent run time errors by the misuse of APIs that are not supported for a runnable, it is recommended to use the runnable based approach of the application header file.

[SWS_Rte_01004] ⌈ The application header file for a component shall contain only information relevant to that component. ⌋*(SRS_Rte_00087, SRS_Rte_00017, SRS_Rte_00167)*

[SWS_Rte_02751] ⌈ If the pre-compiler Symbol `RTE_RUNNABLEAPI_<rn>` is defined for a runnable with short name `<rn>` when the application header file is included, the application header file shall not declare APIs that are not valid to be used by the runnable *rn*. ⌋*(SRS_Rte_00017)*

For example, to restrict the application header file of the SW-C `mySwc` to the API of the runnable `myRunnable`, the following sequence can be used:

```
#define RTE_RUNNABLEAPI_myRunnable
#include <Rte_mySwc.h>

// runnable source code
```

Note that this mechanism does not support to restrict the application header file to the super set of two or more runnable APIs. In other words, runnables should be kept in separate source files, if the runnable based approach is used.

Requirements [SWS_Rte_01004] and [SWS_Rte_02751] mean that compile time checks ensure that a component (or runnable) that uses the application header file only accesses the generated data structures and functions to which it has been configured. Any other access, e.g. to fields not defined in the customized data structures or RTE API, will fail with a compiler error [SRS_Rte_00017].

The definitions of the RTE API contained in the application header file can be optimized during the “RTE Generation” phase when the mapping of software-components to ECUs and the communication matrix is known. Consequently multiple application header files must not be included in the same source module to avoid conflicting definitions of the RTE API definitions that the files contains.

Listing 5.1 illustrates the code structure for the declaration of the entry point of a runnable entity that provides the implementation for a ServerPort in component `c1`. The RTE generator is responsible for creating the API and tasks used to execute the server and the symbol name of the entry point is extracted from the attribute symbol of the runnable entity. The example shows that the first parameter of the entry point function is the software-component's instance handle [SWS_Rte_01016].

Listing 5.1: Skeleton server runnable entity

```
#include <Rte_c1.h>

void runnable_entry(Rte_Instance instance)
{
  /* ... server code ... */
}
```

Listing 5.1 includes the component-specific application header file `Rte_c1.h` created by the RTE generator. The RTE generator will also create the supporting data structures and the task body to which the runnable is mapped.

The RTE is also responsible for preventing conflicting concurrent accesses when the runnable entity implementing the server operation is triggered as a result of a request from a client received via the communication service or directly via inter-task communication.

5.3.3.3 File Contents

Multiple application header file must not be included in the same module ([SWS_Rte_01004]) and therefore the file contents should contain a mechanism to enforce this requirement.

[SWS_Rte_01006] ⌈ An application header file shall include the following mechanism before any other definitions.

```
#ifdef RTE_APPLICATION_HEADER_FILE
#error Multiple application header files included.
#endif /* RTE_APPLICATION_HEADER_FILE */
#define RTE_APPLICATION_HEADER_FILE
```

⌋*(SRS_Rte_00087)*

[SWS_Rte_07131] ⌈ The application header file shall include the *Application Types Header File*. ⌋*(SRS_Rte_00087)*

The name of the *Application Types Header File* is defined in Section 5.3.6.

[SWS_Rte_07924] ⌈ The application header file shall include the *RTE Data Handle Types Header File* (see Section 5.3.5). ⌋*(SRS_Rte_00087)*

[SWS_Rte_01005] ⌈ The application header file shall be valid for both C and C++ source. ⌋*(SRS_Rte_00126, SRS_Rte_00138)*

Requirement [SWS_Rte_01005] is met by ensuring that all definitions within the application header file are defined using C linkage if a C++ compiler is used.

[SWS_Rte_03709] ⌈ All definitions within in the application header file shall be preceded by the following fragment;

```
#ifdef __cplusplus
extern "C" {
#endif /* __cplusplus */
```

⌋*(SRS_Rte_00126, SRS_Rte_00138)*

[SWS_Rte_03710] ⌈ All definitions within the application header file shall be suffixed by the following fragment;

```
#ifdef __cplusplus
} /* extern "C" */
#endif /* __cplusplus */
```

⌋*(SRS_Rte_00126, SRS_Rte_00138)*

5.3.3.3.1 Instance Handle

The RTE uses an instance handle to identify different instances of the same component type. The definition of the instance handle type [SWS_Rte_01148] is unique to each component type and therefore should be included in the application header file.

[SWS_Rte_01007] ⌈ The application header file shall define the type of the instance handle for the component. ⌋*(SRS_Rte_00012)*

All runnable entities for a component are passed the same instance handle type (as the first formal parameter [SWS_Rte_01016]) and can therefore use the same type definition from the component's application header file.

The example 5.24 illustrates the definition of an instance handle.

5.3.3.3.2 Runnable Entity Prototype

The application header file also includes a prototype for each runnable entity entry point ([SWS_Rte_01132]) and the API mapping ([SWS_Rte_01274]).

5.3.3.3.3 Initial Values

[SWS_Rte_05078] ⌈ The *Application Header File* shall define the init value of non-queued `VariableDataPrototype`s of sender receiver or non volatile data ports and typed by an `ImplementationDataType` or `ApplicationDataType` of category `VALUE`.

```
#define Rte_InitValue_<Port>_<DEPType> <initValue><suffix>
```

where <Port> is the PortPrototype shortName, <DEPType> is the shortName of the VariableDataPrototype, and <initValue> is the initValue specified in the NonqueuedReceiverComSpec respectively NonqueuedSenderComSpec. <suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋*(SRS_Rte_00068, SRS_Rte_00087, SRS_Rte_00108)*

Note that the initValue defined may be subject to change due to the fact that for COM configuration it may be possible to change this value during ECU Configuration or even post-build time.

5.3.3.3.4 PerInstanceMemory

The *Application Header File* shall type definitions for PerInstanceMemory's as defined in Chapter 5.2.5, [SWS_Rte_07133].

5.3.3.3.5 RTE-Component Interface

The application header file defines the "interface" between a component and the RTE. The interface consists of the RTE API for the component and the prototypes for runnable entities. The definition of the RTE API requires that both relevant data structures and API calls are defined.

The data structures required to support the API are defined in the Application Header file (CDS) (see chapter 5.3.3), in the Application Types Header file (see chapter 5.3.6), in the RTE Types Header file (see chapter 5.3.1) and in the RTE Data Handle Types Header file (see chapter 5.3.5).

The data structure types are declared in the header files whereas the instances are defined in the generated RTE. The necessary data structures for object-code software-components are defined in chapter 5.5.2 and chapter 5.4.2.

The RTE generator is required [SWS_Rte_01004] to limit the contents of the application header file to only that information that is relevant to that component type. This requirement includes the definition of the API mapping. The API mapping is described in chapter 5.2.6.

Requirement [SWS_Rte_01004] and [SWS_Rte_01006] ensure that attempts to invoke invalid API calls will be rejected as a compile-time error [SRS_Rte_00017].

5.3.3.3.6 Application Errors

The concept of client server supports application specific error codes. Symbolic names for Application Errors are defined in the application header file to avoid conflicting definitions between several AtomicSwComponentTypes mapped one ECU. See [SWS_Rte_02575] and [SWS_Rte_02576].

5.3.4 RTE Types Header File

The *RTE Types Header File* includes the RTE specific type declarations derived from the ImplementationDataTypes created from the definitions of AUTOSAR meta-model classes within the RTE generator's input. The available meta-model classes are defined by the AUTOSAR software-component template and include classes for defining primitive values, structures, arrays and pointers.

The types declared in the *RTE Types Header File* intend to be used for the implementation of RTE internal data buffers as well as for RTE API.

[SWS_Rte_01160] ⌈ The RTE generator shall create the *RTE Types Header File* including the type declarations corresponding to the ImplementationDataTypes defined in the input configuration as well as the RTE implementation types. ⌋*()*

The RTE Data Types header file should be output for "RTE Contract" and "RTE Generation" phases.

5.3.4.1 File Contents

[SWS_Rte_02648] ⌈ The *RTE Types Header File* shall include the type declarations, structure defintions, and union definitions for all the AUTOSAR Data Types according to [SWS_Rte_07104], [SWS_Rte_07110], [SWS_Rte_06706], [SWS_Rte_06707], [SWS_Rte_06708] [SWS_Rte_07111], [SWS_Rte_07114], [SWS_Rte_06812], [SWS_Rte_07144], [SWS_Rte_06813], [SWS_Rte_07109] and [SWS_Rte_07148] depending on the values of attributes typeEmitter and nativeDeclaration but irrespective of their use by the generated RTE. ⌋*()*

The attribute typeEmitter controls which part of the AUTOSAR toolchain is supposed to provide data type definitions. For legacy reasons the RTE generator is supposed to generate the corresponding data type if the ImplementationDataType defines no typeEmitter.

[SWS_Rte_06709] ⌈ The RTE generator shall generate the corresponding data type definition if the value of attribute typeEmitter is NOT defined. ⌋*()*

[SWS_Rte_06710] ⌈ The RTE generator shall generate the corresponding data type definition if the value of attribute typeEmitter is set to "RTE". ⌋*()*

[SWS_Rte_06711] ⌈ The RTE generator shall reject configurations where the attribute typeEmitter is not defined or set to "RTE", and the ImplementationDataType references a SwBaseType without defined nativeDeclaration. ⌋*()*

[SWS_Rte_06712] ⌈ The RTE generator shall silently not generate the corresponding data type definition if the value of attribute typeEmitter is set to anything else but "RTE". ⌋*()*

This requirement ensures the availability of ImplementationDataTypes for the internal use in AUTOSAR software components.

Nevertheless the *RTE Types Header File* does not contain any data type belonging to an ImplementationDataType where typeEmitter is set to anything else but "RTE" regardless if the ImplementationDataType references SwBaseTypes and if this SwBaseTypes define nativeDeclarations.

[SWS_Rte_08732] ⌈ The RTE generator shall generate the type Rte_Cs_TransactionHandleType of the transaction handle for inter-ECU Client-Server communication as a structure:

```
typedef struct {
    uint16 clientId;
    uint16 sequenceCounter;
} Rte_Cs_TransactionHandleType;
```

where clientId and sequenceCounter contain the client identifier and sequence counter as specified in [SWS_Rte_02649].

⌋*()*

The types header file may need types in terms of BSW types (from the file Std_Types.h) or from the implementation specific RTE header file to declare types. However, since the RTE header file includes the file Std_Types.h already so only the RTE header file needs direct inclusion within the types header file.

[SWS_Rte_01163] ⌈ The *RTE Types Header File* shall include the *RTE Header File*. ⌋ *(SRS_BSW_00353)*

5.3.4.2 Classification of Implementation Data Types

The type model ImplementationDataTypes is able to express following kinds of data types:

- Primitive Implementation Data Type
- Array Implementation Data Type
- Structure Implementation Data Type
- Union Implementation Data Type
- Redefinition Implementation Data Type
- Pointer Implementation Data Type

A *Primitive Implementation Data Type* is classified that it directly refers by its SwDataDefProps to a SwBaseType in the role baseType. The category attribute is set to VALUE.

An *Array Implementation Data Type* is classified that it defines ImplementationDataTypeElements for each dimension of the array. The swArraySize specifies the number of array elements of the dimension. The category attribute *Array Implementation Data Type* is set to ARRAY.

A *Structure Implementation Data Type* is categorized that it has ImplementationDataTypeElement's. The category attribute of the ImplementationDataType is set to STRUCTURE. Each ImplementationDataTypeElement it self can be one of the listed kinds again.

A *Union Implementation Data Type* is categorized that it has ImplementationDataTypeElement's. The category attribute of the ImplementationDataType is set to UNION. Each ImplementationDataTypeElement it self can be one of the listed kinds again.

A *Redefinition Implementation Data Type* is classified that it refers to other ImplementationDataTypes. The category attribute of the referring ImplementationDataType has to be set to TYPE_REFERENCE.

A *Pointer Implementation Data Type* is classified that its SwDataDefProps has a swPointerTargetProps attribute. The swDataDefProps in the role swPointerTargetProps is specifying the target to which the pointer refers. The category attribute of the ImplementationDataType has to be set to DATA_REFERENCE.

5.3.4.3 Primitive Implementation Data Type

The *RTE Types Header File* declares C types for all Primitive Implementation Data Types where the referred BaseType has a nativeDeclaration attribute.

[SWS_Rte_07104] ⌈ For each Primitive Implementation Data Type with a nativeDeclaration attribute, the *RTE Types Header File* shall include the corresponding type declaration as:

```
typedef <nativeDeclaration> <name>;
```

where <nativeDeclaration> is the nativeDeclaration attribute of the referred BaseType and <name> is the Implementation Data Type symbol of the Primitive Implementation Data Type. ⌋*(SRS_Rte_00055, SRS_Rte_00166, SRS_Rte_00168, SRS_BSW_00353)*

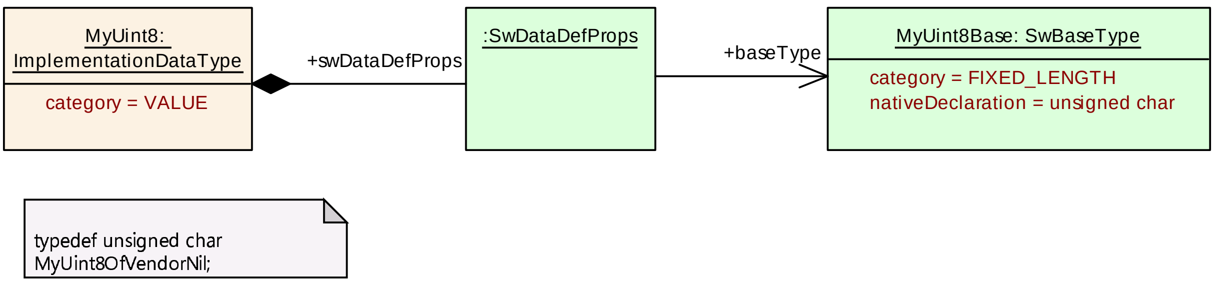

Figure 5.2: Primitive Implementation Data Type

Note: All Primitive Implementation Data Types where the referred BaseType has **no** nativeDeclaration attribute resulting not in a type declaration. This is intended to prevent the redeclaration of the predefined Standard Types and Platform Types.

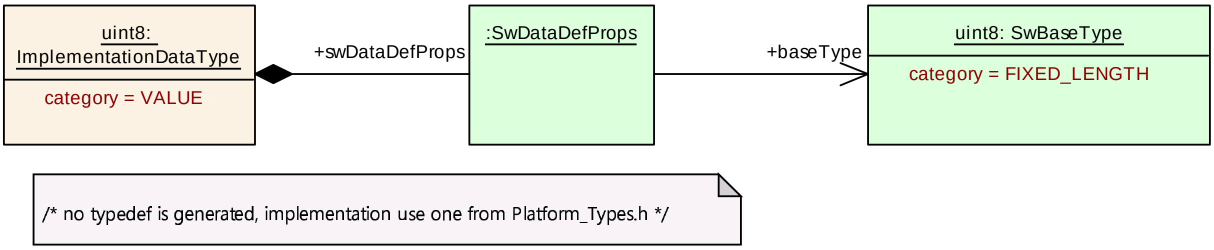

Figure 5.3: Primitive Implementation Data Type included from Platform_Types.h

[SWS_Rte_07105] ⌈ If more than one Primitive Implementation Data Type with equal shortName and equal nativeDeclaration attribute of the referred BaseType are defined, the *RTE Types Header File* shall include only once the corresponding type declaration according to [SWS_Rte_07104]. ⌋*(SRS_Rte_00165)*

Note: This avoids the redeclaration of C types due to the multiple descriptions of equivalent Primitive Implementation Data Types in the ECU extract.

5.3.4.4 Array Implementation Data Type

In addition to the primitive data-types defined in the previous section, it is also necessary for the RTE generator to declare composite data-types: arrays and records.

An array definition following information:

- the array type
- the number of dimensions
- the number of elements for each dimension.

[SWS_Rte_07110] ⌈ For each Array Implementation Data Type which leaf ImplementationDataTypeElement is typed by a BaseType, the *RTE Types Header File* shall include the corresponding type declaration as:

```
typedef <nativeDeclaration> <name>[<size 1>]{[<size 2>]...
[<size n>]};
```

where <nativeDeclaration> is the nativeDeclaration attribute of the referred BaseType,

<name> is the Implementation Data Type symbol of the Array Implementation Data Type,

[<size x>] is the arraySize of the Array's ImplementationDataTypeElement.

For each array dimension defined by one Array's ImplementationDataTypeElement one array dimension definition [<size x>] is defined. The array dimension definitions [<size 1>], [<size 2>] ... [<size n>] ordered from the root to the leaf ImplementationDataTypeElement. ⌋*(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_07111] ⌈ For each Array Implementation Data Type which leaf ImplementationDataTypeElement is typed by an ImplementationDataType, the *RTE Types Header File* shall include the corresponding type declaration as:

```
typedef <type> <name>[<size 1>]{[<size 2>]...[<size n>]};
```

where <type> is the shortName of the referred ImplementationDataType,

<name> is the Implementation Data Type symbol of the Array Implementation Data Type,

[<size x>] is the arraySize of the Array's ImplementationDataTypeElement.
For each array dimension defined by one Array's ImplementationDataTypeElement one array dimension definition [<size x>] is defined.

The array dimension definitions [<size 1>], [<size 2>] ... [<size n>] ordered from the root to the leaf ImplementationDataTypeElement. ⌋*(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_03609] ⌈ For each Array Implementation Data Type which last ImplementationDataTypeElement is of category STRUCTURE, the RTE *Types Header File* shall include the corresponding type declaration as:

```
typedef struct { <elements> } <name>;
```

where <elements> is the record element specification and

<name> is the Implementation Data Type Element shortName of the Array Implementation Data Type.

For each record element defined by one ImplementationDataTypeElement one record element specification <elements> is defined. The record element specifications are ordered according the order of the related ImplementationDataTypeElements in the input configuration.
Sequent record elements are separated with a semicolon. ⌋*(SRS_Rte_00055, SRS_Rte_00164)*

The definition of the record element specification is defined in section 5.3.4.5.

[SWS_Rte_06706] ⌈ For each Array Implementation Data Type which last ImplementationDataTypeElement is of category STRUCTURE, the RTE *Types Header File* shall include the corresponding type declaration as:

```
typedef <type> <name>[<size 1>]{[<size 2>]...[<size n>]};
```

where `<type>` is the `Implementation Data Type Element shortName`, `<name>` is the `Implementation Data Type symbol` of the `Array Implementation Data Type`, `[<size x>]` is the `arraySize` of the Array's `ImplementationDataTypeElement`.

For each array dimension defined by one Array's `ImplementationDataTypeElement` one array dimension definition `[<size x>]` is defined.

The array dimension definitions `[<size 1>], [<size 2>] ... [<size n>]` ordered from the root to the last `ImplementationDataTypeElement` belonging to the array definition. ⌋*(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_03610] ⌈For each `Array Implementation Data Type` which last `ImplementationDataTypeElement` is of category `UNION`, the RTE *Types Header File* shall include the corresponding type declaration as:

`typedef union { <elements> } <name>;`
where `<elements>` is the union element specification and `<name>` is the `Implementation Data Type Element shortName` of the `Array Implementation Data Type`.

For each union element defined by one `ImplementationDataTypeElement` one union element specification `<elements>` is defined. The union element specifications are ordered according the order of the related `ImplementationDataTypeElements` in the input configuration.
Sequent union elements are separated with a semicolon. ⌋*(SRS_Rte_00055, SRS_Rte_00164)*

The definition of the union element specification is defined in section 5.3.4.6.

[SWS_Rte_06707] ⌈For each `Array Implementation Data Type` which last `ImplementationDataTypeElement` is of category `UNION`, the RTE *Types Header File* shall include the corresponding type declaration as:

`typedef <type> <name>[<size 1>]{[<size 2>] ... [<size n>]};`

where `<type>` is the `Implementation Data Type Element shortName`, `<name>` is the `Implementation Data Type symbol` of the `Array Implementation Data Type`, `[<size x>]` is the `arraySize` of the Array's `ImplementationDataTypeElement`. For each array dimension defined by one Array's `ImplementationDataTypeElement` one array dimension definition `[<size x>]` is defined.

The array dimension definitions `[<size 1>], [<size 2>] ... [<size n>]` ordered from the root to the last `ImplementationDataTypeElement` belonging to the array definition. ⌋*(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_06708] ⌈For each `Array Implementation Data Type` which last `ImplementationDataTypeElement` is of category `DATA_REFERENCE`, the RTE *Types Header File* shall include the corresponding type declaration as:

```
typedef <tqlA> <addtqlA> <type> * <tqlB> <addtqlB> <name> [<size
1>]{[<size 2>]...[<size n>]};
```

where <name> is the Implementation Data Type symbol of the Array Implementation Data Type and

[<size x>] is the arraySize of the Array's ImplementationDataTypeElement. For each array dimension defined by one Array's ImplementationDataTypeElement one array dimension definition [<size x>] is defined. The array dimension definitions [<size 1>], [<size 2>] ... [<size n>] ordered from the root to the last ImplementationDataTypeElement belonging to the array definition. ⌋ *(SRS_Rte_00055, SRS_Rte_00164)*

For the definition of <tqlA> and <tqlB> see [SWS_Rte_07149] and [SWS_Rte_07166].

For the definition of <addtqlA> and <addtqlB> see [SWS_Rte_07036] and [SWS_Rte_07037].

[SWS_Rte_07112] ⌈ If more than one Array Implementation Data Type with equal shortName of the ImplementationDataType and equal nativeDeclaration attribute of the referred BaseType are defined, the *RTE Types Header File* shall include only once the corresponding type declaration according to [SWS_Rte_07110]. ⌋ *(SRS_Rte_00165)*

[SWS_Rte_07113] ⌈ If more than one Array Implementation Data Type with equal shortName of the ImplementationDataType and equal shortName of the referred ImplementationDataType are defined, the *RTE Types Header File* shall include only once the corresponding type declaration according to [SWS_Rte_07111]. ⌋ *(SRS_Rte_00165)*

Note: This avoids the redeclaration of C types due to the multiple descriptions of equivalent Array Implementation Data Types in the ECU extract.

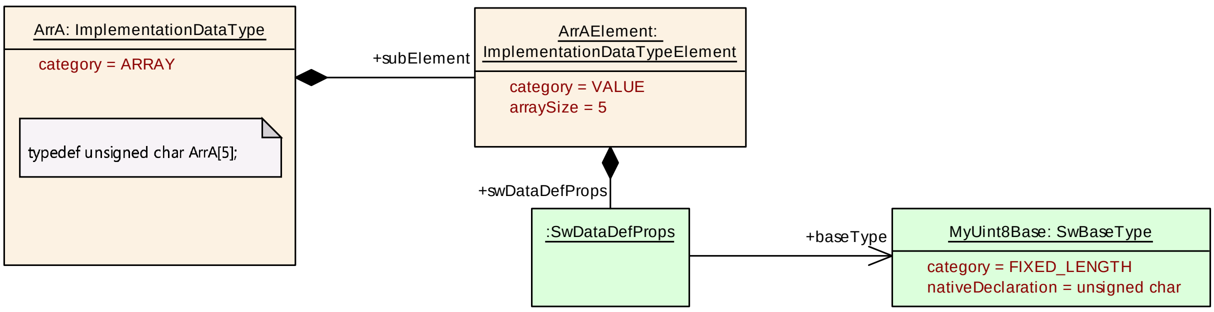

Figure 5.4: Example of a single dimension array typed by an BaseType

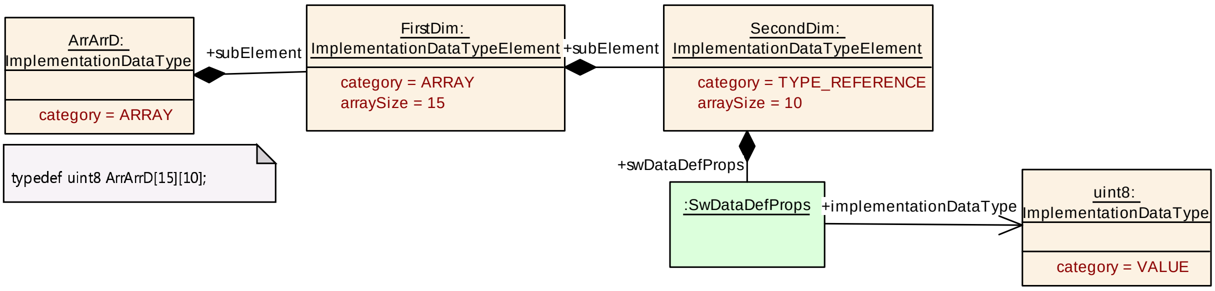

Figure 5.5: Example of a two dimension array typed by an ImplementationDataType

ANSI C does not allow a type declaration to have zero elements and therefore we require that the "number of elements" to be a positive integer.

[SWS_Rte_CONSTR_09042] Array Implementation Data Types needs at least one element ⌈ The arraySize defining number of elements in one dimension of an *Array Implementation Data Type* shall be an integer that is ≥ 1 for each dimension.
⌋*()*

5.3.4.5 Structure Implementation Data Type

[SWS_Rte_07114] ⌈ For each Structure Implementation Data Type, the *RTE Types Header File* shall include the corresponding structure declaration as:

```
struct Rte_struct_<name> { <elements> };
```

where <elements> is the record element specification and <name> is the Implementation Data Type symbol of the Structure Implementation Data Type.

For each record element defined by one ImplementationDataTypeElement one record element specification <elements> is defined. The record element specifications are ordered according the order of the related ImplementationDataTypeElements in the input configuration. Sequent record elements are separated with a semicolon. ⌋ *(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_06812] ⌈ For each Structure Implementation Data Type, the *RTE Types Header File* shall include the corresponding type declaration as:

```
typedef struct Rte_struct_<name> <name>;
```

where <name> is the Implementation Data Type symbol of the Structure Implementation Data Type. ⌋*(SRS_Rte_00055, SRS_Rte_00164)*

An example is listed as ARXML and 'C'-code in Appendix F.4.

5.3.4.6 Union Implementation Data Type

[SWS_Rte_07144] ⌈ For each Union Implementation Data Type, the *RTE Types Header File* shall include the corresponding union declaration as:

```
union Rte_union_<name> { <elements> };
```

where <elements> is the union element specification and <name> is the Implementation Data Type symbol of the Union Implementation Data Type.

For each union element defined by one ImplementationDataTypeElement one union element specification <elements> is defined. The union element specifications are ordered according the order of the related ImplementationDataTypeElements in the input configuration. Sequent union elements are separated with a semicolon. ⌋ *(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_06813] ⌈ For each Union Implementation Data Type, the *RTE Types Header File* shall include the corresponding type declaration as:

```
typedef union Rte_union_<name> <name>;
```

where <name> is the Implementation Data Type symbol of the Union Implementation Data Type. ⌋ *(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_07115] ⌈ Record and Union element specifications <elements> shall be generated as

```
<nativeDeclaration> <name>;
```

if the ImplementationDataTypeElement has the category attribute set to VALUE and if it refers to an BaseType. The meaning of the fields is identical to [SWS_Rte_07104] ⌋ *(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_07116] ⌈ Record and Union element specifications <elements> shall be generated as

```
<type> <name>;
```

if the ImplementationDataTypeElement has the category attribute set to TYPE_REFERENCE and if it refers to an ImplementationDataType. <type> is the Implementation Data Type symbol of the referred ImplementationDataType and <name> is the shortName of the ImplementationDataTypeElement. ⌋ *(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_07117] ⌈ Record and Union element specifications <elements> shall be generated as

```
<nativeDeclaration> <name>[<size 1>]{[<size 2>]...[<size n>]};
```

if the ImplementationDataTypeElement has the category attribute set to ARRAY and which leaf ImplementationDataTypeElement has the category attribute set to VALUE and is typed by an BaseType. The meaning and order of the fields is identical to [SWS_Rte_07110] ⌋*(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_07118] ⌈ Record and Union element specifications <elements> shall be generated as

<type> <name>[<size 1>]{[<size 2>]...[<size n>]};

if the ImplementationDataTypeElement has the category attribute set to ARRAY and which leaf ImplementationDataTypeElement has the category attribute set to TYPE_REFERENCE and is typed by an ImplementationDataType. The meaning and order of the fields is identical to [SWS_Rte_07111] ⌋*(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_07119] ⌈ Record and Union element specifications <elements> shall be generated as

struct { <elements> } <name>;

if the ImplementationDataTypeElement has the category attribute set to STRUCTURE. The meaning and order of the fields is identical to [SWS_Rte_07114] Sequent elements are separated with a semicolon. ⌋*(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_07145] ⌈ Record and Union element specifications <elements> shall be generated as

union { <elements> } <name>;

if the ImplementationDataTypeElement has the category attribute set to UNION. The meaning and order of the fields is identical to [SWS_Rte_07144]. Sequent elements are separated with a semicolon. ⌋*(SRS_Rte_00055, SRS_Rte_00164)*

[SWS_Rte_07146] ⌈ Pointer element specifications <elements> shall be generated as

<tqlA> <addtqlA> <type> * <tqlB> <addtqlB> <name>;

if the ImplementationDataTypeElement has the category attribute set to DATA_REFERENCE where <name> is the shortName of the ImplementationDataTypeElement. ⌋*(SRS_Rte_00055, SRS_Rte_00164)*

For the definition of <tqlA> and <tqlB> see [SWS_Rte_07149] and [SWS_Rte_07166].

For the definition of <addtqlA> and <addtqlB> see [SWS_Rte_07036] and [SWS_Rte_07037].

For the definition of <type> see [SWS_Rte_07162], [SWS_Rte_07163].

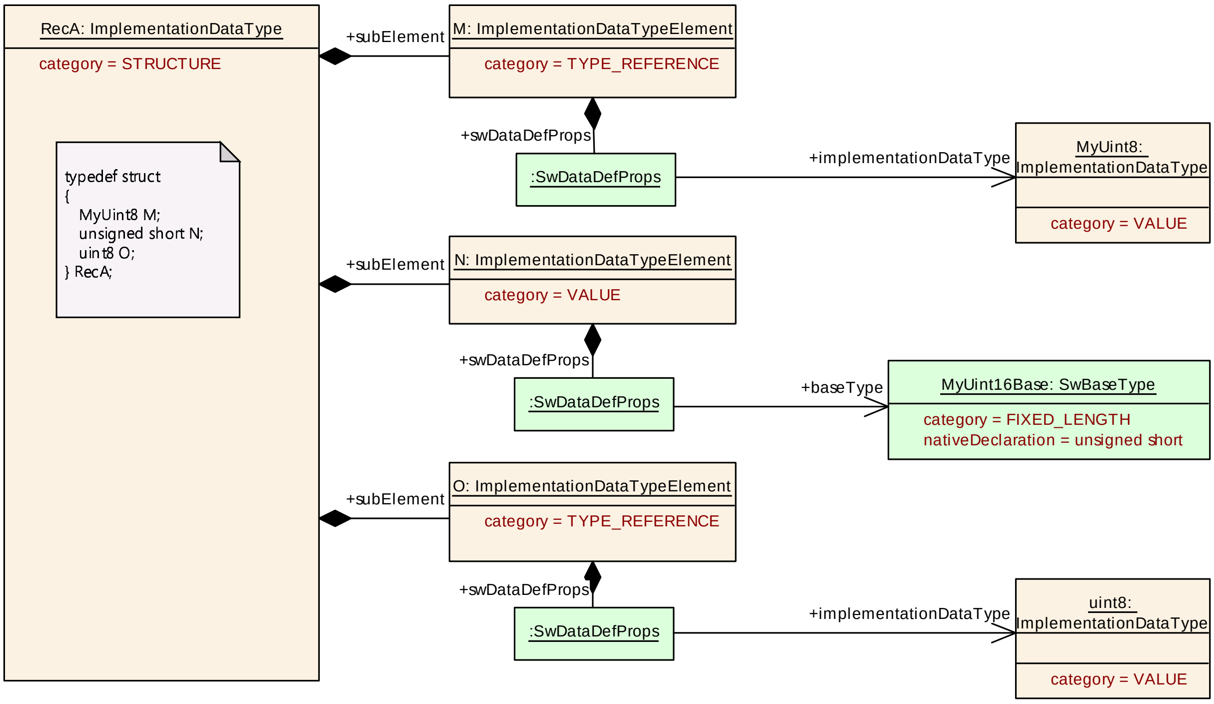

Figure 5.6: Example of a structure type

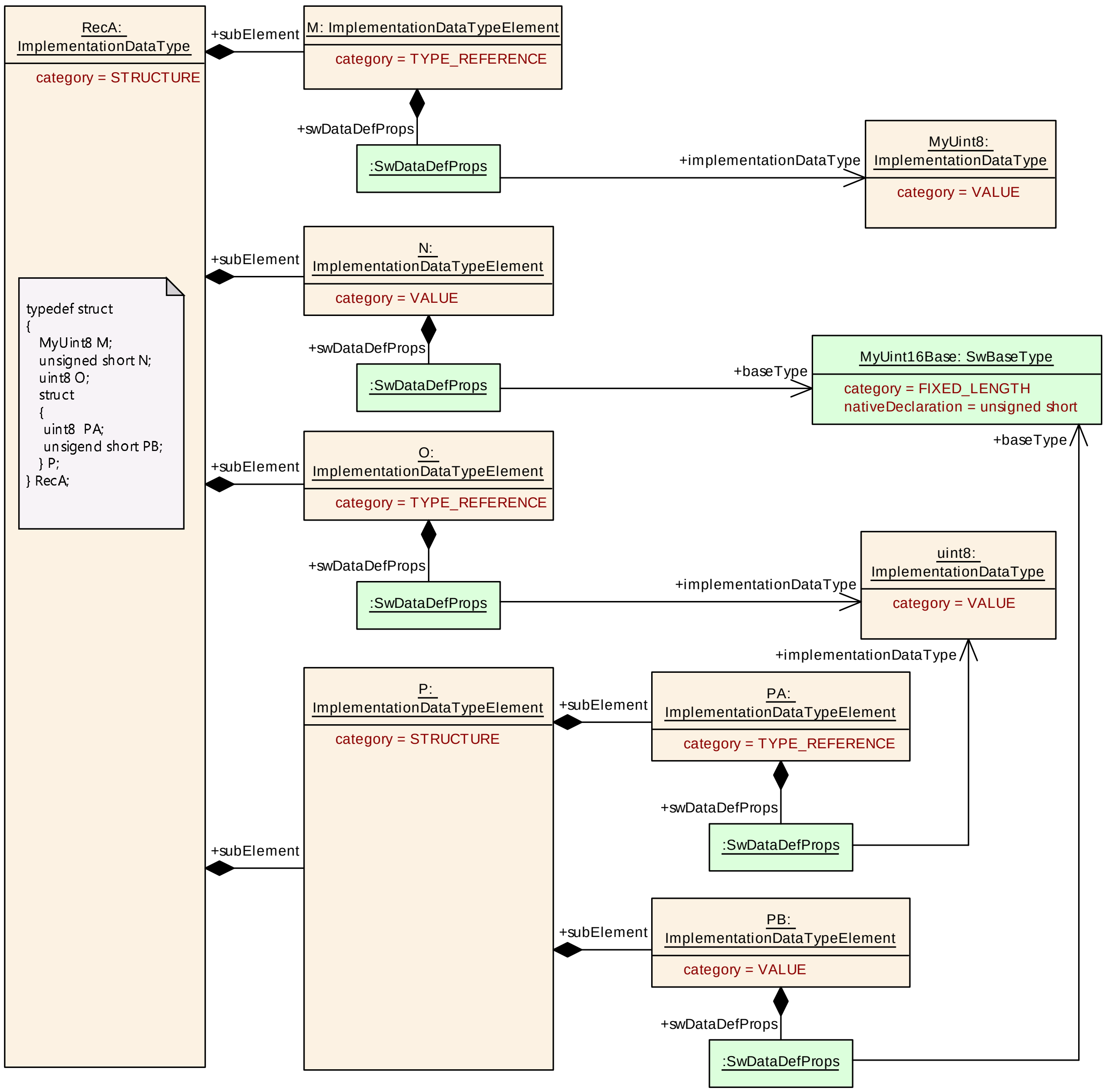

Figure 5.7: Example of a nested structure type

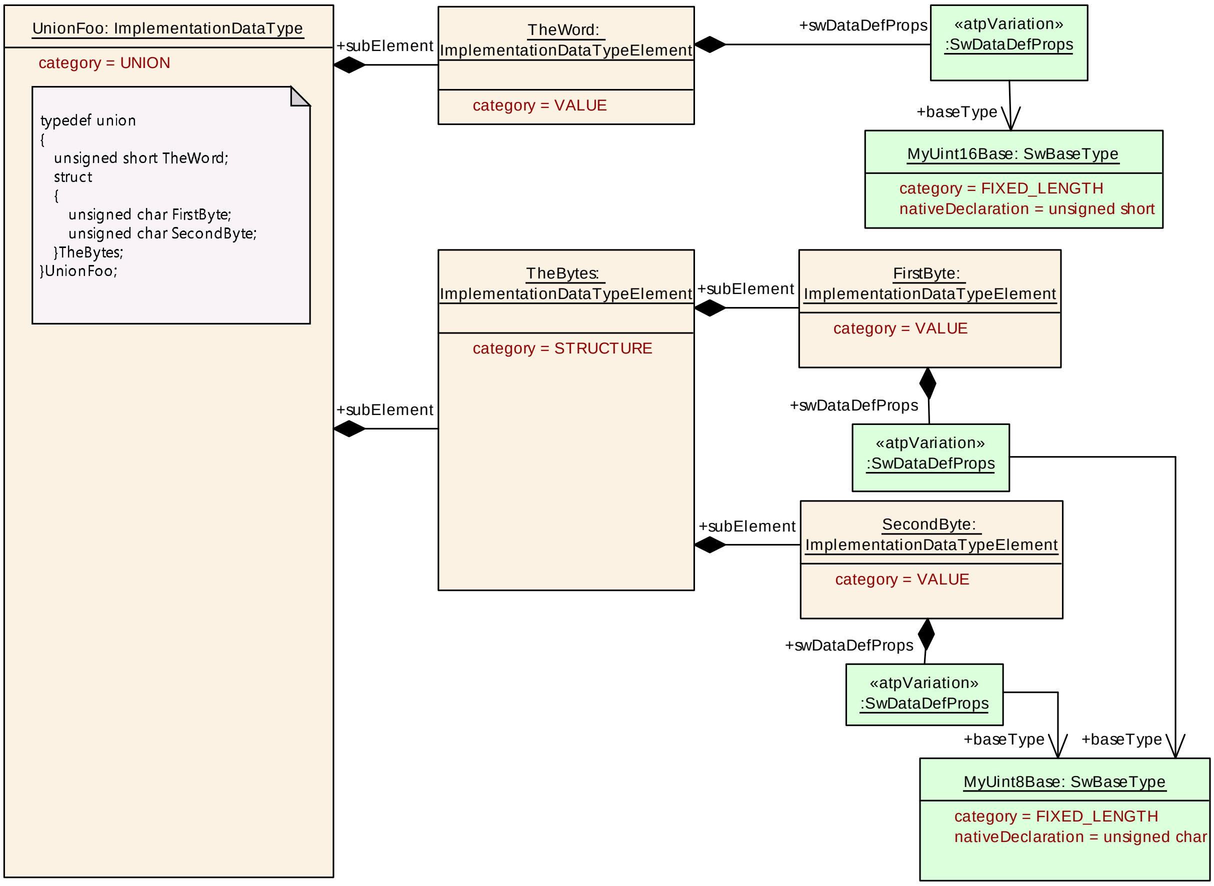

Figure 5.8: Example of a union type

[SWS_Rte_07107] ⌈ If more than one `Structure Implementation Data Type` or `Union Implementation Data Type` with equal `shortName` of the `ImplementationDataType` are defined, the *RTE Types Header File* shall include only once the corresponding type declaration according to [SWS_Rte_07114] or [SWS_Rte_07144]. ⌋*(SRS_Rte_00165)*

Note: This avoids the redeclaration of C types due to the multiple descriptions of equivalent `Structure Implementation Data Types` and `Union Implementation Data Types` in the ECU extract.

ANSI C does not allow a `struct` to have zero elements and therefore we require that a record include at least one element.

[SWS_Rte_CONSTR_09043] `Structure Implementation Data Types` needs at least one element ⌈ A structure shall include at least one element defined by a `ImplementationDataTypeElement`. ⌋*()*

A union data type describes a kind of structural overlay. Defining only one sub element of a `union` ist therefore not reasonable and indicates an error.

5.3.4.7 Implementation Data Type redefinition

[SWS_Rte_07109] ⌈ For each Redefinition Implementation Data Type which is typed by an ImplementationDataType, the *RTE Types Header File* shall include the corresponding type declaration as:

typedef <type> <name>;

where <type> is the Implementation Data Type symbol of the referred ImplementationDataType and <name> is the Implementation Data Type symbol of the Primitive Implementation Data Type. ⌋*(SRS_Rte_00055, SRS_Rte_00166)*

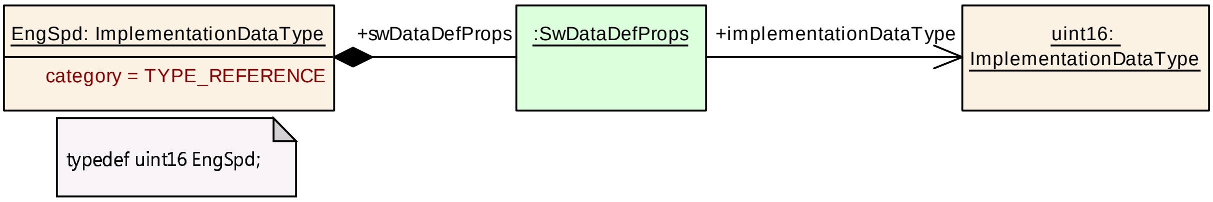

Figure 5.9: Example of an Implementation Data Type redefinition

[SWS_Rte_07167] ⌈ If more than one Redefinition Implementation Data Types with equal shortNames which are referring to compatible ImplementationDataTypes with identical shortNames are defined, the *RTE Types Header File* shall include only once the corresponding type declaration according to [SWS_Rte_07109]. ⌋*(SRS_Rte_00165)*

Note: This avoids the redeclaration of C types due to the multiple descriptions of equivalent Redefinition Implementation Data Type in the ECU extract.

5.3.4.8 Pointer Implementation Data Type

[SWS_Rte_07148] ⌈ For each Pointer Implementation Data Type, the *RTE Types Header File* shall include the corresponding type declaration as:

typedef <tqlA> <addtqlA> <type> * <tqlB> <addtqlB> <name>;

where <name> is the Implementation Data Type symbol of the Pointer Implementation Data Type. ⌋*(SRS_Rte_00055, SRS_Rte_00166)*

[SWS_Rte_07149] ⌈ <tqlA> (type qualifier A) of a Pointer Implementation Data Type ([SWS_Rte_07148]) or *Pointer element specification*s ([SWS_Rte_07146]) shall be set to const if the swImplPolicy of the swPointerTargetProps is set to const and shall be omitted for all other values of swImplPolicy. ⌋*(SRS_Rte_00055, SRS_Rte_00166)*

[SWS_Rte_07166] ⌈ <tqlB> (type qualifier B) of a Pointer Implementation Data Type ([SWS_Rte_07148]) or *Pointer element specification*s

([SWS_Rte_07146]) shall be set to `const` if the `swImplPolicy` of the `SwDataDefProps` of the `ImplementationDataType` respectively `ImplementationDataTypeElement` is set to `const` and shall be omitted for all other values of `swImplPolicy`. ⌋*(SRS_Rte_00055, SRS_Rte_00166)*

[SWS_Rte_07036] ⌈ `<addtqlA>` (additional type qualifier A) of a `Pointer Implementation Data Type` ([SWS_Rte_07148]) or *Pointer element specifications* ([SWS_Rte_07146]) shall be set to the content of the `additionalNativeTypeQualifier` attribute of the `swPointerTargetProps` if the attribute exists and shall be omitted if such `additionalNativeTypeQualifier` attribute dose not exist. ⌋*(SRS_Rte_00055, SRS_Rte_00166)*

[SWS_Rte_07037] ⌈ `<addtqlB>` (additional type qualifier B) of a `Pointer Implementation Data Type` ([SWS_Rte_07148]) or *Pointer element specifications* ([SWS_Rte_07146]) shall be set to the content of the `additionalNativeTypeQualifier` attribute of the `SwDataDefProps` of the `ImplementationDataType` respectively `ImplementationDataTypeElement` and shall be omitted if such `additionalNativeTypeQualifier` attribute dose not exist. ⌋*(SRS_Rte_00055, SRS_Rte_00166)*

[SWS_Rte_07162] ⌈ `<type>` shall be set to the `nativeDeclaration` attribute of the referred `BaseType` if the `targetCategory` of a `Pointer Implementation Data Type` ([SWS_Rte_07148]) or *Pointer element specifications* ([SWS_Rte_07146]) is set to `VALUE` ⌋*(SRS_Rte_00055, SRS_Rte_00166)*

[SWS_Rte_07163] ⌈ `<type>` shall be the `Implementation Data Type symbol` of the referred `ImplementationDataType` if the `targetCategory` of a `Pointer Implementation Data Type` ([SWS_Rte_07148]) or *Pointer element specifications* ([SWS_Rte_07146]) is set to `TYPE_REFERENCE` ⌋*(SRS_Rte_00055, SRS_Rte_00166)*

[SWS_Rte_07169] ⌈ If more than one `Pointer Implementation Data Types` with equal `shortName`s which are resulting in the same C pointer type declaration are defined, the *RTE Types Header File* shall include only once the corresponding type declaration according to [SWS_Rte_07148]. ⌋*(SRS_Rte_00165)*

Note: This avoids the redeclaration of C types due to the multiple descriptions of equivalent `Pointer Implementation Data Type` in the ECU extract.

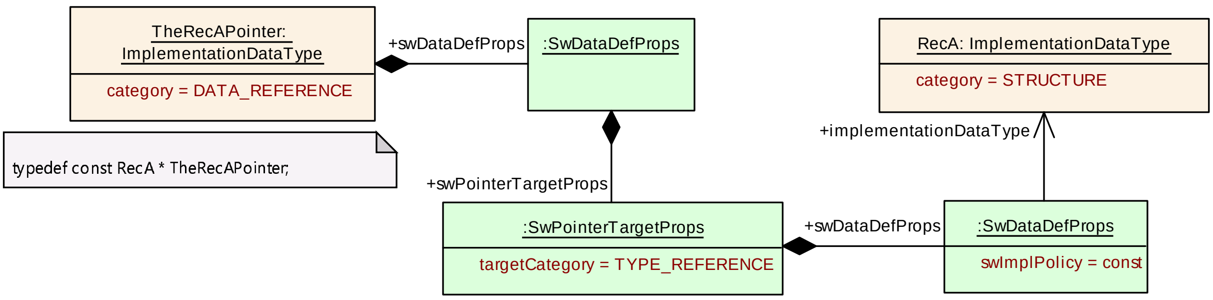

Figure 5.10: Example of a Pointer Implementation Data Type

5.3.4.9 ImplementationDataTypes with VariationPoints

[SWS_Rte_06539] ⌈

The RTE Generator shall wrap each code related to ImplementationDataType-Elements which are subject to variability in Structure Implementation Data Type and Union Implementation Data Type (see 4.24 if the variability shall be implemented.

```
#if (<condition>)

<elements>

#endif
```

where <condition> are the *condition value macro*(s) of the VariationPoints according table 4.24 and

<elements> is the code according invariant ImplementationDataType-Elements (see also [SWS_Rte_07115], [SWS_Rte_07116], [SWS_Rte_07117], [SWS_Rte_07118], [SWS_Rte_07119], [SWS_Rte_07145], [SWS_Rte_07146])

⌋*(SRS_Rte_00201)*

[SWS_Rte_06540] ⌈ The RTE Generator shall implement the <size x> of an Array Implementation Data Type for each arraySize which is subject to variability with the corresponding *attribute value macro* according table 4.24 if the variability shall be implemented. ⌋*(SRS_Rte_00201)*

5.3.4.10 Naming of data types

The Implementation Data Type symbol is defined as follows:

[SWS_Rte_06716] ⌈ The Implementation Data Type symbol shall be the shortName of the ImplementationDataType if no symbol attribute for this ImplementationDataTypeis defined. ⌋*(SRS_Rte_00167)*

Example 5.19

The Primitive Implementation Data Type in example 5.2 results in the type definition:

```
/* RTE Types Header File */
typedef unsigned char MyUint8;
```

[SWS_Rte_06717] ⌈ The Implementation Data Type symbol shall be the value of the SymbolProps.symbol attribute of the ImplementationDataType if the symbol attribute is defined. ⌋*(SRS_Rte_00167)*

[SWS_Rte_06718] ⌈ If the *RTE Types Header File* contains a generated C data type whose Implementation Data Type symbol differs from the ImplementationDataType shortName, the *Application Type Header File*s of each software component using the type shall contain a definition which redefines the Implementation Data Type symbol to the shortName of the ImplementationDataType. ⌋*(SRS_Rte_00167)*

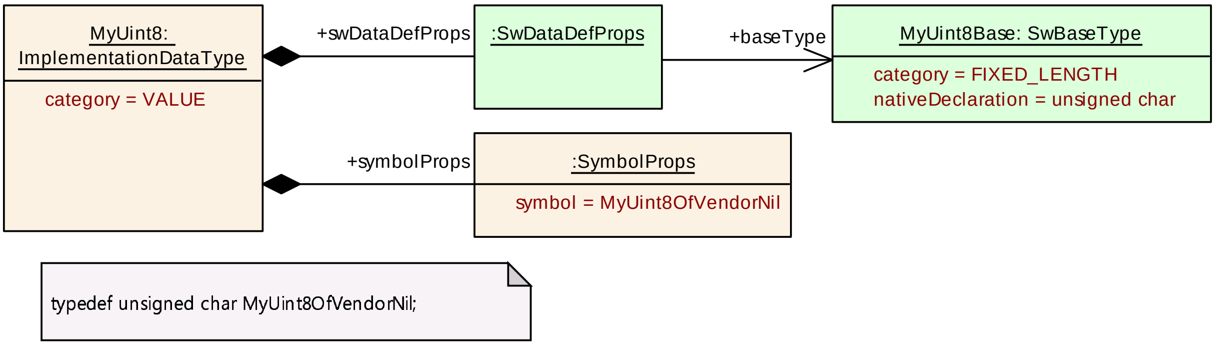

Figure 5.11: Primitive Implementation Data Type with SymbolProps

Example 5.20

If the input configuration contains a two ImplementationDataTypes with same name but different definition the SymbolProps can be used to avoid the name clash. The Primitive Implementation Data Type in example 5.11 results in following definition:

```
/* RTE Types Header File */
typedef unsigned char MyUint8OfVendorNil;
```

The *Application Types Header File* an using component contain the remapping to the original name:

```
/* Application Types Header File */
define MyUint8 MyUint8OfVendorNil;
```

[SWS_Rte_06719] ⌈ The RTE generator shall reject configurations where ImplementationDataTypes result in the same Implementation Data Type symbol but whose definition would not resulting in the same type declaration. ⌋*(SRS_Rte_00018)*

Note: This would result in compiler errors due to incompatible redefinition of C types.

[SWS_Rte_06724] ⌈ The RTE generator shall reject configurations where the same software component uses ImplementationDataTypes with equal shortNames which would result in the mapping to different Implementation Data Type symbols. ⌋*(SRS_Rte_00018)*

Note: This would result in compiler errors due to incompatible redefinition of the mapping from ImplementationDataType.shortName to Implementation Data Type symbol

5.3.4.11 C/C++

The following requirements apply to RTEs generated for C and C++.

[SWS_Rte_01161] ⌈ The name of the *RTE Types Header File* shall be `Rte_Type.h`. ⌋*(SRS_BSW_00300)*

[SWS_Rte_01162] ⌈ Within the *RTE Types Header File*, each data type shall be declared using `typedef`. ⌋*(SRS_Rte_00126)*

A `typedef` is used when declaring a new data type instead of a `#define` even though C only provides weak type checking since other static analysis tools can then be used to overlay strong type checking onto the C before it is compiled and thus detect type errors before the module is even compiled.

5.3.5 RTE Data Handle Types Header File

The *RTE Data Handle Types Header File* contains the Data Handle type declarations necessary for the component data structures (see Section 5.4.2). The *RTE Data Handle Types Header File* code is not allowed to create objects in memory.

[SWS_Rte_07920] ⌈ The RTE generator shall create the *RTE Data Handle Types Header File* including the type declarations of

`data element without status` ([SWS_Rte_01363], [SWS_Rte_01364], [SWS_Rte_02607]),

`data element with status` ([SWS_Rte_01365], [SWS_Rte_01366], [SWS_Rte_03734], [SWS_Rte_02666], [SWS_Rte_02589], [SWS_Rte_02590]),

and `data element with extended status` ([SWS_Rte_06817], [SWS_Rte_06818], [SWS_Rte_06819], [SWS_Rte_06820], [SWS_Rte_06821], [SWS_Rte_06822], [SWS_Rte_06823], [SWS_Rte_06824], [SWS_Rte_06825], [SWS_Rte_06826]). ⌋*()*

[SWS_Rte_07921] ⌈ The *RTE Data Handle Types Header File* shall not contain code that creates object in memory. ⌋*(SRS_BSW_00308)*

The *RTE Data Handle Types Header File* should be an output of the “RTE Contract” and “RTE Generation” phases.

5.3.5.1 File Name

[SWS_Rte_07922] ⌈ The name of the *RTE Data Handle Types Header File* shall be `Rte_DataHandleType.h`. ⌋*(SRS_BSW_00300)*

5.3.5.2 File Contents

The *RTE Data Handle Types Header File* contains the type declarations of data element without status and data element with status (see Section 5.4.2).

[SWS_Rte_07923] ⌈ The *RTE Data Handle Types Header File* shall include the following mechanism to prevent multiple inclusions.

```
#ifndef RTE_DATA_HANDLE_TYPE_H
#define RTE_DATA_HANDLE_TYPE_H

/* File contents */

#endif /* RTE_DATA_HANDLE_TYPE_H */
```

⌋*(SRS_Rte_00126)*

5.3.6 Application Types Header File

The *Application Types Header File* provides a component local name space for enumeration literals and range values. The *Application Types Header File* is not allowed to create objects in memory.

The *Application Types Header File* file should be identical output for “RTE Contract” and “RTE Generation” phases.

[SWS_Rte_07120] ⌈ The RTE generator shall create an *Application Types Header File* for each software-component type (excluding ParameterSwComponentTypes and NvBlockSwComponentTypes) defined in the input. ⌋*(SRS_Rte_00024, SRS_Rte_00140, SRS_BSW_00447)*

[SWS_Rte_07121] ⌈ The *Application Types Header File* shall not contain code that creates objects in memory. ⌋*(SRS_BSW_00308)*

5.3.6.1 File Name

[SWS_Rte_07122] ⌈ The name of the *Application Types Header File* shall be formed by prefixing the AUTOSAR software-component type name with Rte_[Byps_] and appending the result with _Type.h. [Byps_] is an optionnal infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00300, SRS_Rte_00167)*

Example 5.21

The following declaration in the input XML:

```
<APPLICATION-SW-COMPONENT-TYPE>
    <SHORT-NAME>Source</SHORT-NAME>
</APPLICATION-SW-COMPONENT-TYPE>
```

should result in the *Application Types Header File* `Rte_Source_Type.h` being generated when the component wrapper method for bypass support is disabled.

5.3.6.2 Scope

[SWS_Rte_07123] ⌈ The *Application Types Header File* for a component shall contain only information relevant for that component. ⌋*(SRS_Rte_00167, SRS_Rte_00017)*

[SWS_Rte_07124] ⌈ The *Application Types Header File* shall be valid for both C and C++ source. ⌋*(SRS_Rte_00126, SRS_Rte_00138)*

Requirement [SWS_Rte_07124] is met by ensuring that all definitions within the *Application Types Header File* are defined using C linkage if a C++ compiler is used.

[SWS_Rte_07125] ⌈ All definitions within in the *Application Types Header File* shall be preceded by the following fragment;

```
#ifdef __cplusplus
extern "C" {
#endif /* __cplusplus */
```

⌋*(SRS_Rte_00126, SRS_Rte_00138)*

[SWS_Rte_07126] ⌈ All definitions within the application types header file shall be suffixed by the following fragment;

```
#ifdef __cplusplus
} /* extern "C" */
#endif /* __cplusplus */
```

⌋*(SRS_Rte_00126, SRS_Rte_00138)*

[SWS_Rte_07678] ⌈ The *Application Types Header File* shall be protected against multiple inclusions:

```
#ifndef RTE_<SWC>_TYPE_H
#define RTE_<SWC>_TYPE_H
...
/*
 * Contents of file
 */
...
#endif /* !RTE_<SWC>_TYPE_H */
```

Where `<SWC>` is the AUTOSAR software-component type name.[3] ⌋*(SRS_Rte_00126)*

[3] No additional capitalization is applied to the names.

5.3.6.3 File Contents

In contrast to the *Application Header File* the *Application Types Header File* supports that multiple *Application Types Header File*'s are included in the same module. This is necessary if for instance a BSW module uses several AUTOSAR Services.

[SWS_Rte_07127] ⌈ The *Application Types Header File* shall include the *RTE Types Header File*. ⌋*(SRS_Rte_00087)*

The name of the *RTE Types Header File* is defined in Section 5.3.4.

5.3.6.4 RTE Modes

The *Application Types Header File* shall contain identifiers for the `ModeDeclaration`s and type definitions for `ModeDeclarationGroup`'s as defined in Chapter 5.5.4

5.3.6.5 Enumeration Data Types

The *Application Types Header File* shall contain the enumeration constants as defined in Chapter 5.5.5

5.3.6.6 Range Data Types

The *Application Types Header File* shall contain definitions of `Range` constants as defined in Chapter 5.5.6

5.3.6.7 Implementation Data Type symbols

The *Application Types Header File* may contain definitions to redefine the `Implementation Data Type symbol` to the `shortName` of the `ImplementationDataType` in order to provide the expected type name to the software component implementation. See section 5.3.4.10.

5.3.6.8 Macros for accessing Availability Information in Structs for optional Members

AUTOSAR supports that elements of Structure Implementation Data Types are defined as optional. In the meta model, the attribute `isOptional` of those `ImplementationDataTypeElement`s is set to True. These members may or may not exist at runtime.

Structure Implementation Data Types with optional members have to fulfill special structural requirements (see [2] for details). The availability information is stored in a special ImplementationDataTypeElement with the shortName availabilityBitfield which is a fixed-size array of uint8.

The software component needs support to evaluate and set the availability information for optional members.

[SWS_Rte_03617] DRAFT ⌈ A macro to access the availability information shall be generated for each ImplementationDataTypeElement of an ImplementationDataType where the attribute isOptional is set true. The macro shall be generated in the *Application Types Header File* of each software component using this type as follows:

```
#define Rte_IsAvailable_<i>_<e>(data) (((data)->availabilityBitfield[<
    pos/8>]) & (1<<(<pos mod 8>)) != 0)
```

Where

- <i> is the shortName of the ImplementationDataType
- <e> is the shortName of the ImplementationDataTypeElement
- <pos> is the position of the optional ImplementationDataTypeElement among all optional ImplementationDataTypeElements within the ImplementationDataType starting with pos = 0.

⌋*(SRS_Rte_00261)*

[SWS_Rte_03618] DRAFT ⌈ A macro to set the availability information shall be generated for each ImplementationDataTypeElement of an ImplementationDataType where the attribute isOptional is set true. The macro shall be generated in the *Application Types Header File* of each software component using this type as follows:

```
#define Rte_SetAvailable_<i>_<e>(data, available)              \
(                                                              \
 (data)->availabilityBitfield[<pos/8>] = ((available) ?        \
 (data)->availabilityBitfield[<pos/8>] | (1<<(<pos mod 8>)) :  \
 (data)->availabilityBitfield[<pos/8>] & ~(1<<(<pos mod 8>)) ) \
)
```

Where

- <i> is the shortName of the ImplementationDataType
- <e> is the shortName of the ImplementationDataTypeElement
- <pos> is the position of the optional ImplementationDataTypeElement among all optional ImplementationDataTypeElements within the ImplementationDataType starting with pos = 0.

⌋*(SRS_Rte_00261)*

Note: Non-optional `ImplementationDataTypeElements` do not count since they do not need a bit in the `availabilityBitfield`. So the bit position within the `availabilityBitfield` is determined by the order of the optional `ImplementationDataTypeElements`.

Examples:

- 1st optional ImplementationDataTypeElement (pos=0): (availabilityBitfield[0] & 0x01) != 0
- 8th optional ImplementationDataTypeElement (pos=7): (availabilityBitfield[0] & 0x08) != 0
- 9th optional ImplementationDataTypeElement (pos=8): (availabilityBitfield[1] & 0x01) != 0

5.3.7 VFB Tracing Header File

The VFB Tracing Header File defines the configured VFB Trace events.

[SWS_Rte_01319] ⌈ The VFB Tracing Header File shall be created by the RTE Generator during *RTE Generation Phase* or *Basic Software Scheduler Generation Phase* only. ⌋*(SRS_Rte_00045)*

The VFB Tracing Header file is included by the generated RTE and by the user in the module(s) that define the configured hook functions. The header file includes prototypes for the configured functions to ensure consistency between the invocation by the RTE and the definition by the user.

5.3.7.1 C/C++

The following requirements apply to RTEs generated for C and C++.

[SWS_Rte_01250] ⌈ The name of the VFB Tracing Header File shall be `Rte_Hook.h`. ⌋*(SRS_Rte_00045)*

5.3.7.2 File Contents

[SWS_Rte_01251] ⌈ The VFB Tracing header file shall include the *RTE Configuration Header File* (Section 5.3.8). ⌋*(SRS_Rte_00045)*

[SWS_Rte_01357] ⌈ The VFB Tracing header file shall include the *RTE Types Header file* (Section 5.3.4). ⌋*(SRS_Rte_00003, SRS_Rte_00004)*

[SWS_Rte_03607] ⌈ The VFB Tracing header file shall include `Os.h`. ⌋*(SRS_Rte_00005, SRS_Rte_00008)*

[SWS_Rte_01320] ⌈ The VFB Tracing header file shall contain the following code immediately after the include of the *RTE Configuration Header File*.

```
#ifndef RTE_VFB_TRACE
#define RTE_VFB_TRACE (FALSE)
#endif /* RTE_VFB_TRACE */
```

⌋*(SRS_Rte_00008, SRS_Rte_00005)*

Requirement [SWS_Rte_01320] enables VFB tracing to be globally enabled/disabled within the RTE Configuration Header File and ensures that it defaults to 'disabled'.

[SWS_Rte_01236] ⌈ For each trace event hook function defined in Section 5.11.5, the RTE generator shall define the following code sequence in the VFB Tracing header file:

```
#if defined(<trace event>) && (RTE_VFB_TRACE == FALSE)
#undef <trace event>
#endif
#if defined(<trace event>)
#undef <trace event>
extern void <trace event>(<params>);
#else
#define <trace event>(<params>) ((void)(0))
#endif /* <trace event> */
```

where `<trace event>` is the name of trace event hook function and `<params>` is the list of parameter names of the trace event hook function prototype as defined in Section 5.11.5. ⌋*(SRS_Rte_00008)*

The code fragment within [SWS_Rte_01236] benefits from a brief analysis of its structure. The first `#if` block ensures that an individually configured trace event in the RTE Configuration Header File [SWS_Rte_01324] is disabled if tracing is globally disabled [SWS_Rte_01323]. The second `#if` block emits the prototype for the hook function only if enabled in the RTE Configuration file and thus ensures that only configured trace events are prototyped. The `#undef` is required to ensure that the trace event function is invoked as a function by the generated RTE. The `#else` block comes into effect if the trace event is disabled, either individually [SWS_Rte_01325] or globally, and ensures that it has no run-time effect. Within the `#else` block the definition to `((void)(0))` enables the hook function to be used within the API Mapping in a comma-expression.

An individual trace event defined in Section 5.11.5 actually defines a class of hook functions. A member of the class is created for each RTE object created (e.g. for each API function, for each task) and therefore an individual trace event may give rise to many hook function definitions in the VFB Tracing header file.

Example 5.22

Consider an API call `Rte_Write_p1_a` for an instance of SW-C `c`. This will result in two trace event hook functions being created by the RTE generator:

```
Rte_WriteHook_c_p1_a_Start
```

and

```
Rte_WriteHook_c_p1_a_Return
```

5.3.8 RTE Configuration Header File

The *RTE Configuration Header File* contains user definitions that affect the behavior of the generated RTE.

The directory containing the required *RTE Configuration Header File* should be included in the compiler's include path when using the VFB tracing header file. The *RTE Configuration Header File* is generated by the RTE generator.

5.3.8.1 C/C++

The following requirements apply to RTEs generated for C and C++.

[SWS_Rte_01321] ⌈ The name of the *RTE Configuration Header File* shall be `Rte_Cfg.h`. ⌋*(SRS_Rte_00008, SRS_Rte_00045)*

5.3.8.2 File Contents

[SWS_Rte_07641] ⌈ The *RTE Configuration Header File* shall include the file `Std_Types.h`. ⌋*(SRS_Rte_00149, SRS_Rte_00150, SRS_BSW_00353)*

5.3.8.2.1 VFB tracing configuration

[SWS_Rte_01322] ⌈ The RTE generator shall globally enable VFB tracing when `RTE_VFB_TRACE` is defined in the *RTE Configuration Header File* as a vale which does not evaluate as `FALSE`. ⌋*(SRS_Rte_00008, SRS_Rte_00005)*

Note that, as observed in Section 5.11, VFB tracing enables debugging of software components, not the RTE itself.

[SWS_Rte_01323] ⌈ The RTE generator shall globally disable VFB tracing when `RTE_VFB_TRACE` is defined in the RTE configuration header file as `FALSE`. ⌋ *(SRS_Rte_00008, SRS_Rte_00005)*

As well as globally enabling or disabling VFB tracing, the RTE Configuration header file also configures those individual VFB tracing events that are *enabled*.

[SWS_Rte_01324] ⌈ The RTE generator shall enable VFB tracing for a given hook function when there is a `#define` in the *RTE Configuration Header File* for the hook function name and tracing is globally enabled. ⌋*(SRS_Rte_00008)*

Note that the particular value assigned by the #define, if any, is not significant.

[SWS_Rte_01325] ⌈ The RTE generator shall disable VFB tracing for a given hook function when there is no #define in the *RTE Configuration Header File* for the hook function name even if tracing is globally enabled. ⌋*(SRS_Rte_00008)*

Example 5.23

Consider the trace events from Example 5.22. The trace event for API start is enabled by the following definition;

```
#define Rte_WriteHook_i1_p1_a_Start
```

And the trace event for API termination is enabled by the following definition;

```
#define Rte_WriteHook_i1_p1_a_Return
```

5.3.8.2.2 Condition Value Macros

The *Condition Value Macros* are generated in the *PreBuild Data Set Contract Phase* and *PreBuild Data Set Generation Phase*. To do this a particular variant out of the pre-build variability of the input configuration has to be chosen by the means described in by [SWS_Rte_06500].

[SWS_Rte_06514] ⌈ If evaluated BooleanValueVariationPoints or ConditionByFormulas are resulting to true the <value> for *Condition Value Macros* shall be coded as TRUE and if these are resulting to false the value shall be coded as FALSE. ⌋*(SRS_Rte_00201, SRS_Rte_00203)*

[SWS_Rte_06513] ⌈ For each VariationPointProxy which bindingTime = PreCompileTime the *RTE Configuration Header File* shall contain a definition of a *Condition Value Macro* in the *RTE PreBuild Data Set Contract Phase* and *RTE PreBuild Data Set Generation Phase*

```
#define Rte_SysCon_<cts>_<name> <value><suffix>
```

Where <cts> is the component type symbol of the AtomicSwComponentType,

<name> is the shortName of the VariationPointProxy,

<value> is the evaluated value of the AttributeValueVariationPoint or ConditionByFormula

and <suffix> shall

- be set to "U" if the VariationPointProxy's implementationDataType boils down to a SwBaseType with baseTypeEncoding set to NONE and the baseTypeSize <= 16

- be set to "UL" if the VariationPointProxy's implementationDataType boils down to a SwBaseType with baseTypeEncoding set to NONE and the baseTypeSize > 16 and <= 32
- be set to "ULL" if the VariationPointProxy's implementationDataType boils down to a SwBaseType with baseTypeEncoding set to NONE and the baseTypeSize > 32
- be set to "L" if the VariationPointProxy's implementationDataType boils down to a SwBaseType with baseTypeEncoding set to 2C and the baseTypeSize > 16 and <= 32
- be set to "LL" if the VariationPointProxy's implementationDataType boils down to a SwBaseType with baseTypeEncoding set to 2C and the baseTypeSize > 32
- be set to "F" if the VariationPointProxy's implementationDataType boils down to a SwBaseType with baseTypeEncoding set to IEEE754 and the baseTypeSize <= 32
- be left empty if
  - the VariationPointProxy's implementationDataType boils down to a SwBaseType with baseTypeEncoding set to BOOLEAN

    or
  - a SwBaseType with baseTypeEncoding set to IEEE754 and the baseTypeSize > 32

    or
  - to a SwBaseType with baseTypeEncoding set to 2C and baseTypeSize <= 16

.

⌋*(SRS_Rte_00203, SRS_Rte_00167)*

This requirements makes the SwSystemconst values available to resolve the pre-build variability in the software components via the Preprocessor. This might be used to

- read the actual value of the value assigned to a SwSystemconst
- read the setting of an attribute (e.g. array size) dependent from a SwSystemconst
- check the existence of a conditional existent object, e.g. an code fragment implementing a particular functionality

Please note the Rte_SysCon macro holds the internal value of the evaluated AttributeValueVariationPoint or ConditionByFormula. Therefore the RTE does not perform value conversions for SwSystemconst using a compuMethod. See [TPS_GST_00262].

[SWS_Rte_03854] ⌈ For each VariationPointProxy which bindingTime = Pre-CompileTime the *RTE Application Header File* shall contain a definition

```
#define Rte_SysCon_<name> Rte_SysCon_<cts>_<name>
```

where <cts> is the component type symbol of the AtomicSwComponentType and

<name> is the shortName of the VariationPointProxy. ⌋*(SRS_Rte_00203, SRS_Rte_00167)*

[SWS_Rte_06515] ⌈ For each RTE API which is subject to variability and following the form *component port* or *entity port* in table 4.17 the *RTE Configuration Header File* shall contain one definition of a *Condition Value*

```
#define Rte_VPCon_<cts>_<re>[_<resl>]_<p>_<o>[_<psl>] <value>
```

where <cts> is the component type symbol of the AtomicSwComponentType,

<re> is the short name of the RunnableEntity,

<resl> is the shortLabel of the RunnableEntity's VariationPoint containing the reference element (e.g. a VariableAccess) to the PortInterface element,

<p> is the name of the PortPrototype,

<o> is the short name of the PortInterface element and

<psl> is the shortLabel of the PortPrototype's VariationPoint which is referred by the VariableAccess

If there is no VariationPoint at the RunnableEntity owning the VariableAccess the <resl> with leading underscore is omitted ([_<resl>]).

If there is no VariationPoint at the PortPrototype referred by the VariableAccess the <psl> with leading underscore is omitted ([_<psl>]).

<value> is the evaluated value of the ConditionByFormula of the VariationPoint vary the existence of the RTE API in table 4.17. ⌋*(SRS_Rte_00201, SRS_Rte_00167)*

[SWS_Rte_08789] ⌈ For each VariationPointProxy which bindingTime = Pre-CompileTime the *RTE Configuration Header File* shall contain a definition of a *Condition Value Macro* in the *RTE PreBuild Data Set Contract Phase* and *RTE PreBuild Data Set Generation Phase*

```
#define SchM_SysCon_<bsnp>[_<vi>_<ai>]_<ki>_<name> <value>
```

Where

<bsnp> is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the BSW module,

<ai> is the vendorApiInfix of the BSW module,

<ki> is the *kind infix* according table 4.28,

<name> is the short name of the element which is subject to variability in table 4.28 defining the *Basic Software Scheduler* API name infix and

<value> is the evaluated value of the AttributeValueVariationPoint or ConditionByFormula.

The sub part in squared brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋*(SRS_Rte_00229, SRS_BSW_00347)*

This requirement makes the SwSystemconst value available to resolve the pre-build variability in the BSW module via the Preprocessor. This might be used to

- read the actual value of the value assigned to a SwSystemconst
- read the setting of an attribute (e.g. array size) dependent from a SwSystemconst
- check the existence of a conditional existent object, e.g. a code fragment implementing a particular functionality

[SWS_Rte_06518] ⌈ For each RTE API which is subject to variability and following the form *component internal* in table 4.17 the *RTE Configuration Header File* shall contain one definition of a *Condition Value*

```
#define Rte_VPCon_<cts>_<ki>_<name>_<sl> <value>
```

where <cts> is the component type symbol of the AtomicSwComponentType,

<ki> is the *kind infix* according table 4.17,

<name> is the short name of the element which is subject to variability in table 4.17 and is defining the API name infix,

<sl> is the shortLabel of the elements' VariationPoint defining the API name infix.

<value> is the evaluated value of the ConditionByFormula of the VariationPoint defining the variant existence of the RTE API in table 4.17. ⌋*(SRS_Rte_00201, SRS_Rte_00167)*

[SWS_Rte_06519] ⌈ For each RTE API which is subject to variability and which variability shall be implemented and which is following the form *entity internal* in table 4.17 the *RTE Configuration Header File* shall contain one definition of a *Condition Value*

```
#define Rte_VPCon_<cts>_<re>[_<resl>]_<ki>_<name>_<sl> <value>
```

where <cts> is the component type symbol of the AtomicSwComponentType,

<re> is the short name of the RunnableEntity,

<resl> is the shortLabel of the RunnableEntity's VariationPoint containing the reference element (e.g. a VariableAccess) to the PortInterface element,

<ki> is the *kind infix* according table 4.17 and

<name> is the short name of the element which is subject to variability in table 4.17 and is defining the API name infix.

<sl> is the shortLabel of the elements' VariationPoint defining the API name infix.

If there is no VariationPoint at the RunnableEntity owning the reference element (e.g. a VariableAccess) to the PortInterface element the <resl> with leading underscore is omitted ([_<resl>]).

<value> is the evaluated value of the ConditionByFormula of the VariationPoint defining the variant existence of the RTE API in table 4.17. ⌋*(SRS_Rte_00201, SRS_Rte_00167)*

[SWS_Rte_06520] ⌈ For each PortPrototype which is subject to variability and which variability shall be implemented the *RTE Configuration Header File* shall contain one definition of a *Condition Value*

```
#define Rte_VPCon_<cts>_<p>_<psl> <value>
```

where <cts> is the component type symbol of the AtomicSwComponentType,

<p> is the short name of the PortPrototype and

<psl> is the shortLabel of the PortPrototype's VariationPoint and

<value> is the evaluated value of the ConditionByFormula of the VariationPoint defining the variant existence of the PortPrototype in table 4.17. ⌋*(SRS_Rte_00201, SRS_Rte_00167)*

[SWS_Rte_06530] ⌈ For each RunnableEntity which is subject to variability and which variability shall be implemented the *RTE Configuration Header File* shall contain one definition of a *Condition Value*

```
#define Rte_VPCon_<cts>_<re>_<resl> <value>
```

where <cts> is the component type symbol of the AtomicSwComponentType,

<re> is the short name of the RunnableEntity

<resl> is the shortLabel of the RunnableEntity's VariationPoint containing the reference element (e.g. a VariableAccess) to the PortInterface element,

<value> is the evaluated value of the ConditionByFormula of the VariationPoint defining the variant existence of the RunnableEntity in table 4.20. ⌋*(SRS_Rte_00201, SRS_Rte_00167)*

[SWS_Rte_06541] ⌈ For each arraySize which subject to variability the *RTE Configuration Header File* shall contain one definition of a *Attribute Value*

```
#define Rte_VPVal_<t>_<e 1>[_<e 2> ... _<e n>] <value>
```

where <t> is the shortName of the ImplementationDataType,

[<e x>] are the shortNames of the Array's ImplementationDataTypeElements with a leading underscore ordered from the root to the Array's ImplementationDataTypeElement with the arraySize being subject to variability and

<value> is the evaluated value of the AttributeValueVariationPoint of the arraySize ⌋*(SRS_Rte_00201, SRS_Rte_00167)*

[SWS_Rte_06542] ⌈ For each Array's ImplementationDataTypeElement which subject to variability the *RTE Configuration Header File* shall contain one definition of a *Condition Value*

```
#define Rte_VPCon_<t>_<e 1>[_<e 2> ... _<e n>] <value>
```

where <t> is the shortName of the ImplementationDataType,

[<e x>] are the shortNames of the Array's ImplementationDataTypeElements with a leading underscore ordered from the root to the Array's ImplementationDataTypeElement being subject to variability and

<value> is the evaluated value of the ConditionByFormula of the VariationPoint defining the conditional existence of the Array's ImplementationDataTypeElement ⌋*(SRS_Rte_00201, SRS_Rte_00167)*

[SWS_Rte_06551] ⌈ For each DataConstr referenced by a ApplicationPrimitiveDataType where the upperLimit is subject to PreCompileTime variability the *RTE Configuration Header File* shall contain one definition of a *Attribute Value Macro*

```
#define Rte_VPVal_<cts>_<prefix><t>_UpperLimit <upperValue><suffix>
```

where <cts> is the component type symbol of the AtomicSwComponentType,

<t> is the shortName of the ApplicationPrimitiveDataType,

<prefix> is the optional literalPrefix attribute defined by the IncludedDataTypeSet referring the AutosarDataType to which the DataConstr belongs,

<upperValue> are the upperLimit value of the dataConstr referenced by the ApplicationPrimitiveDataType onto which the corresponding CompuMethod has been applied (see [SWS_Rte_07038]). The value in the macro definitions shall always reflect the closed interval, regardless of the interval type specified by the DataConstr.

<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋*(SRS_Rte_00201, SRS_Rte_00167)*

[SWS_Rte_06552] ⌈ For each DataConstr referenced by a ApplicationPrimitiveDataType where the lowerLimit is subject to PreCompileTime variability the *RTE Configuration Header File* shall contain one definition of a *Attribute Value Macro*

```
#define Rte_VPVal_<cts>_<prefix><t>_LowerLimit <lowerValue><suffix>
```

where <cts> is the component type symbol of the AtomicSwComponentType,

<t> is the shortName of the ApplicationPrimitiveDataType,

<prefix> is the optional literalPrefix attribute defined by the IncludedDataTypeSet referring the AutosarDataType to which the DataConstr belongs,

<lowerValue> are the lowerLimit value of the dataConstr referenced by the ApplicationPrimitiveDataType onto which the corresponding CompuMethod has been applied (see [SWS_Rte_07038]). The value in the macro definitions shall always reflect the closed interval, regardless of the interval type specified by the DataConstr.

<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋ *(SRS_Rte_00201, SRS_Rte_00167)*

[SWS_Rte_06535] ⌈ For each *Basic Software Scheduler* API which is subject to variability and following the form *module internal* in table 4.28 the *RTE Configuration Header File* shall contain one definition of a *Condition Value*

```
#define SchM_VPCon_<bsnp>[_<vi>_<ai>]_<ki>_<name>_<sl> <value>
```

where here

<bsnp> is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the BSW module,

<ai> is the vendorApiInfix of the BSW module,

<ki> is the *kind infix* according table 4.28,

<name> is the short name of the element which is subject to variability in table 4.28 defining the *Basic Software Scheduler* API name infix and

<sl> is the shortLabel of the elements' VariationPoint defining the API name infix.

<value> is the evaluated value of the ConditionByFormula of the VariationPoint defining the variant existence of the *Basic Software Scheduler* API in table 4.28.

The sub part in squared brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋ *(SRS_Rte_00229, SRS_BSW_00347)*

[SWS_Rte_06536] ⌈ For each *Basic Software Scheduler* API which is subject to variability and which variability shall be implemented and which is following the form *module external* and *entity internal* in table 4.28 the *RTE Configuration Header File* shall contain one definition of a *Condition Value*

```
#define SchM_VPCon_<bsnp>[_<vi>_<ai>]_<ki>_
                    <entity>[_<esl>]_<name>[_<sl>] <value>
```

where here

`<bsnp>` is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

`<vi>` is the `vendorId` of the BSW module,

`<ai>` is the `vendorApiInfix` of the BSW module,

`<ki>` is the *kind infix* according table 4.28,

`entity` is the `shortName` of the `BswModuleEntity`

`<esl>` is the `shortLabel` of the `BswModuleEntity`'s `VariationPoint` containing the subject to variability,

`<name>` is the `shortName` of the element/referenced element which is subject to variability in table 4.28 defining the *Basic Software Scheduler* API name infix and

`<sl>` is the `shortLabel` of the elements's `VariationPoint` defining the API name infix.

`<value>` is the evaluated value of the `ConditionByFormula` of the `VariationPoint` defining the variant existence of the *Basic Software Scheduler* API in table 4.28.

The sub part in squared brackets `[_<vi>_<ai>]` is omitted if no `vendorApiInfix` is defined for the *Basic Software Module*. See [SWS_Rte_07528].

If there is no `VariationPoint` at the `BswModuleEntity` referring to the subject to variability in table 4.28 the `<esl>` with leading underscore is omitted (`[_<esl>]`).

If there is no `VariationPoint` at the elements defining the *Basic Software Scheduler* API name infix 4.28 the `<sl>` with leading underscore is omitted (`[_<sl>]`). ⌋ *(SRS_Rte_00229, SRS_BSW_00347)*

[SWS_Rte_06532] ⌈ For each `BswSchedulableEntity` which is subject to variability and which variability shall be implemented the *RTE Configuration Header File* shall contain one definition of a *Condition Value*

```
#define SchM_VPCon_<bsnp>[_<vi>_<ai>]_<entry>_<esl> <value>
```

where here

`<bsnp>` is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the BSW module,

<ai> is the vendorApiInfix of the BSW module,

<entry> is the shortName of the implemented (implementedEntry) entry point and

<esl> is the shortLabel of the BswModuleEntity's VariationPoint

<value> is the evaluated value of the ConditionByFormula of the VariationPoint defining the variant existence of the BswSchedulableEntity in table 4.30.

The sub part in squared brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋*(SRS_Rte_00229, SRS_BSW_00347)*

An example about the usage of condition value macros is shown in 5.6.

5.3.9 Generated RTE

Figure 5.1 defines the relationship between generated and standardized header files. It is **not** necessary to standardize the relationship between the C module, Rte.c, and the header files since when the RTE is generated the application header files are created anew along with the RTE. This means that details of which header files are included by Rte.c can be left as an implementation detail.

5.3.9.1 Header File Usage

[SWS_Rte_01257] ⌈ In compatibility mode, the Generated RTE module shall include Os.h. ⌋*(SRS_Rte_00145)*

[SWS_Rte_03794] ⌈ In compatibility mode, the generated RTE module shall include Com.h. ⌋*(SRS_Rte_00145)*

[SWS_Rte_01279] ⌈ In compatibility mode, the Generated RTE module shall include Rte.h. ⌋*(SRS_Rte_00145)*

[SWS_Rte_01326] ⌈ In compatibility mode, the Generated RTE module shall include the VFB Tracing header file. ⌋*(SRS_Rte_00045, SRS_Rte_00145)*

[SWS_Rte_03788] ⌈ Except for the declaration of entry points for components (see [SWS_Rte_07194]), the RTE shall map its memory objects with the file Rte_MemMap.h, using the AUTOSAR memory mapping mechanism (see [28]). ⌋*(SRS_Rte_00148)*

[SWS_Rte_07692] ⌈ The Generated RTE module shall perform Inter Module Checks to avoid integration of incompatible files. The imported included files shall be checked by preprocessing directives.

The following version numbers shall be verified:

- <MODULENAME>_AR_RELEASE_MAJOR_VERSION
- <MODULENAME>_AR_RELEASE_MINOR_VERSION

Where <MODULENAME> is the module short name of the other (external) modules which provide header files included by the Generated RTE module.

If the values are not identical to the expected values, an error shall be reported. ⌋ *(SRS_BSW_00004)*

Figure 5.12 provides an example of how the RTE header and generated header files could be used by a generated RTE.

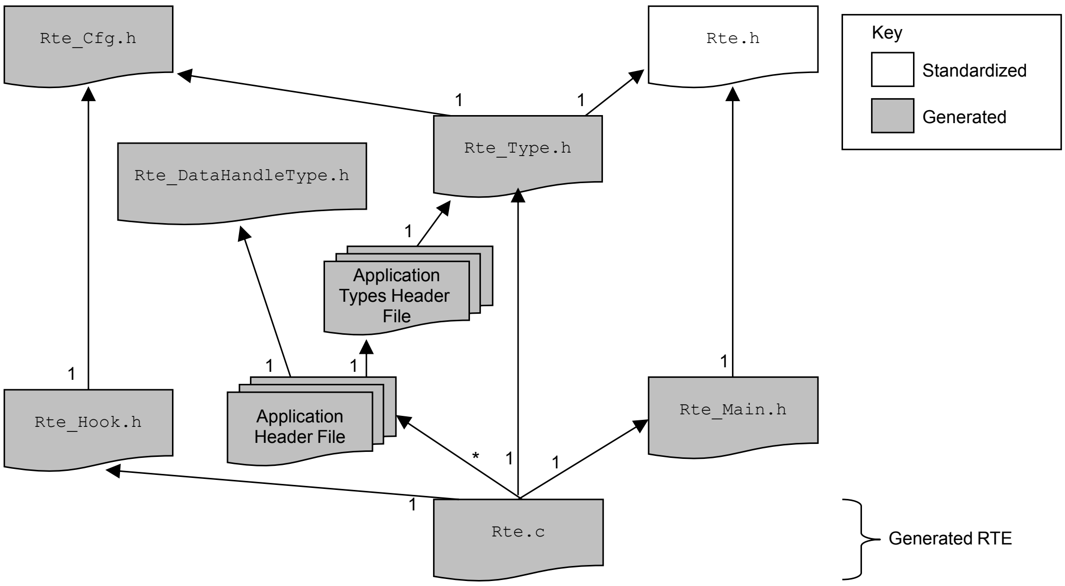

Figure 5.12: Example of header file use by the generated RTE.

In the example in Figure 5.12, the generated RTE C module requires access to the data structures created for each AUTOSAR software-component and therefore includes each application header file[4]. In the example, the generated RTE also includes the RTE header file and the lifecycle header file in order to obtain access to RTE and lifecycle related definitions.

Note: Inclusion of *Application Header File*s of different software components into the RTE C module needs support in the *Application Header File*s in order to avoid that some local definitions of software components are producing name clashes. If the RTE C module does not include any *Application Header File*, some type definitions (e.g. component data structure) might have to be generated twice.

[4]The requirement that a software module include at most one application header file applies only to modules that actually implement a software-component and therefore does not apply to the generated RTE.

5.3.9.2 C/C++

The following requirements apply to RTEs generated for C and C++.

Note: The `<PartitionName>`s referred to in requirements [SWS_Rte_02712], [SWS_Rte_02713] and [SWS_Rte_02740] are implementation-specific identifiers for the modules. They need not be the same as the `CoreId` identifiers configured for the multi core OS. Refer to section 4.3.4 for a discussion of the allocation of ECU execution logic to partitions and the allocation of partitions to cores.

[SWS_Rte_01169] ⌈ The name of the C module containing the generated RTE code that is shared by all cores of an ECU shall be `Rte.c`. ⌋*(SRS_BSW_00300, SRS_Rte_00126)*

[SWS_Rte_02711] ⌈ On a multi core ECU, RTE shall only use global and static variables in the `Rte.c` module, if it is used in a single image system that supports shared memory. In this case, RTE shall guarantee consistency of this memory, e.g. by using OS mechanisms. ⌋*()*

[SWS_Rte_02712] ⌈ On a multi partition ECU, there shall be additional code and header files named `Rte_Partition_<PartitionName>` for the core specific code parts of RTE where `<PartitionName>` is the `shortName` of the container `EcucPartition`. ⌋*()*

[SWS_Rte_02713] ⌈ There shall not be symbol redefinitions between different `Rte_Partition_<PartitionName>` files. ⌋*()*

These requirements makes sure, that all Rte modules can be linked in one image. On a multi core ECU, the RTE may be linked in one image or distributed over separate images, one per core.

An RTE that includes configured code from an object-code or source-code library may use additional modules. Further on due to the encapsulation of a component local name space [SRS_Rte_00167], it might be required to encapsulate part of the generated RTE code in component specific files as well to avoid name clashes in the RTE's implementation.

[SWS_Rte_07140] ⌈ The RTE generator is allowed to partition the generated RTE module in several files additionally to `Rte.c` and `Rte_Partition_<PartitionName>`. ⌋*(SRS_Rte_00167)*

5.3.9.3 File Contents

By its very nature the contents of the generated RTE is largely vendor specific. It is therefore only possible to define those common aspects that are visible to the "outside world" such as the names of generated APIs and the definition of component data structures that apply any operating mode.

5.3.9.3.1 Component Data Structures

The *Component Data Structure* (Section 5.4.2) is a per-component data type used to define instance specific information required by the generated RTE.

[SWS_Rte_03711] ⌈The generated RTE shall contain an instance of the relevant Component Data Structure for each software-component instance on the ECU for which the RTE is generated. ⌋*(SRS_Rte_00011)*

[SWS_Rte_03712] ⌈ The name of a Component Data Structure instantiated by the RTE generator shall be `Rte_Instance_<name>` where `<name>` is an automatically generated name, created in some manner such that all instance data structure names are unique. The name of a Component Data Structure instantiated by the RTE generator shall be `Rte_Instance_<name>` where `<name>` is an automatically generated name, created in some manner such that all instance data structure names are unique. ⌋*(SRS_BSW_00307)*

The software component instance name referred to in [SWS_Rte_03712] is never made visible to the users of the generated RTE. There is therefore no need to specify the precise form that the unique name takes. The `Rte_Instance_` prefix is mandated in order to ensure that no name clashes occur and also to ensure that the structures are readily identifiable in map files, debuggers, etc.

The `Rte_Instance_` prefix does NOT mean that the Component Data Structure instance is identical to the instance handle type `Rte_Instance` described in section 5.5.2; the prefix is mandated in order to ensure that no name clashes occur and also to ensure that the structures are readily identifiable in map files, debuggers, etc.

5.3.9.3.2 Generated API

[SWS_Rte_01266] ⌈ The RTE module shall define the generated functions that will be invoked when an AUTOSAR software-component makes an RTE API call. ⌋ *(SRS_Rte_00051)*

The semantics of the generated functions are not defined (since these will obviously vary depending on the RTE API call that it is implementing) nor are the implementation details (which are vendor specific). However, the names of the generated functions defined in Section 5.2.6.1.

The signature of a generated function is the same as the signature of the relevant RTE API call (see Section 5.6) with the exception that the instance handle can be omitted since the generated function is applicable to a specific software-component instance.

5.3.9.3.3 Callbacks

In addition to the generated functions for the RTE API, the RTE module includes callbacks invoked by COM when signal events (receptions, transmission acknowledgement, etc.) occur.

[SWS_Rte_01264] ⌈ The RTE module shall define COM callbacks for relevant signals. ⌋*(SRS_Rte_00019)*

The required callbacks are defined in Section 5.9.

[SWS_Rte_03795] ⌈ The RTE generator shall generate a separate header file containing the prototypes of callback functions. ⌋*(SRS_Rte_00019)*

[SWS_Rte_03796] ⌈ The name of the header file containing the callback prototypes shall be `Rte_Cbk.h` in a C/C++ environment. ⌋*(SRS_Rte_00019)*

[SWS_Rte_03796] refers to the callbacks defined in section 5.9.

5.3.9.3.4 Task bodies

The RTE module define task bodies for tasks created by the RTE generator only in compatibility mode.

[SWS_Rte_01277] ⌈ In compatibility mode [SWS_Rte_01257], the RTE module shall define all task bodies created by the RTE generator. ⌋*(SRS_Rte_00145)*

Note that in vendor mode it is assumed that greater knowledge of the OS is available and therefore the above requirement does *not* apply so that specific optimizations, such as creating each task in a separate module, can be applied.

5.3.9.3.5 Lifecycle API

[SWS_Rte_01197] ⌈ The RTE module shall define the RTE lifecycle API. ⌋ *(SRS_Rte_00051)*

The RTE lifecycle API is defined in Section 5.8.

5.3.9.4 Reentrancy

All code invoked by generated RTE code that can be subject to concurrent execution must be reentrant. This requirement for reentrancy can be overridden if the generated code is not subject to concurrent execution, for example, if protected by a data consistency mechanism to ensure that access to critical regions is call serialized.

5.3.10 RTE Post Build Variant Sets

[SWS_Rte_06620] ⌈ The RTE generator shall generate in the *Rte_PBcfg.h* file the `SchM_ConfigType` type declaration of the predefined post build variants data structure. This header file must be used by other RTE modules to resolve their runtime variabilities. ⌋*(SRS_Rte_00201)*

[SWS_Rte_06638] ⌈ The RTE generator must generate a *Rte_PBcfg.c* file containing the declarations and initializations of one or more RTE post build variants. Only one of these variants can be active at runtime. ⌋*(SRS_Rte_00201, SRS_BSW_00346)*

Within an RTE with post build variants, one active `RtePostBuildVariantConfiguration` will exist. It is a pointer to this structure that shall be passed to `SchM_Init`. Also note that the container `PredefinedVariant` is only a Meta Model construct to allow the designer to create a validated collection of values assigned to a criterion. It is up to the implementer of the RTE generator to optimize variant configurations either for size and/or performance by using different levels of indirection to the `PostBuildVariantCriterionValue`s. For the least amount of indirection for example one can have the criterion values at the level of the `Sch_ConfigType`. If you use post build loadable then you may want to reduce memory storage by reusing variant sets if they remain unchanged across two or more predefined variants.

The following subsections provide examples for the `SchM_ConfigType` declaration and instantiation only for demonstration purposes. No requirement what so ever is implied.

5.3.10.1 Example 1: File Contents Rte_PBcfg.h

An example of a flat data structure to represent the criterion values defined in the *Rte_PBcfg.h* file containing the`SchM_ConfigType` type which can contain the list of unique `PostBuildVariantCriterion` members. This approach immediately enforces that only one single criterion assignment can exist. The member names can, for example, follow the template defined below where `<sn>` is the `PostBuildVariantCriterion shortName`.

```
struct SchM_ConfigType {
  /* The PostBuildVariantCriterion shortname */
    int VarCri_<sn>;
    .
    .
    .
};
```

5.3.10.2 Example 2: File Contents Rte_PBcfg.h

An example showing an additional level of indirection and as such allows for reuse of variant sets to optimize memory storage acorss for example several predefined variants is shown below. The RTE generator in this case can reuse some PostBuildVariantCriterionValueSets to reduce the memory resource consumption of an ECU. The RTE generator can declare in the *Rte_PBcfg.h* file a structure type for each **distinct unique** collection of PostBuildVariantCriterionValueSets containing the PostBuildVariantCriterions as members. This implies that if two PredefinedVariants are defined each referring to a named PostBuildVariantCriterionValueSet and the list of PostBuildVariantCriterions in each of these PostBuildVariantCriterionValueSets is identical that only one type is defined for these two named PostBuildVariantCriterionValueSets. The name of the type can, for example, follow the pattern below where the <id> is a unique identifier for that type (e.g. a counter).

```
struct Rte_VarSet_<id>_t {
  /* The PostBuildVariantCriterion shortname */
    int VarCri_<sn>;
    .
    .
    .
};
```

Now the SchM_ConfigType type can be declared with pointers to these variant sets. The member names of this struct can, for example, follow the template below where <id> is a unique identifier.

```
struct SchM_ConfigType {
  /* The PostBuildVariantCriterion shortname */
    Rte_VarSet_<id>_t* VarSet_<id>_Ptr;
    .
    .
    .
};
```

5.3.10.3 Examples: File Contents Rte_PBcfg.c

In correlation with example 1 of the header file the RTE generator can declare and optionally initialize a default variant configuration named Rte_VarCfg in the *Rte_PBcfg.c* file of the SchM_ConfigType type.

For example (the initializers are the criterion values):

```
const struct SchM_ConfigType Rte_VarCfg = {1,2,3,4,5};
```

And likewise for the example 2 header file the RTE generator can declare and initialize in the *Rte_PBcfg.c* file all possible PostBuildVariantCriterionValueSets and the RtePostBuildVariantConfiguration using references to these variant sets.

For example:

```
const struct Rte_VarSet_1_t Rte_VarSet_1a = {1,2,3};
const struct Rte_VarSet_1_t Rte_VarSet_1b = {1,4,1};
const struct Rte_VarSet_2_t Rte_VarSet_2 = {2,5,7,3,2};
.
.
.
```

```
const struct SchM_ConfigType Rte_VarCfg_1 =
    {&Rte_VarSet_1a,&Rte_VarSet_2};
const struct SchM_ConfigType Rte_VarCfg_2 =
    {&Rte_VarSet_1b,&Rte_VarSet_2};
.
.
.
```

When SchM_Init is called, a pointer to the active SchM_ConfigType will be passed along which shall be assigned to the named Rte_VarCfgPtr which is of type SchM_ConfigType*. This pointer shall be used to determine the values for actual used PostBuildVariantCriterions and for variant validation when the DET is enabled.

Example 1 pseudo code evaluating the criterions

```
switch(Rte_VarCfg->VarCri_1)
{
    case 1:
        /* DO SOMETHING */
        break;
    case 2:
        /* DO SOMETHING ELSE */
}
```

Example 2 pseudo code evaluating the criterions

```
switch(Rte_VarCfgPtr->VarSet_1_Ptr->VarCri_1)
{
    case 1:
        /* DO SOMETHING */
        break;
    case 2:
        /* DO SOMETHING ELSE */
}
```

Another type of optimization strategy (besides flattening) that can be applied is double buffering for frequently used variant criterion values. The additional buffer can then be used in the conditions to optimize the performance of the RTE, e.g.

```
BufferedVarCri_1 = Rte_VarCfgPtr->VarSet_1->VarCri_1;
```

.

5.4 RTE Data Structures

Object-code software components are compiled against an application header file created during the “RTE Contract” phase but are linked against an RTE (and application header file) created during the “RTE Generation” phase. When generated in compatibility mode, an RTE has to work for object-code components compiled against an application header file created in compatibility mode, even if the application header file was created by a different RTE generator. It is thus necessary to define the data structures and naming conventions for the compatibility mode to ensure that the object-code is compatible with the generated RTE. An RTE generated in vendor mode only has to work for those object-code components that were compiled against application header files created in vendor mode by a compatible RTE generator (which in general would mean an RTE generator supplied by the same vendor).

The use of standardized data structures imposes tight constraints on the RTE implementation and therefore restricts the freedom of RTE vendors to optimize the solution of object-code components but has the advantage that RTE generators from different vendors can be used to compile an object-code software-component and to generate the RTE. No such restrictions apply for the vendor mode. If an RTE generator operating in vendor mode is used for an object-code component in both phases, vendor-specific optimizations can be used.

Note that with the exception of data structures required for support object-code software components in compatibility mode, the data structures used for “RTE Generation” phase are not defined. This permits vendor specific API mappings and data structures to be used for a generated RTE without loss of portability.

The following definitions only apply to RTE generators operating in compatibility mode – in this mode the instance handle and the component data structure have to be defined even for those (object-code) software components for which multiple instantiation is forbidden to ensure compatibility.

5.4.1 Instance Handle

The RTE is required to support object-code components as well as multiple instances of the same AUTOSAR software-component mapped to an ECU [SRS_Rte_00011]. To minimise memory overhead all instances of a component on an ECU share code [SRS_Rte_00012] and therefore both the RTE and the component instances require a means to distinguish different instances.

Support for both object-code components and multiple instances requires a level of indirection so that the correct generated RTE custom function is invoked in response to a component action. The indirection is supplied by the instance handle in combination with the API mapping defined in Section 5.2.6.

[SWS_Rte_01012] ⌈ The component instance handle shall identify particular instances of a component. ⌋ *(SRS_BSW_00312, SRS_Rte_00011)*

The instance handle is passed to each runnable entity in a component when it is activated by the RTE as the first parameter of the function implementing the runnable entity [SWS_Rte_01016]. The instance handle is then passed back by the runnable entity to the RTE, as the first parameter of each direct RTE API call, so that the RTE can identify the correct component instance making the call. This scheme permits multiple instances of a component on the same ECU to share code.

The instance handle indirection permits the name of the RTE API call that is used within the component to be unique within the scope of a component as well as independent of the component's instance name. It thus enables object-code AUTOSAR software-components to be compiled before the final "RTE Generation" phase when the instance name is fixed.

[SWS_Rte_01013] ⌈ For the RTE C/C++ API, any call that can operate on different instances of a component that supports multiple instantiation `supportsMultipleInstantiation` shall have an instance handle as the first formal parameter. ⌋ *(SRS_Rte_00011)*

[SWS_Rte_03806] ⌈ If a component does not support multiple instantiation, the instance handle parameter shall be omitted in the RTE C/C++ API and in the signature of the RTE Hook functions. ⌋*(SRS_Rte_00011)*

If the component does not support multiple instantiation, the instance handle is not passed to the API calls and runnable entities as parameters. In order to support access to the component data structure the name of the CDS is specified.

[SWS_Rte_03793] ⌈ If a software component does not support multiple instantiation, the name of the component data instance shall be `Rte_Inst_<cts>`, where `<cts>` is the `component type symbol` of the `AtomicSwComponentType`. ⌋ *(SRS_Rte_00011)*

The data type of the instance handle is defined in Section 5.5.2.

Example 5.24

```
// --------------------------------------
// Application header file
// --------------------------------------

// ComponentDataStructure declaration
// [SWS_Rte_02310],[SWS_Rte_03733]
struct Rte_CDS_c
{
    Rte_DE_uint8* re1_p_a;
    Rte_DES_uint8* re2_p_a;
    ...
};

// [SWS_Rte_02311]
typedef struct Rte_CDS_c Rte_CDS_c;

// Instance handle type
// [SWS_Rte_01007], [SWS_Rte_01148],[SWS_Rte_01150],[SWS_Rte_06810]
```

```
typedef CONSTP2CONST(Rte_CDS_c, AUTOMATIC, RTE_CONST) Rte_Instance;

// Instance handle declaration for swc without multiple instantiation
// [SWS_Rte_03793]
#define RTE_START_SEC_CONST_UNSPECIFIED
#include "Rte_MemMap.h"
extern CONSTP2CONST(Rte_CDS_c, RTE_CONST, RTE_CONST) Rte_Inst_c;
#define RTE_STOP_SEC_CONST_UNSPECIFIED
#include "Rte_MemMap.h"

//Api
#define Rte_IWrite_re1_p_a(v) ((Rte_Inst_c)->re1_p_a->value = (v))
#define Rte_IRead_re2_p_a() ((Rte_Inst_c)->re2_p_a->value)
#define Rte_IStatus_re2_p_a() ((Rte_Inst_c)->re2_p_a->status)

// -----------------------------------
// Rte.c file
// -----------------------------------

// ComponentDataStructure definition
// [SWS_Rte_03711],[SWS_Rte_03712],[SWS_Rte_03715]
const Rte_CDS_c Rte_Instance_c1 =
{
    ...
};

// Instance handle definition for swc without multiple instantiation
// [SWS_Rte_03793]
#define RTE_START_SEC_CONST_UNSPECIFIED
#include "Rte_MemMap.h"
CONSTP2CONST(Rte_CDS_c, RTE_CONST, RTE_CONST) Rte_Inst_c = &
   Rte_Instance_c1;
#define RTE_STOP_SEC_CONST_UNSPECIFIED
#include "Rte_MemMap.h"
```

5.4.2 Component Data Structure

Different component instances share many common features - not least of which is support for shared code. However, each instance is required to invoke different RTE API functions and therefore the instance handle is used to access the component data structure that defines all instance specific data.

It is necessary to define the component data structure to ensure compatibility between the two RTE phases when operating in compatibility mode – for example, a “clever” compiler and linker may encode type information into a pointer type to ensure type-safety. In addition, the structure definition cannot be empty since this is an error in ANSI C.

[SWS_Rte_02310] ⌈ The *Application Header* File shall include a structure declaration for the component data structure as follows:

```c
struct Rte_[Byps_]CDS_<cts> { <component data sections> };
```

where `<cts>` is the `component type symbol` of the `AtomicSwComponentType`. `[Byps_]` is an optional infix used when component wrapper method for bypass support is enabled for the related software componenttype (See chapter 4.9.2). ⌋ *(SRS_BSW_00305, SRS_Rte_00011, SRS_Rte_00167)*

[SWS_Rte_02311] ⌈ The *Application Header* File shall include a type declaration for the component data structure type as follows:

```c
typedef struct Rte_[Byps_]CDS_<cts> Rte_[Byps_]CDS_<cts>;
```

where `<cts>` is the `component type symbol` of the `AtomicSwComponentType`.`[Byps_]` is an optional infix used when component wrapper method for bypass support is enabled for the related software componenttype (See chapter 4.9.2). ⌋ *(SRS_BSW_00305, SRS_Rte_00011, SRS_Rte_00167)*

The members of the component data structure include function pointers. It is important that such members are not subject to run-time modification and therefore the component data structure is required to be placed in read-only memory.

[SWS_Rte_03715] ⌈ All instances of the component data structure shall be defined as “const” (i.e. placed in read-only memory). ⌋ *(SRS_BSW_00007)*

The elements of the component data structure are sorted into sections, each of which defines a logically related section. The sections defined within the component data structure are:

- **[SWS_Rte_03718]** ⌈ Data Handles section. ⌋ *(SRS_Rte_00011, SRS_Rte_00051)*
- **[SWS_Rte_03719]** ⌈ Per-instance Memory Handles section. ⌋ *(SRS_Rte_00011, SRS_Rte_00051)*
- **[SWS_Rte_01349]** ⌈ Inter-runnable Variable Handles section. ⌋ *(SRS_Rte_00011, SRS_Rte_00051)*
- **[SWS_Rte_03720]** ⌈ Calibration Parameter Handles section. ⌋ *(SRS_Rte_00011, SRS_Rte_00051)*
- **[SWS_Rte_03721]** ⌈ Exclusive-area API section. ⌋ *(SRS_Rte_00011, SRS_Rte_00051)*
- **[SWS_Rte_03716]** ⌈ Port API section. ⌋ *(SRS_Rte_00011, SRS_Rte_00051)*
- **[SWS_Rte_03717]** ⌈ Inter Runnable Variable API section. ⌋ *(SRS_Rte_00011, SRS_Rte_00051)*
- **[SWS_Rte_07225]** ⌈ Inter Runnable Triggering API section. ⌋ *(SRS_Rte_00011, SRS_Rte_00051)*
- **[SWS_Rte_07837]** ⌈ Instance Id section. ⌋ *(SRS_Rte_00011, SRS_Rte_00051, SRS_Rte_00244)*

- **[SWS_Rte_08091]** ⌈ RAM Block Data Updated Handles section. ⌋ *(SRS_Rte_00011, SRS_Rte_00051, SRS_Rte_00245)*
- **[SWS_Rte_03722]** ⌈ Vendor specific section. ⌋ *(SRS_Rte_00011)*

The order of elements within each section of the component data structure is defined as follows;

[SWS_Rte_03723] ⌈ Section entries shall be sorted alphabetically (ASCII / ISO 8859-1 code in ascending order) unless stated otherwise. ⌋ *(SRS_Rte_00051)*

The sorting of entries is applied to each section in turn.

Note that there is *no* prefix associated with the name of each entry within a section; the component data structure as a whole has the prefix and therefore there is no need for each member to have the same prefix.

ANSI C does not permit empty structure definitions yet an instance handle is required for the RTE to function. Therefore if there are no API calls then a single dummy entry is defined for the RTE.

[SWS_Rte_03724] ⌈ If all sections of the Component Data Structure are empty the Component Data Structure shall contain a `uint8` with name `Rte_Dummy`. ⌋ *(SRS_Rte_00126)*

5.4.2.1 Data Handles Section

The data handles section is required to support the `Rte_IRead` and `Rte_IWrite` calls (see Section 5.2.4).

[SWS_Rte_03733] ⌈ Data Handles shall be named `<re>_<p>_<o>` where `<re>` is the runnable entity name that reads (or writes) the data item, `<p>` the port name, `<o>` the data element. ⌋ *(SRS_BSW_00305, SRS_Rte_00051)*

A `RunnableEntity` can read and write to the same port/data element in case of a `PRPortPrototype`s where as `PPortPrototype`s and `RPortPrototype`s are inherently uni-directional (a provide port can only be written, a require port can only be read). Please note that for read and write access of a runnable to data in a `PRPortPrototype` only one data handle exist.

[SWS_Rte_06827] ⌈ The Data Handle shall be a pointer to a `data element with extended status` if and only if the runnable has write access via a `PRPortPrototype` and acknowledgement is enabled for this data element. ⌋ *(SRS_Rte_00051, SRS_Rte_00185)*

[SWS_Rte_02608] ⌈ The Data Handle shall be a pointer to a `data element with status` if and only if either

- the runnable has read access (via a `RPortPrototype` or `PRPortPrototype`) and either

  - data element outdated notification or
  - data element invalidation or
  - data element never received status or
  - data element range check or
  - handleDataStatus

  is activated for this data element, or

- the runnable has write access via a PPortPrototype and acknowledgement is enabled for this data element.

⌋*(SRS_Rte_00051, SRS_Rte_00185)*

[SWS_Rte_02588] ⌈ Otherwise, the data type for a Data Handle shall be a pointer to a data element without status. ⌋*(SRS_Rte_00051)*

See below for the definitions of these terms.

[SWS_Rte_06529] ⌈ The RTE Generator shall wrap each entry of *Data Handles Section* in the component data structure of a variant existent Rte_IRead or Rte_IWrite API if the variability shall be implemented.

```
#if (<condition>)

<Data Handles Section Entry>

#endif
```

where condition is the condition value macro of the VariationPoint relevant for the variant existence of the Rte_IRead or Rte_IWrite API (see [SWS_Rte_06515]), Data Handles Section Entry is the code according an invariant *Data Handles Section Entry* (see also [SWS_Rte_03733], [SWS_Rte_02608], [SWS_Rte_02588]) ⌋*(SRS_Rte_00201)*

[SWS_Rte_08777] ⌈ If the software component does not support multiple instantiation nor requires compatibility mode, the data handles section shall be empty. ⌋*(SRS_Rte_00051)*

5.4.2.1.1 Data Element without Status

[SWS_Rte_01363] ⌈ The data type for a "data element without status" shall be named Rte_DE_<dt> where <dt> is the data element's ImplementationDataType name. ⌋*(SRS_Rte_00051)*

[SWS_Rte_01364] ⌈ A data element without status shall be a structure containing a single member named value. ⌋*(SRS_Rte_00051)*

[SWS_Rte_02607] ⌈ The `value` member of a `data element without status` shall have the same data type as the corresponding data element. ⌋*(SRS_Rte_00051, SRS_Rte_00147, SRS_Rte_00078)*

Note that requirements [SWS_Rte_01364] and [SWS_Rte_02607] together imply that creating a variable of data type `Rte_DE_<dt>` allocates enough memory to store the data copy.

5.4.2.1.2 Data Element with Status

[SWS_Rte_01365] ⌈ The data type for a "data element with status" shall be named `Rte_DES_<dt>` where `<dt>` is the data element's `ImplementationDataType` name. ⌋*(SRS_Rte_00051)*

[SWS_Rte_01366] ⌈ A `data element with status` shall be a structure containing exactly two members. ⌋*(SRS_Rte_00051)*

[SWS_Rte_03734] ⌈ The first member of each `data element with status` shall be named 'value' ⌋*(SRS_Rte_00051)*

[SWS_Rte_02666] ⌈ The value member of a `data element with status` shall have the type of the corresponding data element. ⌋*(SRS_Rte_00051, SRS_Rte_00147, SRS_Rte_00078, SRS_Rte_00185)*

[SWS_Rte_02589] ⌈ The second member of each `data element with status` shall be named 'status'. ⌋*(SRS_Rte_00051, SRS_Rte_00147, SRS_Rte_00078, SRS_Rte_00185)*

[SWS_Rte_02590] ⌈ The status member of a `data element with status` shall be of the `Std_ReturnType` type. ⌋*(SRS_Rte_00147, SRS_Rte_00078, SRS_Rte_00185)*

[SWS_Rte_02609] ⌈ In case of read access, the status member of a `data element with status` shall contain the error status corresponding to the value member. ⌋*(SRS_Rte_00147, SRS_Rte_00078)*

[SWS_Rte_03836] ⌈ In case of write access, the status member of a `data element with status` shall contain the transmission status corresponding to the value member. ⌋*(SRS_Rte_00185)*

5.4.2.1.3 Data Element with Extended Status

[SWS_Rte_06817] ⌈ The data type for a `data element with extended status` (applies only for `PRPortPrototype`s) shall be named `Rte_DEX_<dt>` where `<dt>` is the data element's `ImplementationDataType` name. ⌋*(SRS_Rte_00051)*

[SWS_Rte_06818] ⌈ A `data element with extended status` shall be a structure containing exactly three members. ⌋*(SRS_Rte_00051)*

[SWS_Rte_06819] ⌈ The first member of each data element with extended status shall be named 'value'. ⌋*(SRS_Rte_00051)*

[SWS_Rte_06820] ⌈ The value member of a data element with extended status shall have the type of the corresponding data element. ⌋*(SRS_Rte_00051, SRS_Rte_00147, SRS_Rte_00078, SRS_Rte_00185)*

[SWS_Rte_06821] ⌈ The second member of each data element with extended status shall be named 'status'. ⌋*(SRS_Rte_00051, SRS_Rte_00147, SRS_Rte_00078, SRS_Rte_00185)*

[SWS_Rte_06822] ⌈ The status member of a data element with extended status shall be of the Std_ReturnType type. ⌋*(SRS_Rte_00147, SRS_Rte_00078, SRS_Rte_00185)*

[SWS_Rte_06823] ⌈ The third member of each data element with extended status shall be named 'feedback'. ⌋*(SRS_Rte_00051, SRS_Rte_00147, SRS_Rte_00078, SRS_Rte_00185)*

[SWS_Rte_06824] ⌈ The feedback member of a data element with extended status shall be of the Std_ReturnType type. ⌋*(SRS_Rte_00147, SRS_Rte_00078, SRS_Rte_00185)*

[SWS_Rte_06825] ⌈ In case of read access, the status member of a data element with extended status shall contain the error status corresponding to the value member. ⌋*(SRS_Rte_00147, SRS_Rte_00078)*

[SWS_Rte_06826] ⌈ In case of write access, the feedback member of a data element with extended status shall contain the transmission status corresponding to the value member. ⌋*(SRS_Rte_00185)*

5.4.2.1.4 Usage

A definition for every required data element with status, every data element without status, and every data element with extended status is emitted in the *RTE Data Handle Types Header File* (see Section 5.3.5).

Example 5.25

Consider a uint8 data element, a, of port p which is accessed using a VariableAccess in the dataWriteAccess role by runnables re1 and re2 and a VariableAccess in the dataReadAccess role by runnable re2 within component c. data element outdated is defined for this dataElement.

The required data types within the *RTE Data Handle Types Header File* would be:

```
typedef struct {
  uint8 value;
} Rte_DE_uint8;

typedef struct {
```

```
  uint8 value;
  Std_ReturnType status;
} Rte_DES_uint8;
```

Considering additionally a `uint16` data element `d`, of a port being a `PRPortPrototype` `pr` which is accessed using a `VariableAccess` in the `dataWriteAccess` role and a `dataReadAccess` role by runnable `re3` within component `c`. `data element outdated` is defined for this `dataElement` and additionally acknowledgement (`transmissionAcknowledge`) is requested.

The required data type within the *RTE Data Handle Types Header File* would be:

```
typedef struct {
  uint16 value;
  Std_ReturnType status;
  Std_ReturnType feedback;
} Rte_DEX_uint16;
```

The component data structure for `c` would also include:

```
Rte_DE_uint8*  re1_p_a;
Rte_DES_uint8* re2_p_a;
Rte_DEX_uint16* re3_pr_d;
```

A software-component that is supplied as object-code or is multiple instantiated requires “general purpose” definitions of `Rte_IRead`, `Rte_IWrite`, `Rte_IStatus` and `Rte_IFeedback` that use the data handles to access the data copies created within the generated RTE. For example:

```
#define Rte_IWrite_re1_p_a(instance,v) ((instance)->re1_p_a->value = (v
    ))
#define Rte_IWrite_re2_p_a(instance,v) ((instance)->re2_p_a->value = (v
    ))
#define Rte_IRead_re2_p_a(instance,v)  ((instance)->re2_p_a->value)
#define Rte_IStatus_re2_p_a(instance)  ((instance)->re2_p_a->status)
#define Rte_IWrite_re3_pr_d(instance,v)   ((instance)->re3_pr_d->value =
     (v))
#define Rte_IRead_re3_pr_d(instance)      ((instance)->re3_pr_d->value)
#define Rte_IStatus_re3_pr_d(instance)    ((instance)->re3_pr_d->status)
#define Rte_IFeedback_re3_pr_d(instance) ((instance)->re3_pr_d->
    feedback)
```

The definitions of `Rte_IRead`, `Rte_IWrite`, `Rte_IStatus`, and `Rte_IFeedback` are type-safe since an attempt to assign an incorrect type will be detected by the compiler.

For source code component that does **not** use multiple instantiation the definitions of `Rte_IRead`, `Rte_IWrite`, `Rte_IStatus`, and `Rte_IFeedback` can remain as above or vendor specific optimizations can be applied without loss of portability.

The values assigned to data handles within *instances* of the component data structure created within the generated RTE depend on the mapping of tasks and runnables – See Section 5.2.4.

5.4.2.2 Per-instance Memory Handles Section

The Per-instance Memory Section Handles section enables to access instance specific memory (sections).

[SWS_Rte_02301] ⌈ The CDS shall contain a handle for each Per-instance Memory. This handle member shall be named `Pim_<name>` where `<name>` is the per-instance memory name. ⌋*(SRS_BSW_00305, SRS_Rte_00051, SRS_Rte_00013)*

The Per-instance Memory Handles are typed; **[SWS_Rte_02302]** ⌈ The data type of each Per-instance Memory Handle shall be a pointer to the type of the per instance memory that is defined in the *Application Header* file. ⌋*(SRS_Rte_00051, SRS_Rte_00013)*

The RTE supports the access to the per-instance memories by the `Rte_Pim` API.

[SWS_Rte_06527] ⌈ The RTE Generator shall wrap each entry of *Per-instance Memory Handles Section* in the component data structure of a variant existent `PerInstanceMemory` or `arTypedPerInstanceMemory` if the variability shall be implemented.

```
#if (<condition>)

<Per-instance Memory Handles Section Entry>

#endif
```

where `condition` is the condition value macro of the `VariationPoint` relevant for the variant existence of the `Rte_Pim` API (see [SWS_Rte_06518]), `Per-instance Memory Handles Section Entry` is the code according an invariant *Per-instance Memory Handles Section Entry* (see also [SWS_Rte_02301], [SWS_Rte_02302]) ⌋ *(SRS_Rte_00201)*

Example 5.26

Referring to the specification items [SWS_Rte_02301], [SWS_Rte_02302], and [SWS_Rte_07133] Example 5.4 can be extended –

with respect to the software-component header:

```
struct Rte_CDS_c {
  ...
  /* per-instance memory handle section */
  Rte_PimType_c_MyMemType *Pim_mem;

  ...
};

typedef struct Rte_CDS_c Rte_CDS_c;

#define Rte_Pim_mem(instance) ((instance)->Pim_mem)
```

and in Rte.c:

```
Rte_PimType_c_MyMemType mem1;

const Rte_CDS_c Rte_Instance_c1 = {
  ...
  /* per-instance memory handle section */
  /* Rte_PimType_c_MyMemType Pim_mem */
  &mem1
  ...
};
```

[SWS_Rte_08778] ⌈ If the software component does not support multiple instantiation nor requires compatibility mode, the per-instance memory handles section shall be empty. ⌋*(SRS_Rte_00051)*

5.4.2.3 Inter Runnable Variable Handles Section

Each runnable may require separate handling for the inter runnable variables that it accesses. The indirection required for explicit access to inter runnable variables is described in section 5.4.2.7. The inter runnable variable handles section within the component data structure contains pointers to the (shadow) memory of inter runnable variables that can be directly accessed with the implicit API macros. The inter runnable variable handles section does not contain pointers for memory to handle inter runnable variables that are accessed with explicit API only.

[SWS_Rte_02636] ⌈ For each runnable and each inter runnable variable that is accessed implicitly by the runnable, there shall be exactly one inter runnable handle member within the component data structure and this inter runnable variable handle shall point to the (shadow) memory of the inter runnable variable for the runnable. ⌋*(SRS_Rte_00142)*

[SWS_Rte_01350] ⌈ The name of each inter runnable variable handle member within the component data structure shall be Irv_<re>_<o> where <o> is the InterRunnable Variable short name and <re> is short name of the runnable name. ⌋*(SRS_Rte_00142)*

[SWS_Rte_01351] ⌈ The data type of each inter runnable variable handle member shall be a pointer to the type of the inter runnable variable. ⌋*(SRS_Rte_00142)*

[SWS_Rte_06528] ⌈ The RTE Generator shall wrap each entry of *Inter Runnable Variable Handles Section* in the component data structure of a variant existent Rte_IrvRead or Rte_IrvWrite if the variability shall be implemented.

```
#if (<condition> [|| <condition>])

<Inter Runnable Variable Handles Section Entry>

#endif
```

where condition are the condition value macro(s) of the VariationPoint relevant for the variant existence of the Rte_IrvRead or Rte_IrvWrite API accessing the same *Inter Runnable Variable* (see [SWS_Rte_06519]), Inter Runnable Variable Handles Section Entry is the code according an invariant *Inter Runnable Variable Handles Section Entry* (see also [SWS_Rte_02636], [SWS_Rte_01350], [SWS_Rte_01351]) ⌋*(SRS_Rte_00201)*

[SWS_Rte_08779] ⌈ If the software component does not support multiple instantiation nor requires compatibility mode, the inter runnable variable handles section shall be empty. ⌋*(SRS_Rte_00051)*

5.4.2.4 Exclusive-area API Section

The exclusive-area API section includes exclusive areas that are accessed explicitly, using the RTE API, by the SW-C. Each entry in the section is a function pointer to the relevant RTE API function generated for the SW-C instance.

[SWS_Rte_03739] ⌈ If the according SwcExclusiveAreaPolicy.apiPrinciple of the ExclusiveArea is set to "common", the name of each Exclusive-area API section entry shall be <root>_<name> where <root> is either Entry or Exit and <name> is the shortName of the ExclusiveArea. ⌋*(SRS_Rte_00051, SRS_Rte_00032)*

[SWS_Rte_04545] ⌈ If the according SwcExclusiveAreaPolicy.apiPrinciple of the ExclusiveArea is set to "perExecutable", the name of each Exclusive-area API section entry shall be <root>_<re>_<name> where <root> is either Entry or Exit, <re> is the shortName of the RunnableEntity with the canEnterExclusiveArea association, and <name> is the shortName of the ExclusiveArea. ⌋*(SRS_Rte_00051, SRS_Rte_00032)*

[SWS_Rte_03740] ⌈ The data type of each Exclusive-area API section entry shall be a function pointer that points to the generated RTE API function. ⌋*(SRS_Rte_00051, SRS_Rte_00032)*

[SWS_Rte_06521] ⌈ The RTE Generator shall wrap each definition of a variant existent Rte_Enter and Rte_Exit in the Exclusive-area API section according table 4.17 if the variability shall be implemented.

```
#if (<condition>)

<Exclusive-area API section entry>

#endif
```

where condition is the condition value macro of the VariationPoint relevant for the variant existence of the Rte_Enter and Rte_Exit API (see [SWS_Rte_06518]), Exclusive-area API section entry is the code according an invariant Exclusive-area section entry (see also [SWS_Rte_03739], [SWS_Rte_03740]) ⌋*(SRS_Rte_00201)*

[SWS_Rte_03812] ⌈ Entries in the Exclusive-area API section shall be sorted alphabetically (ASCII / ISO 8859-1 code in ascending order). ⌋*(SRS_Rte_00051, SRS_Rte_00032)*

Note that two function pointers will be required for each accessed exclusive area; one for the Entry function and one for the Exit function.

[SWS_Rte_08780] ⌈ If the software component does not support multiple instantiation nor requires compatibility mode, the exclusive-area API section shall be empty. ⌋*(SRS_Rte_00051)*

5.4.2.5 Port API Section

Port API section comprises zero or more *function references* within the component data structure type that defines all API functions that access a port and can be invoked by the software-component (instance).

[SWS_Rte_02616] ⌈ The function table entries for port access shall be grouped by the port names into port data structures. ⌋*(SRS_Rte_00051)*

Each entry in the port API section of the component data structure is a "port data structure".

[SWS_Rte_02617] ⌈ The name of each *port data structure* in the component data structure shall be `<p>` where `<p>` is the port short-name. ⌋*(SRS_Rte_00051)*

[SWS_Rte_03799] ⌈ The component data structure shall contain a port data structure for port `p` only if at least one API from table 5.2 is present and either the component supports multiple instantiation, or the component requires compatibility mode, or if the `indirectAPI` attribute for `p` is set to 'true'. ⌋*(SRS_Rte_00051)*

[SWS_Rte_06522] ⌈ The RTE Generator shall wrap each *port data structure* of a variant existent `PortPrototype` if the variability shall be implemented.

```
#if (<condition>)

<port data structure>

#endif
```

where `condition` is the condition value macro of the `VariationPoint` relevant for the variant existence of the `PortPrototype` (see [SWS_Rte_06520], `port data structure` is the code according an invariant *port data structure*s (see also [SWS_Rte_02617], [SWS_Rte_03799]) ⌋*(SRS_Rte_00201)*

[SWS_Rte_03731] ⌈ The data type name for a port data structure shall be
`struct Rte_PDS_<cts>_<i>_<P/R/PR>`

where `<cts>` is the `component type symbol` of the `AtomicSwComponentType`,

`<i>` is the port interface name and

‘P’, ’R’ or ‘PR’ are literals to indicate provide, require or provide-require ports respectively. ⌋*(SRS_BSW_00305, SRS_Rte_00051)*

[SWS_Rte_CONSTR_09080] The *shortNames* of *PortInterfaces* shall be unique within a software component if it supports multiple instantiation or `indirectAPI` attribute is set to ’true’ ⌈ The *shortNames* of *PortInterfaces* shall be unique within a software component for each set of PPortPrototypes or RPortPrototypes if the software component supports multiple instantiation or if the `indirectAPI` attribute is set to ’true’ for at least one require or provide port.

This is required to generate distinguishable Port Data Structure data types. ⌋*()*

[SWS_Rte_08312] ⌈ The RTE generator shall reject a configuration violating the [SWS_Rte_CONSTR_09080]. ⌋*(SRS_Rte_00051)*

[SWS_Rte_07137] ⌈ The port data structure type(s) shall be defined in the *Application Header* file. ⌋*(SRS_Rte_00051)*

A port data structure type is defined for each port interface that types a port. Thus different ports typed by the same port interface structure share the same port data structure type.

[SWS_Rte_07138] ⌈ The *Application Header* file shall contain a definition of a port data structure type for interface `i` and port type `R`, `P`, `PR` only if the component supports multiple instantiation or at least one require, provide or provide-require port exists that has the `indirectAPI` attribute set to ’true’. ⌋*(SRS_Rte_00051)*

[SWS_Rte_06523] ⌈ The RTE Generator shall wrap each *port data structure type* related to variant existent `PortPrototype`s if the variability shall be implemented and if all require `PortPrototype`s or all provide `PortPrototype`s are variant.

```
#if (<condition> [|| <condition>])

<port data structure type>

#endif
```

where `condition` are the condition value macro(s) of the `VariationPoint`s relevant for the variant existence of the `PortPrototype`s requiring the *port data structure type* (see [SWS_Rte_06520]), `port data structure type` is the code according an invariant *port data structure type* (see also [SWS_Rte_03731], [SWS_Rte_07138], [SWS_Rte_03730] [SWS_Rte_02620]) ⌋*(SRS_Rte_00201)*

Note: If any invariant `PortPrototype` requires the *port data structure type* it shall be defined unconditional.

[SWS_Rte_07677] ⌈ The RTE shall support an indirect API for the port access functions listed in table 5.2. ⌋*(SRS_Rte_00051)*

[SWS_Rte_03730] ⌈ A port data structure shall contain a function table entry for each API function associated with the port as referenced in table 5.2. Pure API macros,

like Rte_IRead and other implicit API functions, do not have a function table entry. ⌋
(SRS_Rte_00051)

API function	reference
Rte_Send_<p>_<o>	5.6.5
Rte_Write_<p>_<o>	5.6.5
Rte_Switch_<p>_<o>	5.6.6
Rte_Invalidate_<p>_<o>	5.6.7
Rte_Feedback_<p>_<o>	5.6.8
Rte_SwitchAck_<p>_<o>	5.6.9
Rte_Read_<p>_<o>	5.6.10
Rte_DRead_<p>_<o>	5.6.10
Rte_Receive_<p>_<o>	5.6.12
Rte_Call_<p>_<o>	5.6.13
Rte_Result_<p>_<o>	5.6.14
Rte_Prm_<p>_<o>	5.6.17
Rte_Mode_<p>_<o>	5.6.30
Rte_Trigger_<p>_<o>	5.6.32
Rte_IsUpdated_<p>_<o>	5.6.35

Table 5.2: Table of API functions that are referenced in the port API section.

[SWS_Rte_02620] ⌈ An API function shall only be included in a port data structure, if it is required at least by one port. ⌋*(SRS_Rte_00051)*

[SWS_Rte_02621] ⌈ If a function table entry is available in a port data structure, the corresponding function shall be implemented for all ports that use this port data structure type. API functions related to ports that are not required by the AUTOSAR configuration shall behave like those for an unconnected port. ⌋*(SRS_Rte_00051)*

APIs may be required only for some ports of a software component instance due to differences in for example the need for transmission acknowledgement. [SWS_Rte_02621] is necessary for the concept of the indirect API. It allows iteration over ports.

[SWS_Rte_01055] ⌈ The name of each function table entry in a port data structure shall be <name>_<o> where <name> is the API root (e.g. Call, Write) and <o> the data element or operation name. ⌋*(SRS_BSW_00305, SRS_Rte_00051)*

Requirement [SWS_Rte_01055] does *not* include the port name in the function table entry name since the port is implicit when using a port handle.

[SWS_Rte_03726] ⌈ The data type of each function table entry in a port data structure shall be a function pointer that points to the generated RTE function. ⌋
(SRS_Rte_00051)

The signature of a generated function, and hence the definition of the function pointer type, is the same as the signature of the relevant RTE API call (see Section 5.6) with the exception that the instance handle is omitted.

Example 5.27

This example shows a port data structure for the provide ports of the interface type i2 in an AUTOSAR SW-C c.

i2 is a SenderReceiverInterface which contains a data element prototype of type uint8 with data semantics.

If one of the provide ports of c for the interface i2 has a transmission acknowledgement defined and i2 is not used with data element invalidation, the *Application Header* file would include a port data structure type like this:

```
struct Rte_PDS_c_i2_P {
  Std_ReturnType (*Feedback_a)(uint8);
  Std_ReturnType (*Write_a)(uint8);
}
```

If the provide port p1 of the AUTOSAR SW-C c is of interface i2, the generated *Application Header* file would include the following macros to provide the direct API functions Rte_Feedback_p1_a and Rte_Write_p1_a:

```
/*direct API*/
#define Rte_Feedback_p1_a(inst,data)
        ((inst)->p1.Feedback_a)(data)
#define Rte_Write_p1_a(inst,data) ((inst)->p1.Write_a)(data)
```

[SWS_Rte_02618] ⌈ The port data structures within a component data structure shall first be sorted on the port data structure type name and then on the short name of the port. ⌋*(SRS_Rte_00051)*

The requirements [SWS_Rte_03731] and [SWS_Rte_02618] guarantee, that all port data structures within the component data structure are grouped by their interface type and require/provide-direction.

Example 5.28

This example shows the grouping of port data structures within the component data structure.

The *Application Header* file for an AUTOSAR SW-C c with three provide ports p1, p2, and p3 of interface i2 would include a block of port data structures like this:

```
struct Rte_CDS_c {
  ...
  struct Rte_PDS_c_i1_R z;

/* port data structures          *
 * for provide ports of interface i2  */
  struct Rte_PDS_c_i2_P p1;
  struct Rte_PDS_c_i2_P p2;
  struct Rte_PDS_c_i2_P p3;

/* further port data structures */
  struct Rte_PDS_c_i2_R c;
  ...
}
```

```

typedef struct Rte_CDS_c Rte_CDS_c;
```

If inst is a pointer to a component data structure, and ph is defined by

```
struct Rte_PDS_c_i2_P *ph = &(inst->p1);
```

ph points to the port data structure p1 of the instance handle inst. Since the three provide port data structures p1, p2, and p3 of interface i2 are ordered sequentially in the component data structure, ph can also be interpreted as an array of port data structures. E.g., ph[2] is equal to inst->p3.

In the following, ph will be called a port handle.

[SWS_Rte_01343] ⌈ RTE shall create *port handle types* for each port data structure using typedef to a pointer to the appropriate port data structure. ⌋*(SRS_Rte_00051)*

[SWS_Rte_01342] ⌈ The *port handle type* name shall be Rte_PortHandle_<i>_<P/R/PR> where <i> is the port interface name and 'P', 'R' or 'PR' are literals to indicate provide, require or provide-require ports respectively. ⌋*(SRS_Rte_00051)*

[SWS_Rte_06524] ⌈ The RTE Generator shall wrap each *port handle type* related to variant existent PortPrototypes if the variability shall be implemented and if all require PortPrototypes or all provide PortPrototypes are variant.

```
#if (<condition> [|| <condition>])

<port handle type>

#endif
```

where condition are the condition value macro(s) of the VariationPoints relevant for the variant existence of the PortPrototypes requiring the *port data structure type* (see [SWS_Rte_06520]), port data structure type is the code according an invariant *port data structure type* (see also [SWS_Rte_01343], [SWS_Rte_01342]) ⌋*(SRS_Rte_00201)*

[SWS_Rte_01053] ⌈ The port handle types shall be written to the application header file. ⌋*(SRS_Rte_00051)*

RTE provides port handles for access to the arrays of port data structures of the same interface type and provide/receive direction by the macro Rte_Ports, see section 5.6.1, and to the number of similar ports by the macro Rte_NPorts, see 5.6.1.

Example 5.29

For the provide port i2 of AUTOSAR SW-C c from example 5.27, the following port handle type will be defined in the *Application Header* file:

```
typedef struct Rte_PDS_c_i2_P *Rte_PortHandle_i2_P;
```

The macros to access the port handles for the indirect API might look like this in the generated *Application Header* file:

```
/*indirect (port oriented) API*/
#define Rte_Ports_i2_P(inst) &((inst)->p1)
#define Rte_NPorts_i2_P(inst) 3
```

So, the port handle ph of the previous example 5.28 could be defined by a user as:

```
Rte_PortHandle_i2_P ph = Rte_Ports_i2_P(inst);
```

To write '49' on all ports p1 to p3, the indirect API can be used within the software component as follows:

```
uint8 p;
Rte_PortHandle_i2_P ph = Rte_Ports_i2_P(inst);
for(p=0;p<Rte_NPorts_i_P(inst);p++) {
  ph[p].Write_a(49);
}
```

Software components may also want to set up their own port handle arrays to iterate over a smaller sub group than all ports with the same interface and direction. Rte_Port can be used to pick the port handle for one specific port, see 5.6.3.

5.4.2.6 Calibration Parameter Handles Section

The RTE is required to support access to calibration parameters derived by *per-instance* ParameterDataPrototypes (see 4.2.8.3) using the Rte_CData (see section 5.6.16).

[SWS_Rte_03835] ⌈ The name of each Calibration parameter handle shall be CData_<name> where <name> is the ParameterDataPrototype name. ⌋ *(SRS_Rte_00051, SRS_Rte_00154, SRS_Rte_00155)*

[SWS_Rte_03949] ⌈ The type of each calibration parameter handle shall be a function pointer that points to the generated RTE function. ⌋ *(SRS_Rte_00051, SRS_Rte_00154, SRS_Rte_00155)*

Note that accesses to ParameterDataPrototypes within ParameterSwComponentTypes do not result in any handles within this section since the generated Rte_Prm (see section 5.6.17) API is accessed either directly (single instantiation) or through handles in the port API section (multiple instantiation). Likewise, access to *shared* ParameterDataPrototypes does not result in any handle in the Calibration Parameter Handles Section since, by definition, no per-instance data is present.

[SWS_Rte_08782] ⌈ If the software component does not support multiple instantiation nor requires compatibility mode, the calibration parameter handles section shall be empty. ⌋ *(SRS_Rte_00051)*

5.4.2.7 Inter Runnable Variable API Section

The Inter Runnable Variable API section comprises zero or more *function table entries* within the component data structure type that defines all explicit API functions to access an inter runnable variable by the software-component (instance). The API for implicit access of inter runnable variables does not have any *function table entries*, since the implicit API uses macro's to access the inter runnable variables or their shadow memory directly, see section 5.4.2.3.

Since the entries of this section are only required to access the explicit InterRunnableVariable API if a software component supports multiple instantiation, it shall be omitted for software components which do not support multiple instantiation.

[SWS_Rte_03725] ⌈ If the component supports multiple instantiation, the member name of each function table entry within the component data structure shall be `<name>_<re>_<o>` where `<name>` is the API root (e.g. IrvRead), `<re>` the runnable name, and `<o>` the inter runnable variable name. ⌋*(SRS_Rte_00051)*

[SWS_Rte_03752] ⌈ The data type of each function table entry shall be a function pointer that points to the generated RTE function. ⌋*(SRS_Rte_00051)*

The signature of a generated function, and hence the definition of the function pointer type, is the same as the signature of the relevant RTE API call (see Section 5.6) with the exception that the instance handle is omitted.

[SWS_Rte_02623] ⌈ If the component supports multiple instantiation or requires compatibility mode, the *Inter Runnable Variable API Section* shall contain pointers to API functions as listed in table 5.3. ⌋*(SRS_Rte_00051)*

API function	reference
`Rte_IrvRead_<re>_<o>`	5.6.26
`Rte_IrvWrite_<re>_<o>`	5.6.27

Table 5.3: Table of API functions that are referenced in the inter runnable variable API section

[SWS_Rte_06525] ⌈ The RTE Generator shall wrap each entry of *Inter Runnable Variable API Section* in the component data structure of a variant existent `Rte_IrvRead` or `Rte_IrvWrite` API if the variability shall be implemented.

```
#if (<condition>)

<Inter Runnable Variable API Section Entry>

#endif
```

where `condition` is the condition value macro of the `VariationPoint` relevant for the variant existence of the `Rte_IrvRead` or `Rte_IrvWrite` API (see [SWS_Rte_06519]), `Inter Runnable Variable API Section Entry` is the code according an invariant *Inter Runnable Variable API Section Entry* (see also [SWS_Rte_03725], [SWS_Rte_03752], [SWS_Rte_02623]) ⌋*(SRS_Rte_00201)*

[SWS_Rte_03791] ⌈ If the software component does not support multiple instantiation, the inter runnable variable API section shall be empty. ⌋*(SRS_Rte_00051)*

[SWS_Rte_08783] ⌈ If the software component does not support multiple instantiation, the inter runnable variable API section shall be empty. ⌋*(SRS_Rte_00051)*

5.4.2.8 Inter Runnable Triggering API Section

The Inter Runnable Triggering API Section includes the Inter Runnable Triggering API handles. Each entry in the section is a function pointer to the relevant RTE API function generated for the SW-C instance.

[SWS_Rte_07226] ⌈ The name of each *Inter Runnable Triggering handle* shall be `Rte_IrTrigger_<re>_<name>` where `<re>` is the name of the runnable entity the API might be used and `<name>` is the name of the `InternalTriggeringPoint`. ⌋ *(SRS_Rte_00051, SRS_Rte_00163)*

[SWS_Rte_07227] ⌈ The data type of each *Inter Runnable Triggering handle entry* shall be a function pointer that points to the generated RTE API function defined in 5.6.33. ⌋*(SRS_Rte_00051, SRS_Rte_00163)*

[SWS_Rte_06526] ⌈ The RTE Generator shall wrap each entry of *Inter Runnable Triggering handle* in the component data structure of a variant existent `Rte_IrTrigger` API if the variability shall be implemented.

```
#if (<condition>)

<Inter Runnable Variable API Section Entry>

#endif
```

where `condition` is the condition value macro of the `VariationPoint` relevant for the variant existence of the `Rte_IrTrigger` API (see [SWS_Rte_06519], `Inter Runnable Variable API Section Entry` is the code according an invariant *Inter Runnable Variable API Section Entry* (see also [SWS_Rte_03725], [SWS_Rte_03752], [SWS_Rte_02623]) ⌋*(SRS_Rte_00201)*

[SWS_Rte_07228] ⌈ Entries in the Inter Runnable Triggering handles section shall be sorted alphabetically (ASCII / ISO 8859-1 code in ascending order). ⌋ *(SRS_Rte_00051, SRS_Rte_00163)*

[SWS_Rte_08784] ⌈ If the software component does not support multiple instantiation nor requires compatibility mode, the inter runnable triggering API section shall be empty. ⌋*(SRS_Rte_00051)*

5.4.2.9 Instance Id Section

[SWS_Rte_07838] ⌈ If a software component type supports multiple instantiation, the RTE generator shall add in the Component Data Structure Instance Id Section an element named Instance_Id of type uint8. ⌋*(SRS_Rte_00011, SRS_Rte_00051, SRS_Rte_00244)*

[SWS_Rte_07839] ⌈ For each prototype of a software component type that supports multiple instantiation, the RTE generator shall set the value of the element Instance_Id from 0 to N-1 according to the number (N) of software component prototypes and according to the names of the software component prototypes sorted alphabetically (ASCII / ISO 8859-1 code in ascending order). ⌋*(SRS_Rte_00011, SRS_Rte_00051, SRS_Rte_00244)*

Example: Two prototypes (instances) named A and B of a software component type exist:

- Instance_Id for instance A takes the value 0.
- Instance_Id for instance B takes the value 1.

Note: The Instance_Id should not be used by the runnable implementation. The Instance_Id has been created to support implementation of bypass on software component that supports multiple instantiation.

[SWS_Rte_08785] ⌈ If the software component does not support multiple instantiation, the instance id section shall be empty. ⌋*(SRS_Rte_00051)*

5.4.2.10 RAM Block Data Updated Handles Section

The RAM Block Data Updated Handles section is required to express an update of implicit written NV data in case the `NvBlockSwComponentType` is used (see section 4.2.9.2). For that purpose each RAM Block Updated Handle accesses a separate "dirty flag".

[SWS_Rte_08092] ⌈ The CDS shall contain a handle for each `SwcServiceDependency` defining a `RoleBasedPortAssignment` in the role `NvDataPort`. This handle member shall be named `DF_<name>` where `<name>` is the `SwcServiceDependency` name. ⌋*(SRS_Rte_00051, SRS_Rte_00245)*

[SWS_Rte_08093] ⌈ The data type of each RAM Block Data Updated Handle shall be a pointer to `boolean`. ⌋*(SRS_Rte_00051, SRS_Rte_00245)*

The RTE supports the access to dirty flags for implicit communication by invoking the `Rte_IWrite` and `Rte_IWriteRef` APIs.

[SWS_Rte_08094] ⌈ The invocation of any `Rte_IWrite` or `Rte_IWriteRef` API of a data belonging to a `PPortPrototype` / `PRPortPrototype` referenced in the role `NvDataPort` by a `SwcServiceDependency` shall set the related dirty flag addressed by the RAM Block Updated Handle to `TRUE`. ⌋*(SRS_Rte_00051, SRS_Rte_00245)*

[SWS_Rte_07416] ⌈ For a `VariableDataPrototype` belonging to a `PPortPrototype` / `PRPortPrototype` referenced in the role `NvDataPort` by a `SwcServiceDependency` the RTE shall, after the NvM has been informed, set the related dirty flag addressed by the RAM Block Updated Handle to `FALSE`. ⌋*(SRS_Rte_00051, SRS_Rte_00245)*

The NvM is informed of the status change through either the invocation of `NvM_SetRamBlockStatus` [SWS_Rte_08081] or directly through `NvM_WriteBlock` [SWS_Rte_08085]. The invocation of either is guarded by a check on the dirty flag.

[SWS_Rte_08095] ⌈ The RTE Generator shall wrap each entry of *RAM Block Data Updated Handles Section* related to variant existent `PPortPrototype`s / `PRPortPrototype`s referenced in the role `NvDataPort` by a `SwcServiceDependency` if the variability shall be implemented.

```
#if (<condition>)

<RAM Block Data Updated Handles Section Entry>

#endif
```

where `condition` are the condition value macros of the `VariationPoint`s relevant for the variant existence of the `Rte_IWrite` and `Rte_IWriteRef` APIs (see [SWS_Rte_06518]); the single condition value macros are concatenated with logical `or` (||) operators to ensure the availability of the handle if any relevant API is existent, `RAM Block Data Updated Handles Section Entry` is the code according an invariant *RAM Block Data Updated Handles Section Entry* where `condition` are the condition value macros of the `VariationPoint`s concatenated with logical `or` (||) operators (see also [SWS_Rte_08092], [SWS_Rte_08093]). ⌋*(SRS_Rte_00201)*

[SWS_Rte_03872] ⌈ If the software component does not support multiple instantiation nor requires compatibility mode, the *RAM Block Data Updated Handles Section* shall be empty. ⌋*(SRS_Rte_00051)*

5.4.2.11 Vendor Specific Section

The vendor specific section is used to contain any vendor specific data required to be supported for each instances. By definition the contents of this section are outside the scope of this chapter and only available for use by the RTE generator responsible for the "RTE Generation" phase.

[SWS_Rte_08786] ⌈ If the software component does not support multiple instantiation nor requires compatibility mode, the vendor specific section shall be empty. ⌋*(SRS_Rte_00051)*

5.5 API Data Types

Besides the API functions for accessing RTE services, the API also contains RTE-specific data types.

5.5.1 Std_ReturnType

The specification in [31] specifies a standard API return type `Std_ReturnType`. The `Std_ReturnType` defines the "'status"' and "'error values"' returned by API functions. It is defined as a `uint8` type. The value "0" is reserved for "No error occurred".

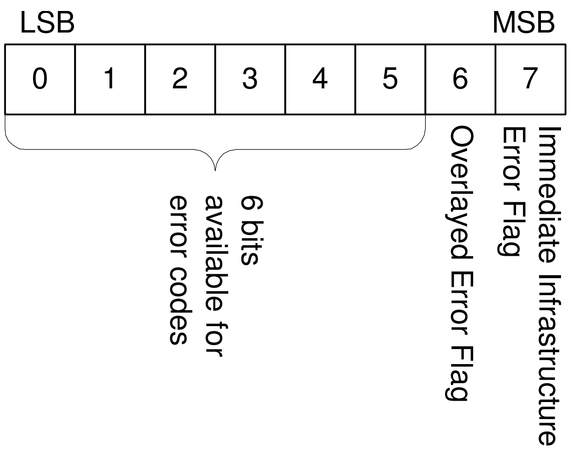

Figure 5.13: Bit-Layout of the Std_ReturnType

Figure 5.13 shows the general layout of `Std_ReturnType`.

The two most significant bits of the `Std_ReturnType` are reserved flags:

- The most significant bit 7 of `Std_ReturnType` is the "Immediate Infrastructure Error Flag" with the following values
  - "1" the error code indicates an immediate infrastructure error.
  - "0" the error code indicates no immediate infrastructure error.
- The second most significant bit 6 of `Std_ReturnType` is the Overlayed Error Flag. The use of this flag depends on the context and will be explained in table 5.5.

In order to avoid explicit access to bit numbers in the code, the RTE provides the three following macros that enables an application to check the return value of an API:

- **[SWS_Rte_07404]** ⌈ For infrastructure errors, this macro is a boolean expression that is true if the corresponding bit is set:

```
#define Rte_IsInfrastructureError(status)   ((status & 128U) !=
    0)
```

⌋*()*

- **[SWS_Rte_07405]** ⌈For overlayed errors, this macro is a boolean expression that is true if the corresponding bit is set:

```
#define Rte_HasOverlayedError(status)   ((status & 64U) != 0)
```

⌋*()*

- **[SWS_Rte_07406]** ⌈For reading only the application error code without the eventual overlayed error, the following macro returns the lower 6 bits of the error code:

```
#define Rte_ApplicationError(status) (status & 63U)
```

⌋*()*

5.5.1.1 Infrastructure Errors

Infrastructure errors are split into two groups:

- "Immediate Infrastructure Errors" can be associated with the currently available data set. These `Immediate Infrastructure Errors` are mutually exclusive. Only one of these errors can be notified to a SW-C with one API call.

  [SWS_Rte_02593] ⌈ `Immediate Infrastructure Errors` shall override any application level error. ⌋*(SRS_Rte_00084, SRS_Rte_00123)*

  `Immediate Infrastructure Error` codes are used on the receiver side for errors that result in no reception of application data and application errors.

  An `Immediate Infrastructure Error` is indicated in the `Std_ReturnType` by the `Immediate Infrastructure Error Flag` being set.

- "Overlayed Errors" are associated with communication events that happened after the reception of the currently available data set, e.g., `data element outdated` notification, or loss of data elements due to queue overflow.

  [SWS_Rte_01318] ⌈ `Overlayed Error Flags` shall be reported using the unique bit of the `Overlayed Error Flag` within the `Std_ReturnType` type. ⌋*(SRS_Rte_00084, SRS_Rte_00094)*

  An `Overlayed Error` can be combined with any other application or infrastructure error code.

5.5.1.2 Application Errors

[SWS_Rte_02573] ⌈ RTE shall support application errors with the following format definition: Application errors are coded in the least significant 6 bits of `Std_ReturnType` with the `Immediate Infrastructure Error Flag` set to "0". The application error code does not use the `Overlayed Error Flag`. ⌋*(SRS_Rte_00124)*

This results in the following value range for application errors:

range	minimum value	maximum value
application errors	1	63

Table 5.4: application error value range

In client server communication, the server may return any value within the application error range. The client will then receive one of the following:

- An Immediate Infrastructure Error to indicate that the communication was not successful, or
- The server return code, or
- The server return code might be overlayed by the Overlayed Error Flag in a future release of RTE. In this release, there is no overlayed error defined for client server communication.

The client can filter the return value, e.g., by using the following code:

```
Std_ReturnType status;
status = Rte_Call_<p>_<o>(<instance>, <parameters>);
if (Rte_HasOverlayedError(status)) {
    /* handle overlayed error flag                     *
     * in this release of the RTE, the flag is reserved *
     * but not used for client server communication    */

}

if(Rte_IsInfrastructureError(status)) {
    /* handle infrastructure error                     */
}
else {
    /* handle application error with error code status  */
    status = Rte_ApplicationError(status);
}
```

5.5.1.3 Predefined Error Codes

For client server communication, application error values are defined per client server interface and shall be passed to the RTE with the interface configuration.

The following standard error and status identifiers are defined:

Symbolic name	Value	Comments
RTE_E_OK	0	[SWS_Rte_01058]
Standard Application Error Values:		
RTE_E_INVALID	1	[SWS_Rte_02594]

Symbolic name	Value	Comments
To be defined by the corresponding AUTOSAR Service	1	Returned by AUTOSAR Services to indicate a generic application error.
`Immediate Infrastructure Error` codes		
RTE_E_COM_STOPPED	128	[SWS_Rte_01060]
RTE_E_TIMEOUT	129	[SWS_Rte_01064]
RTE_E_LIMIT	130	[SWS_Rte_01317]
RTE_E_NO_DATA	131	[SWS_Rte_01061]
RTE_E_TRANSMIT_ACK	132	[SWS_Rte_01065]
RTE_E_NEVER_RECEIVED	133	[SWS_Rte_07384]
RTE_E_UNCONNECTED	134	[SWS_Rte_07655]
RTE_E_IN_EXCLUSIVE_AREA	135	[SWS_Rte_02739]
RTE_E_SEG_FAULT	136	[SWS_Rte_02757]
RTE_E_OUT_OF_RANGE	137	[SWS_Rte_08065]
RTE_E_SERIALIZATION_ERROR, RTE_E_HARD_TRANSFORMER_ERROR	138	[SWS_Rte_08725]
RTE_E_SERIALIZATION_LIMIT, RTE_E_TRANSFORMER_LIMIT	139	[SWS_Rte_08726]
RTE_E_SOFT_TRANSFORMER_ERROR	140	[SWS_Rte_08551]
RTE_E_COM_BUSY	141	[SWS_Rte_01389]
`Overlayed Errors` These errors do not refer to the data returned with the API. They can be overlayed with other Application- or Immediate Infrastructure Errors.		
RTE_E_LOST_DATA	64	[SWS_Rte_02571]
RTE_E_MAX_AGE_EXCEEDED	64	[SWS_Rte_02702]

Table 5.5: RTE Error and Status values

The underlying type for `Std_ReturnType` is defined as a `uint8` for reasons of compatibility – it avoids RTEs from different vendors assuming a different size if an `enum` was the underlying type. Consequently, `#define` is used to declare the error values:

```
typedef uint8 Std_ReturnType;

#define RTE_E_OK 0U
```

[SWS_Rte_01269] ⌈ The standard errors as defined in table 5.5 including `RTE_E_OK` shall be defined in the RTE Header File. ⌋ *(SRS_Rte_00051)*

[SWS_Rte_02575] ⌈ Application Error Identifiers with exception of `RTE_E_INVALID` shall be defined in the Application Header File. ⌋ *(SRS_Rte_00124, SRS_Rte_00167)*

[SWS_Rte_02576] ⌈ The application errors shall have a symbolic name defined as follows:

```
#define RTE_E_<interface>_<error> <error value>U
```

where <interface> PortInterface and <error> ApplicationError are the interface and error names from the configuration.[5] ⌋(SRS_Rte_00123)

An Std_ReturnType value can be directly compared (for equality) with the above pre-defined error identifiers.

[SWS_Rte_07143] ⌈ The RTE generator shall generate symbolic name for application errors with equal <interface> name, <error> name and <error value> only once. ⌋(SRS_Rte_00165)

5.5.1.3.1 No Error

5.5.1.3.1.1 RTE_E_OK

[SWS_Rte_01058] ⌈
Symbolic name: RTE_E_OK
Value: 0
Comments: No error occurred. ⌋(SRS_BSW_00327)

5.5.1.3.2 Standard Application Error Values

5.5.1.3.2.1 RTE_E_INVALID

[SWS_Rte_02594] ⌈
Symbolic name: RTE_E_INVALID
Value: 1
Comments: Generic application error indicated by signal invalidation in sender receiver communication with data semantics on the receiver side. ⌋(SRS_BSW_00327, SRS_Rte_00078)

5.5.1.3.3 Immediate Infrastructure Error Codes

5.5.1.3.3.1 RTE_E_COM_STOPPED

[SWS_Rte_01060] ⌈
Symbolic name: RTE_E_COM_STOPPED
Value: 128
Comments: An IPDU group was disabled while the application was waiting for the transmission acknowledgment. No value is available. This is not considered a fault, since the IPDU group is switched off on purpose.

This semantics are as follows:

[5] No additional capitalization is applied to the names.

- the OUT buffers of a client are not modified,
- the explicit read APIs read the last known value (or init value),
- no runnable with startOnEvent on a DataReceivedEvent for this, VariableDataPrototype is triggered,
- the buffers for implicit read access will keep the previous value.

⌋(*SRS_BSW_00327*)

5.5.1.3.3.2 RTE_E_TIMEOUT

[SWS_Rte_01064] ⌈
Symbolic name: `RTE_E_TIMEOUT`
Value: 129
Comments: A blocking API call returned due to expiry of a local timeout rather than the intended result. OUT buffers are not modified. The interpretation of this being an error depends on the application. ⌋(*SRS_BSW_00327, SRS_Rte_00069*)

5.5.1.3.3.3 RTE_E_LIMIT

[SWS_Rte_01317] ⌈
Symbolic name: `RTE_E_LIMIT`
Value: 130
Comments: An internal RTE limit has been exceeded. Request could not be handled. OUT buffers are not modified. ⌋(*SRS_BSW_00327*)

5.5.1.3.3.4 RTE_E_NO_DATA

[SWS_Rte_01061] ⌈
Symbolic name: `RTE_E_NO_DATA`
Value: 131
Comments: An explicit read API call returned no data. (This is no error.) ⌋(*SRS_BSW_00327*)

5.5.1.3.3.5 RTE_E_TRANSMIT_ACK

[SWS_Rte_01065] ⌈
Symbolic name: `RTE_E_TRANSMIT_ACK`
Value: 132
Comments: Transmission acknowledgement received. ⌋(*SRS_BSW_00327*)

5.5.1.3.3.6 RTE_E_NEVER_RECEIVED

[SWS_Rte_07384] ⌈
Symbolic name: `RTE_E_NEVER_RECEIVED`
Value: 133
Comments: No data received for the corresponding unqueued data element since system start or partition restart. ⌋*(SRS_BSW_00327, SRS_Rte_00184)*

5.5.1.3.3.7 RTE_E_UNCONNECTED

[SWS_Rte_07655] ⌈
Symbolic name: `RTE_E_UNCONNECTED`
Value: 134
Comments: The port used for communication is not connected. ⌋*(SRS_BSW_00327, SRS_Rte_00139, SRS_Rte_00200)*

5.5.1.3.3.8 RTE_E_IN_EXCLUSIVE_AREA

[SWS_Rte_02739] ⌈
Symbolic name: `RTE_E_IN_EXCLUSIVE_AREA`
Value: 135
Comments: The error is returned by a blocking API and indicates that the runnable could not enter a wait state. This could be for example because one `ExecutableEntity` of the current task's call stack has entered an `ExclusiveArea`.
⌋*(SRS_BSW_00327)*

5.5.1.3.3.9 RTE_E_SEG_FAULT

[SWS_Rte_02757] ⌈
Symbolic name: `RTE_E_SEG_FAULT`
Value: 136
Comments: The error can be returned by an RTE API, if the parameters contain a direct or indirect reference to memory that is not accessible from the callers partition.
⌋*(SRS_BSW_00327)*

5.5.1.3.3.10 RTE_E_OUT_OF_RANGE

[SWS_Rte_08065] ⌈
Symbolic name: `RTE_E_OUT_OF_RANGE`
Value: 137
Comments: The received data is out of range. ⌋*(SRS_BSW_00327, SRS_Rte_00180)*

5.5.1.3.3.11 RTE_E_SERIALIZATION_ERROR, RTE_E_HARD_TRANSFORMER_ERROR

[SWS_Rte_08725] ⌈
Symbolic name: RTE_E_SERIALIZATION_ERROR, RTE_E_HARD_TRANSFORMER_ERROR
Value: 138
Comments: An error during transformation occured. ⌋*(SRS_Rte_00091, SRS_BSW_00327)*

5.5.1.3.3.12 RTE_E_SERIALIZATION_LIMIT, RTE_E_TRANSFORMER_LIMIT

[SWS_Rte_08726] ⌈
Symbolic name: RTE_E_SERIALIZATION_LIMIT, RTE_E_TRANSFORMER_LIMIT
Value: 139
Comments: Buffer for transformation operation could not be created. ⌋*(SRS_Rte_00091, SRS_BSW_00327)*

5.5.1.3.3.13 RTE_E_SOFT_TRANSFORMER_ERROR

[SWS_Rte_08551] ⌈
Symbolic name: RTE_E_SOFT_TRANSFORMER_ERROR
Value: 140
Comments: An error during transformation occured which shall be notified to the SWC but still produces valid data as output (comparable to a warning). ⌋*(SRS_Rte_00091, SRS_BSW_00327)*

5.5.1.3.3.14 RTE_E_COM_BUSY

[SWS_Rte_01389] ⌈
Symbolic name: RTE_E_COM_BUSY
Value: 141
Comments: The transmission/reception could not be performed due to another transmission/reception currently ongoing for the same signal. ⌋*(SRS_Rte_00246)*

5.5.1.3.4 Overlayed Error

These errors do not refer to the data returned with the API. They can be overlayed with other Application- or Immediate Infrastructure Errors.

5.5.1.3.4.1 RTE_E_LOST_DATA

[SWS_Rte_02571] ⌈
Symbolic name: RTE_E_LOST_DATA
Value: 64
Comments: An API call for reading received data with event semantics indicates that some incoming data has been lost due to an overflow of the receive queue or due to an error of the underlying communication stack. ⌋*(SRS_BSW_00327, SRS_Rte_00107, SRS_Rte_00110, SRS_Rte_00094)*

5.5.1.3.4.2 RTE_E_LOST_DATA

[SWS_Rte_02702] ⌈
Symbolic name: RTE_E_MAX_AGE_EXCEEDED
Value: 64
Comments: An API call for reading received data with data semantics indicates that the available data has exceeded the aliveTimeout limit. A COM signal outdated callback will result in this error. ⌋*(SRS_BSW_00327, SRS_Rte_00078)*

5.5.2 Rte_Instance

The Rte_Instance data type defines the handle used to access instance specific information from the component data structure.

[SWS_Rte_01148] ⌈The underlying data type for an instance handle shall be a pointer to a *Component Data Structure*. ⌋*(SRS_Rte_00011, SRS_Rte_00051)*

The component data structure (see Section 5.4.2) is uniquely defined for a component type and therefore the data type for the instance handle is automatically unique for each component type.

The instance handle type is defined in the application header file [SWS_Rte_01007].

To avoid long and complex type names within SW-C code the following requirement imposes a fixed name on the instance handle data type.

[SWS_Rte_01150] ⌈ The name of the instance handle type shall be defined, using typedef as Rte_[Byps_]Instance. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00305)*

[SWS_Rte_06810] ⌈The instance handle typedef shall use the CONSTP2CONST macro with memclass AUTOMATIC and ptrclass RTE_CONST. ⌋*(SRS_BSW_00007)*

Requirement [SWS_Rte_06810] uses memclass AUTOMATIC rather than memclass TYPEDEF because the instance handle is used as a function parameter and hence automatic. This means the typedef is guaranteed to be compatible when the RTE implementation must use a pointer to the component data structure rather than the instance handle typedef.

The example 5.24 illustrates the definition of the instance handle typedef.

5.5.3 Rte_TransformerError

The data type `Rte_TransformerError` is a struct which contains the error code and the transformer class to which the error belongs.

[SWS_Rte_08560] ⌈ The data type `Rte_TransformerError` shall be defined as follows:

```
struct Rte_TransformerError {
  Rte_TransformerErrorCode errorCode,
  Rte_TransformerClass transformerClass
};
```

⌋*(SRS_Rte_00249)*

The `Rte_TransformerErrorCode` represents a transformer error in the context of a certain transformer chain. The specific meaning of the values of `Rte_TransformerErrorCode` are always to be seen for the specific transformer chain for which the data type represents the transformer error.

The values are specified for each transformer class in [26, ASWS Transformer General].

[SWS_Rte_08545] ⌈ The underlying data type of the type `Rte_TransformerErrorCode` shall be `uint8`. ⌋*(SRS_Rte_00249)*

The `Rte_TransformerClass` represents the transformer class in which the error occurred.

[SWS_Rte_08543] ⌈ The underlying data type of the type `Rte_TransformerClass` shall be `uint8`. ⌋*(SRS_Rte_00249)*

[SWS_Rte_08544] ⌈ The type `Rte_TransformerClass` shall be an enumeration with the following elements where each element represents a transformer class:

- `RTE_TRANSFORMER_UNSPECIFIED` (0x00) – Transformer of a unspecified transformer class.
- `RTE_TRANSFORMER_SERIALIZER` (0x01) – Transformer of a serializer class.
- `RTE_TRANSFORMER_SAFETY` (0x02) – Transformer of a safety class.
- `RTE_TRANSFORMER_SECURITY` (0x03) – Transformer of a security class.
- `RTE_TRANSFORMER_CUSTOM` (0xff) – Transformer of a custom class not standardized by AUTOSAR.

⌋*(SRS_Rte_00249)*

[SWS_Rte_08561] ⌈ The transformer class `RTE_TRANSFORMER_UNSPECIFIED` shall be used if no transformer error occured. ⌋ *(SRS_Rte_00249)*

[SWS_Rte_08575] ⌈ The mapping from `transformerClass` of `TransformationTechnology` to value of data type `Rte_TransformerClass` shall be:

- `transformerClass` serializer – `RTE_TRANSFORMER_SERIALIZER`
- `transformerClass` safety – `RTE_TRANSFORMER_SAFETY`
- `transformerClass` security – `RTE_TRANSFORMER_SECURITY`
- `transformerClass` custom – `RTE_TRANSFORMER_CUSTOM`

⌋ *(SRS_Rte_00249)*

5.5.4 RTE Modes

[SWS_Rte_02659] ⌈ For each `ModeDeclarationGroup` of category "`ALPHABETIC_ORDER`", used in the SW-C's ports, the *Application Types Header File* shall contain a definition

```
#ifndef RTE_TRANSITION_<prefix><ModeDeclarationGroup>
#define RTE_TRANSITION_<prefix><ModeDeclarationGroup> <n>U
#endif
```

where `<ModeDeclarationGroup>` is the *shortName* of the `ModeDeclarationGroup`,

`<prefix>` is the optional `prefix` attribute defined by the `IncludedModeDeclarationGroupSet` referring the `ModeDeclarationGroup` and

`<n>` is the number of modes declared within the group.[6] ⌋ *(SRS_Rte_00144)*

[SWS_Rte_03858] ⌈ For each `ModeDeclarationGroup` of category "`EXPLICIT_ORDER`", used in the SW-C's ports, the *Application Types Header File* shall contain a definition

```
#ifndef RTE_TRANSITION_<prefix><ModeDeclarationGroup>
#define RTE_TRANSITION_<prefix><ModeDeclarationGroup> \
        <onTransitionValue>U
#endif
```

where `<ModeDeclarationGroup>` is the *shortName* of the `ModeDeclarationGroup`,

`<prefix>` is the optional `prefix` attribute defined by the `IncludedModeDeclarationGroupSet` referring the `ModeDeclarationGroup` and

`<onTransitionValue>` is the `onTransitionValue` of the *ModeDeclarationGroup*. ⌋ *(SRS_Rte_00144)*

[6] No additional capitalization is applied to the names.

[SWS_Rte_07640] ⌈ The RTE Generator shall reject configurations where two ModeDeclarationGroups, used in the SW-C's ports, with the same name but different ModeDeclarations exists. ⌋*(SRS_Rte_00144, SRS_Rte_00018)*

The rational for [SWS_Rte_07640] is to protect against conditions which would lead to [SWS_Rte_02659] to generate conflicting types or macro definitions.

[SWS_Rte_02568] ⌈ For each mode of a ModeDeclarationGroup of category "ALPHABETIC_ORDER", used in the SW-C's ports, the *Application Types Header File* shall contain a definition

```
#ifndef RTE_MODE_<prefix><ModeDeclarationGroup>_<ModeDeclaration>
#define RTE_MODE_<prefix><ModeDeclarationGroup>_<ModeDeclaration> \
            <index>U
#endif
```

where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup,

<prefix> is the optional prefix attribute defined by the IncludedModeDeclarationGroupSet referring the ModeDeclarationGroup

<ModeDeclaration> is the *shortName* of a ModeDeclaration, and <index> is the index of the ModeDeclarations in alphabetic ordering (ASCII / ISO 8859-1 code in ascending order) of the *shortNames* within the ModeDeclarationGroup[7].
The lowest index shall be '0' and therefore the range of assigned values is 0..<n-1> where <n> is the number of modes declared within the group. ⌋*(SRS_Rte_00144)*

[SWS_Rte_03859] ⌈ For each mode of a ModeDeclarationGroup of category "EXPLICIT_ORDER", used in the SW-C's ports, the *Application Types Header File* shall contain a definition

```
#ifndef RTE_MODE_<prefix><ModeDeclarationGroup>_<ModeDeclaration>
#define RTE_MODE_<prefix><ModeDeclarationGroup>_<ModeDeclaration> \
            <value>U
#endif
```

where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup,

<prefix> is the optional prefix attribute defined by the IncludedModeDeclarationGroupSet referring the ModeDeclarationGroup

<ModeDeclaration> is the *shortName* of a ModeDeclaration, and <value> is the *value* specified at the ModeDeclaration. ⌋*(SRS_Rte_00144)*

5.5.5 Enumeration Data Types

Enumeration is not a plain primitive ImplementationDataType. Rather a range of integers can be used as a structural description. The mapping of integers on "labels"

[7]No additional capitalization is applied to the names.

in the enumeration is actually modeled in the SwC-T with the semantics class CompuMethod of a SwDataDefProps [2]. Enumeration data types are modeled as ImplementationDataTypes having a SwDataDefProps referencing a CompuMethod that contains only CompuScales with point ranges (i. e. lower and upper limit of a CompuScale are identical).

[SWS_Rte_03809] ⌈ The *Application Types Header File* shall include the definitions of all constants of ImplementationDataTypes and ApplicationDataTypes for each ImplementationDataType/ApplicationDataTypes used (See [SWS_Rte_08802] for the meaning of the term "used") by this software component.

This includes constants for CompuMethods referenced by ImplementationDataTypeElements of ImplementationDataTypes directly referenced by the software component and constants for CompuMethods of ImplementationDataTypes which are referenced indirectly via ImplementationDataTypes / ImplementationDataTypeElements of category TYPE_REFERENCE. ⌋*(SRS_Rte_00167)*

[SWS_Rte_03809] is applicable regardless if the AutosarDataType is referenced by an DataPrototypes in PortInterfaces used for SwComponentTypes Ports, DataPrototypes defined in the InternalBehavior of the SwComponentType or AutosarDataTypes which are only referenced by the IncludedDataTypeSet.

This requirement ensures the availability of AutosarDataType constants for the internal use in AUTOSAR software components, for example enumeration constants.

The name of those constants bases on the CompuScale symbolic name as defined in [TPS_SWCT_01569].

[SWS_Rte_03810] ⌈ For each CompuScale which has a point range and is located in the *compuInternalToPhys* container of a CompuMethod referenced by an *ImplementationDataType* or ApplicationPrimitiveDataType according [SWS_Rte_03809] with *category* "TEXTTABLE", "SCALE_LINEAR_AND_TEXTTABLE", "SCALE_RATIONAL_AND_TEXTTABLE", or BITFIELD_TEXTTABLE, the *Application Types Header File* file shall contain a definition

```
#ifndef <prefix><EnumLiteral>
#define <prefix><EnumLiteral> <value><suffix>
#endif /* <prefix><EnumLiteral> */
```

where the name of the enumeration literal <EnumLiteral> is derived according to the following rule:

if (attribute symbol of CompuScale is available and not empty) {
  <EnumLiteral> **:=** C identifier specified in symbol attribute of CompuScale
} **else** {
  if (string specified in the VT element of the CompuConst of the CompuScale
    is a valid C identifier) {
    <EnumLiteral> **:=**
      string specified in the VT element of the CompuConst of the CompuScale
  } **else** {

if (attribute shortLabel of CompuScale is available and not empty) {
<EnumLiteral> **:=**
string specified in shortLabel attribute of CompuScale
}
}
}

<prefix> is the optional literalPrefix attribute defined by the IncludedDataTypeSet referring the AutosarDataType using the CompuMethod.
<value> is the value representing the CompuScale's point range.
<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋ *(SRS_Rte_00167)*

Please note that the IncludedDataTypeSet.literalPrefix applies only to the AutosarDataType(s) explicitly referenced by the IncludedDataTypeSet and does not automatically propagate to other AutosarDataType(s) associated via DataTypeMaps. Both ApplicationDataType and mapped ImplementationDataType must be explicitly referenced if all associated labels are to have the prefix.

[SWS_Rte_03810] implies that the RTE does add prefix to the names of the enumeration constants on explicit demand only. This is necessary in order to handle enumeration constants supplied by Basic Software modules which all use their own prefix convention. Such Enumeration constant names have to be unique in the whole AUTOSAR system.

[SWS_Rte_08401] ⌈ In the case that the same ImplementationDataType or ApplicationPrimitiveDataType is referenced via different IncludedDataTypeSets with different literalPrefix attributes, the definition according to [SWS_Rte_03810] has to be provided once for each different literalPrefix. ⌋ *(SRS_Rte_00167)*

[SWS_Rte_03851] ⌈ If the input of the RTE generator contains a CompuMethod with category "TEXTTABLE", "SCALE_LINEAR_AND_TEXTTABLE", "SCALE_RATIONAL_AND_TEXTTABLE", or BITFIELD_TEXTTABLE that contains a CompuScale with a point range, and

- neither the attribute symbol of the CompuScale is available and not empty,
- nor the string specified in the VT element of the CompuConst of the CompuScale is a valid C identifier,
- nor the attribute shortLabel of CompuScale is available and not empty,

the RTE generator shall reject this input as an invalid configuration. ⌋ *(SRS_Rte_00018)*

[SWS_Rte_03813] ⌈ The RTE shall reject configurations where the same software component type uses ImplementationDataTypes and ApplicationPrimitiveDataTypes referencing two or more CompuMethods with category "TEXTTABLE", "SCALE_LINEAR_AND_TEXTTABLE", "SCALE_RATIONAL_AND_TEXTTABLE", or BITFIELD_TEXTTABLE that both contain a CompuScale with a different point range and an identical CompuScale symbolic names as an invalid configuration. The only exception is that the usage of the ImplementationDataTypes and ApplicationPrimitiveDataTypes are defined with non identical <literalPrefix>es. ⌋*(SRS_Rte_00018)*

[SWS_Rte_07175] ⌈ The RTE generator shall reject configurations violating the [constr_1434]. ⌋*(SRS_Rte_00018)*

This rejects configurations where an ImplementationDataType or an ApplicationPrimitiveDataType references a CompuMethod which is of category "TEXTTABLE", "SCALE_LINEAR_AND_TEXTTABLE", "SCALE_RATIONAL_AND_TEXTTABLE", or BITFIELD_TEXTTABLE and has CompuScales with identical CompuScale Value symbolic names.

Note that there might exist additional CompuScales with non-point ranges inside a CompuMethod of category "TEXTTABLE", "SCALE_LINEAR_AND_TEXTTABLE", "SCALE_RATIONAL_AND_TEXTTABLE", or BITFIELD_TEXTTABLE , but for those no enumeration literals are generated by the RTE generator.

The RTE generator does not support the use of C enums for DataPrototypes used in application software.

[SWS_Rte_03862] ⌈ The RTE generator shall reject configurations violating the [constr_1244], so where a DataPrototype that is used in an AtomicSwComponentType has set the swDataDefProps.additionalNativeTypeQualifier attribute set to enum. ⌋*(SRS_Rte_00018)*

[SWS_Rte_08802] The meaning of the term "used" with respect to AutosarDataTypes ⌈ An AutosarDataType is used if it meets any one of the following conditions:

- it is referenced by a DataPrototype in the SwcInternalBehavior, or
- it is referenced by a VariationPointProxy in the SwcInternalBehavior, or
- it is referenced by a DataPrototype in a PortInterface referenced by a PortPrototype, or
- it is referenced by an IncludedDataTypeSet in the SwcInternalBehavior, or
- it is the ImplementationDataType mapped to an ApplicationDataType (i.e. via the DataTypeMappingSet) that is used in one of the above ways, or
- it is an ImplementationDataTypeElement of a complex ImplementationDataType that is used in one of the above ways, or
- it is referenced as the target type of an ImplementationDataType or ImplementationDataTypeElement of category TYPE_REFERENCE that is used in one of the above ways, or

- it is an ApplicationDataType referenced as the type of a sub-element of a complex ApplicationDataType that is used in one of the above ways.

⌋*()*

5.5.6 Range Data Types

For the ApplicationPrimitiveDataType a Range might be specified by referencing a data constraint (dataConstr) giving the lowerLimit and the upperLimit. To allow a Software Component the access to these values two definitions for these values shall be generated.

[SWS_Rte_05051] ⌈ The *Application Types Header File* shall include the definitions of all lowerLimit and upperLimit constants of each ApplicationPrimitiveDataType used by this software component once per ApplicationPrimitiveDataType if the ApplicationPrimitiveDataType is not referenced via different IncludedDataTypeSets. ⌋*(SRS_Rte_00167)*

[SWS_Rte_08402] ⌈ The Application Types Header File shall include the definitions of all lowerLimit and upperLimit constants of each ApplicationPrimitiveDataType used by this software component for each combination of different literalPrefix and ApplicationPrimitiveDataType when the same ImplementationDataType or ApplicationPrimitiveDataType is referenced via different IncludedDataTypeSets. ⌋*(SRS_Rte_00167)*

[SWS_Rte_05052] ⌈ The lowerLimit and upperLimit constants for *ApplicationPrimitiveDataType* referencing a DataConstr shall be generated by RTE generator in the *Application Type Header File* as:

```
#define <prefix><DataType>_LowerLimit <lowerValue><suffix>
#define <prefix><DataType>_UpperLimit <upperValue><suffix>
```

where <DataType> is the name of the ApplicationPrimitiveDataType used by the software component.

<prefix> is the optional literalPrefix attribute defined by the IncludedDataTypeSet referring the AutosarDataType to which the DataConstr belongs.

<lowerValue> and <upperValue> are the values lowerLimit and upperLimit of the dataConstr referenced by the *ApplicationPrimitiveDataType* onto which the corresponding CompuMethod has been applied (see [SWS_Rte_07038]). The values in the macro definitions shall always reflect the closed interval, regardless of the interval type specified by the dataConstr.

<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋*(SRS_Rte_00167)*

Please note that [SWS_Rte_07196] is not applicable for [SWS_Rte_05052]. Further on it's possible that a DataPrototype using an *ApplicationPrimitiveDataType* might reference additional dataConstr (see [SWS_Rte_07196]). In this case the upperLimit and lowerLimit definitions according [SWS_Rte_05052] do not reflect the real applicable range of the DataPrototype. No macros are generated for DataPrototype specific data constraints.

Please note that the prefix can either be defined that the IncludedDataTypeSet with a literalPrefix attribute references the ApplicationDataType or it references the ImplementationDataType.

Rationale: ApplicationPrimitiveDataType is taken as the basis for the generation of limits (as opposed to take the corresponding ImplementationDataType) because the limits defined on the ImplementationDataType) may be wider than the limits of the ApplicationPrimitiveDataType ((see subsection "Data Types for Single Values" in the AUTOSAR SW-C Template [2]).

[SWS_Rte_08403] ⌈ For AUTOSAR data types which have an invalidValue specified, the Application Types header file shall contain the definition

```
#define InvalidValue_<prefix><DataType> <invalidValue><suffix>
```

where

<prefix> is the optional literalPrefix attribute defined by the Included-DataTypeSet referring the AutosarDataType

<DataType> is the short name of the data type.

<invalidValue> is the value defined as invalidValue for the data type.

<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋*()*

[SWS_Rte_08416] ⌈ The Application Types Header File shall include the definitions of all invalidValue constants used by this software component for each combination of different literalPrefix and ApplicationPrimitiveDataType when the same ImplementationDataType or ApplicationPrimitiveDataType is referenced via different IncludedDataTypeSets. ⌋*(SRS_Rte_00167)*

5.5.7 Data Types with bitfield conversions

AutosarDataTypes associated with a CompuMethod of category BITFIELD_TEXTTABLE support the concatenation of a value set inside a single scalar variable. Thereby single bits may get an individual (boolean) meaning or a set of bits is used carry an enumeration. Please note that those data types are not mapped to C bit fields rather than to scalars (e.g. uint8). Thereby the RTE Generator provides a set of definitions for the "Bit Mask", "Bit Start Position" and the "Number of Bits" in order to support the usage of the AUTOSAR Bit Handling Routines [32] for those kind of data types. For some operations on a set of bits (the set may contain only 1 bit) the AUTOSAR bitfield library requires a single contiguous bit field which means that all bits set to 1 in the in the CompuScale.mask attribute value are adjoining, e.g. 0b00010000 or 0b00111100.

[SWS_Rte_07410] ⌈ For each unique CompuScale.shortLabel / CompuScale.mask value pair for a CompuScale which is located in the compuInternalToPhys container of a CompuMethod referenced by an ImplementationDataType or ApplicationPrimitiveDataType according [SWS_Rte_03809] with category BITFIELD_TEXTTABLE the *Application Types Header File* shall contain a definition for the bit field mask

```
#ifndef <prefix><BflMaskLabel>_BflMask
#define <prefix><BflMaskLabel>_BflMask <mask><suffix>
#endif /* <prefix><BflMaskLabel>_BflMask */
```

where
<BflMaskLabel> is the value of the attribute CompuScale.shortLabel
<mask> is the value of the attribute mask
<prefix> is the optional literalPrefix attribute defined by the IncludedDataTypeSet referring the AutosarDataType using the CompuMethod.
<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋
(SRS_Rte_00167)

[SWS_Rte_07411] ⌈ For each unique CompuScale.shortLabel / CompuScale.mask value pair for a CompuScale with a single contiguous bit field which is located in the compuInternalToPhys container of a CompuMethod referenced by an ImplementationDataType or ApplicationPrimitiveDataType according [SWS_Rte_03809] with category BITFIELD_TEXTTABLE the *Application Types Header File* shall contain a definition for the bit start position

```
#ifndef <prefix><BflStartPnLabel>_BflPn
#define <prefix><BflStartPnLabel>_BflPn <BflStartPnNumber><suffix>
#endif /* <prefix><BflStartPnLabel>_BflPn */
```

where
<BitStartPnLabel> is the value of the attribute CompuScale.shortLabel
<BflStartPnNumber> is the number of the first bit in the attribute value CompuScale.mask which is set to 1. Thereby the bit counting starts from 0 (LSB) to n (MSB).
<prefix> is the optional literalPrefix attribute defined by the IncludedDataTypeSet referring the AutosarDataType using the CompuMethod.
<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋
(SRS_Rte_00167)

[SWS_Rte_07412] ⌈ For each unique CompuScale.shortLabel / CompuScale.mask value pair for a CompuScale with a single contiguous bit field which is located in the compuInternalToPhys container of a CompuMethod referenced by an ImplementationDataType or ApplicationPrimitiveDataType according [SWS_Rte_03809] with category BITFIELD_TEXTTABLE the *Application Types Header File* shall contain a definition for the bit field length

```
#ifndef <prefix><BflLengthLabel>_BflLn
#define <prefix><BflLengthLabel>_BflLn <BflLength><suffix>
#endif /* <prefix><BflLengthLabel>_BflLn */
```

where
<BflLengthLabel> is the value of the attribute shortLabel <BflLength> is the number of contiguous bits set to 1 in the attribute value CompuScale.mask. <prefix> is the optional literalPrefix attribute defined by the IncludedDataTypeSet referring the AutosarDataType using the CompuMethod.
<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋ *(SRS_Rte_00167)*

Please note the example in section F.3.

[SWS_Rte_07414] ⌈ The requirements [SWS_Rte_07410], [SWS_Rte_07411], and [SWS_Rte_07412] are only applied to CompuScales where the attribute shortLabel is defined. ⌋*(SRS_Rte_00167)*

5.6 API Reference

The functions described in this section are organized by the RTE API mapping name used by C and C++ AUTOSAR software-components to access the API. The API mapping hides from the AUTOSAR software-component programmer any need to be aware of the steps taken by the RTE generator to ensure that the generated API functions have unique names.

The instance handle as the first parameter of the API calls is marked as an optional parameter in this section. If an AUTOSAR software-component supports multiple instantiation, the instance handle shall be passed [SWS_Rte_01013].

Note that [SWS_Rte_03806] requires that the instance handle parameter does not exist if the AUTOSAR software-component does not support multiple instantiation.

5.6.1 Rte_Ports

Purpose: Provide an array of the ports of a given interface type and a given provide / require usage that can be accessed by the indirect API.

Signature: **[SWS_Rte_02619]** ⌈

```
Rte_PortHandle_<i>_<R/P/PR>
Rte_[Byps_]Ports_<i>_<R/P/PR>([IN Rte_Instance <instance>])
```

Where here <i> is the port interface name and ‘P’,‘R’ or ‘PR’ are literals to indicate provide, require or provide-require ports respectively. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_Rte_00051)*

Existence: **[SWS_Rte_02613]** ⌈ An Rte_Ports API shall be created for each interface type and usage by a port in at least one PreCompileTime variant when the indirectAPI attribute of that port is set to true. ⌋ *(SRS_Rte_00051)*

Please note that the usage of the Rte_Ports API is not restricted to particular runnables of the software component. Nevertheless the constraints with respect to RTE API usage by specific runnables are applicable for the according elements in the port data structure.

Description: The Rte_Ports API provides access to an array of ports for the port oriented API.

[SWS_Rte_03602] ⌈ Rte_Ports API shall return an array of ports which contains only those ports for which the indirect API was generated or it shall return a NULL_PTR if the port data structure for this port interface does not exist. ⌋*(SRS_Rte_00051)*

Return Value: Array of port data structures of the corresponding interface type and usage.

Notes: The existence condition for the port data structure is specified in [SWS_Rte_03799].

5.6.2 Rte_NPorts

Purpose: Provide the number of ports of a given interface type and provide / require usage that can be accessed through the indirect API.

Signature: **[SWS_Rte_02614]** ⌈

```
uint8
Rte_[Byps_]NPorts_<i>_<R/P/PR>([IN Rte_Instance <instance>])
```

Where here <i> is the port interface name and 'P', 'R' or 'PR' are literals to indicate provide, require or provide-require ports respectively. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_Rte_00051)*

Existence: **[SWS_Rte_02615]** ⌈ An Rte_NPorts API shall be created for each interface type and usage by a port in at least one PreCompileTime variant when the indirectAPI attribute of the port is set to true. ⌋ *(SRS_Rte_00051)*

Description: The Rte_NPorts API supports access to an array of ports for the port oriented API.

[SWS_Rte_03603] ⌈ The Rte_NPorts shall return the number of ports of a given interface and provide / require usage for which the indirect API was generated or 0 if the port port data structure for this port interface does not exist. ⌋*(SRS_Rte_00051)*

Return Value: Number of port data structures of the corresponding interface type and usage.

Notes: The existance condition for the port data structure is specified in [SWS_Rte_03799].

5.6.3 Rte_Port

Purpose: Provide access to the port data structure for a single port of a particular software component instance. This allows a software component to extract a sub-group of ports characterized by the same interface in order to iterate over this sub-group.

Signature: **[SWS_Rte_01354]** ⌈

```
Rte_PortHandle_<i>_<R/P/PR>
Rte_[Byps_]Port_<p>([IN Rte_Instance <instance>])
```

where `<i>` is the port interface name and `<p>` is the name of the port. `[Byps_]` is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_Rte_00051)*

Existence: **[SWS_Rte_01355]** ⌈ An `Rte_Port` API shall be created for each port of an AUTOSAR SW-C, for which the `indirectAPI` attribute is set to true. ⌋*(SRS_Rte_00051)*

Please note that the usage of the `Rte_Port` API is not restricted to particular runnables of the software component. Nevertheless the constraints with respect to RTE API usage by specific runnables are applicable for the according elements in the port data structure.

Description: The `Rte_Port` API provides a pointer to a single port data structure, in order to support the indirect API.

Return Value: Pointer to port data structure for the appropriate port.

Notes: None.

5.6.4 Rte_Write

Purpose: Initiate an “explicit” sender-receiver transmission of data elements with “data” semantic (`swImplPolicy` different from `queued`).

Signature: **[SWS_Rte_01071]** ⌈

```
Std_ReturnType
Rte_[Byps_]Write_<p>_<o>([IN Rte_Instance <instance>],
        IN <data>,
        [OUT Rte_TransformerError transformerError])
```

Where <p> is the port name and <o> the VariableDataPrototype within the sender-receiver interface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00098, SRS_Rte_00028, SRS_Rte_00131)*

Existence: **[SWS_Rte_01280]** ⌈ The presence of a VariableAccess in the dataSendPoint role for a provided VariableDataPrototype with data semantics shall result in the generation of an Rte_Write API for the provided VariableDataPrototype. ⌋*(SRS_Rte_00051)*

[SWS_Rte_CONSTR_09015] Rte_Write API may only be used by the runnable that describe its usage ⌈ The Rte_Write API may only be used by the runnable that contains the corresponding VariableAccess in the dataSendPoint role ⌋*()*

[SWS_Rte_08574] ⌈ The optional OUT parameter transformerError of the API shall be generated if the PortPrototype of port <p> is referenced by a PortAPIOption which has the attribute errorHandling set to transformerErrorHandling. ⌋*(SRS_Rte_00249)*

Description: The Rte_Write API call initiates a sender-receiver communication where the transmission occurs at the point the API call is made (cf. explicit transmission).

The Rte_Write API call includes the IN parameter <data> to pass the data element to write.

The IN parameter <data> is passed by value or reference according to the ImplementationDataType as described in the section 5.2.6.5.

If the IN parameter <data> is passed by reference, the pointer must remain valid until the API call returns.

The OUT parameter transformerError contains the transformer error which occured during execution of the transformer chain. See chapter 4.10.5.

The RTE generator shall take into account the kind of connected require port which might not be just a variable but also a NV data. The table 4.7 gives an overview of compatibility rules.

Return Value: The return value is used to indicate errors detected by the RTE during execution of the Rte_Write.

- **[SWS_Rte_07820]** ⌈ RTE_E_OK – data passed to communication service successfully. ⌋*(SRS_Rte_00094)*

- **[SWS_Rte_07822]** ⌈ RTE_E_COM_STOPPED – the RTE could not perform the operation because the communication service is currently not available (inter ECU communication only). RTE shall return RTE_E_COM_STOPPED when:
  - in case of COM the corresponding service returns COM_SERVICE_NOT_AVAILABLE
  - in case of LdCom the corresponding LdCom_Transmit returns E_NOT_OK

  ⌋*(SRS_Rte_00094)*
- **[SWS_Rte_02756]** ⌈ RTE_E_SEG_FAULT – a segmentation violation is detected in the handed over parameters to the RTE API as required in [SWS_Rte_02752] and [SWS_Rte_02753]. No transmission is executed. ⌋*(SRS_Rte_00210)*
- **[SWS_Rte_01390]** ⌈ RTE_E_COM_BUSY – The transmission is rejected due to a currently ongoing transmission. The transmission is not executed. ⌋*(SRS_Rte_00246)*

  Note: API call can be retried after the currently ongoing request has finished.
- **[SWS_Rte_08546]** ⌈ RTE_E_HARD_TRANSFORMER_ERROR – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_08557]** ⌈ RTE_E_SOFT_TRANSFORMER_ERROR – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*

Notes: The Rte_Write call is used to transmit “data” (swImplPolicy not queued).

[SWS_Rte_07824] ⌈ In case of inter ECU communication, the Rte_Write shall cause an immediate transmission request. ⌋ *(SRS_Rte_00028, SRS_Rte_00131)*

Note that depending on the configuration a transmission request may not result in an actual transmission, for example transmission may be rate limited (time-based filtering) and thus dependent on other factors than API calls.

[SWS_Rte_07826] ⌈ In case of inter ECU communication, the Rte_Write API shall return when the signal has been passed to the communication service for transmission. ⌋*(SRS_Rte_00028, SRS_Rte_00131)*

Depending on the communication server the transmission may or may not have been acknowledged by the receiver at the point the API call returns.

[SWS_Rte_02635] ⌈ In case of intra ECU communication, the `Rte_Write` API call shall return after copying the data to RTE local memory or using IOC buffers. ⌋*(SRS_Rte_00028, SRS_Rte_00131)*

[SWS_Rte_01080] ⌈ If the transmission acknowledgement is enabled, the RTE shall notify component when the transmission is acknowledged or a transmission error occurs. ⌋*(SRS_Rte_00122)*

[SWS_Rte_01082] ⌈ If a provide port typed by a sender-receiver interface has multiple require ports connected (i.e. it has multiple receivers), then the RTE shall ensure that writes to all receivers are independent. ⌋*(SRS_Rte_00028)*

Requirement [SWS_Rte_01082] ensures that an error detected by the RTE when writing to one receiver, e.g. communication is stopped, does not prevent the transmission of this message to other components.

[SWS_Rte_08413] ⌈ If a provide port typed by a sender-receiver interface has multiple require ports connected (i.e. it has multiple receivers), then the RTE shall return `RTE_E_OK` only if no error at all occurred. ⌋*(SRS_Rte_00028)*

[SWS_Rte_08414] ⌈ In case of multiple faults during a call of `Rte_Write` the resulting return value shall be derived according to the following priority rules (highest priority first):

1. `RTE_E_SEG_FAULT`
2. `RTE_E_HARD_TRANSFORMER_ERROR`
3. `RTE_E_COM_STOPPED`
4. `RTE_E_SOFT_TRANSFORMER_ERROR`

⌋*(SRS_Rte_00028)*

5.6.5 Rte_Send

Purpose: Initiate an “explicit” sender-receiver transmission of data elements with “event” semantic (`swImplPolicy` equal to `queued`).

Signature: **[SWS_Rte_01072]** ⌈

```
Std_ReturnType
Rte_[Byps_]Send_<p>_<o>([IN Rte_Instance <instance>],
        IN <data>,
        [OUT Rte_TransformerError transformerError])
```

Where <p> is the port name and <o> the VariableDataPrototype within the sender-receiver interface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00141, SRS_Rte_00028, SRS_Rte_00131)*

Existence: **[SWS_Rte_01281]** ⌈ The presence of a VariableAccess in the dataSendPoint role for a provided VariableDataPrototype with event semantics shall result in the generation of an Rte_Send API for the provided VariableDataPrototype. ⌋*(SRS_Rte_00051)*

[SWS_Rte_CONSTR_09016] Rte_Send API may only be used by the runnable that describes its usage ⌈ The Rte_Send API may only be used by the runnable that contains the corresponding VariableAccess in the dataSendPoint role ⌋*()*

[SWS_Rte_08562] ⌈ The optional OUT parameter transformerError of the API shall be generated if the PortPrototype of port <p> is referenced by a PortAPIOption which has the attribute errorHandling set to transformerErrorHandling. ⌋*(SRS_Rte_00249)*

Description: The Rte_Send API call initiates a sender-receiver communication where the transmission occurs at the point the API call is made (cf. explicit transmission).

The Rte_Send API call includes the IN parameter <data> to pass the data element to send.

The IN parameter <data> is passed by value or reference according to the ImplementationDataType as described in the section 5.2.6.5.

If the IN parameter <data> is passed by reference, the pointer must remain valid until the API call returns.

The OUT parameter transformerError contains the transformer error which occured during execution of the transformer chain. See chapter 4.10.5.

The RTE generator has to take into account the kind of connected require port which might not be just a variable but also a NV data. The table 4.7 gives an overview of compatibility rules.

Return Value: The return value is used to indicate errors detected by the RTE during execution of the Rte_Send.

- **[SWS_Rte_07821]** ⌈ RTE_E_OK – data passed to communication service successfully. ⌋*(SRS_Rte_00094)*

- **[SWS_Rte_07823]** ⌈ RTE_E_COM_STOPPED – the RTE could not perform the operation because the communication service is currently not available (inter ECU communication only). RTE shall return RTE_E_COM_STOPPED when:
  - in case of COM the corresponding service returns COM_SERVICE_NOT_AVAILABLE
  - in case of LdCom the corresponding LdCom_Transmit returns E_NOT_OK

  ⌋*(SRS_Rte_00094)*
- **[SWS_Rte_02634]** ⌈ RTE_E_LIMIT – an 'event' has been discarded due to a full queue by one of the ECU local receivers (intra ECU communication only). ⌋*(SRS_Rte_00143)*
- **[SWS_Rte_02754]** ⌈ RTE_E_SEG_FAULT – a segmentation violation is detected in the handed over parameters to the RTE API as required in [SWS_Rte_02752] and [SWS_Rte_02753]. No transmission is executed. ⌋*(SRS_Rte_00210)*
- **[SWS_Rte_08547]** ⌈ RTE_E_HARD_TRANSFORMER_ERROR – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_08553]** ⌈ RTE_E_SOFT_TRANSFORMER_ERROR – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*

Notes: The Rte_Send call is used to transmit "events" (swImplPolicy = queued).

[SWS_Rte_07825] ⌈ In case of inter ECU communication, the Rte_Send shall cause an immediate transmission request. ⌋*(SRS_Rte_00028, SRS_Rte_00131)*

Note that depending on the configuration a transmission request may not result in an actual transmission, for example transmission may be rate limited (time-based filtering) and thus dependent on other factors than API calls.

[SWS_Rte_07827] ⌈ In case of inter ECU communication, the Rte_Send API shall return when the signal has been passed to the communication service for transmission. ⌋*(SRS_Rte_00028, SRS_Rte_00131)*

Depending on the communication server the transmission may or may not have been acknowledged by the receiver at the point the API call returns.

[SWS_Rte_02633] ⌈ In case of intra ECU communication, the `Rte_Send` API call shall return after attempting to enqueue the data in the IOC or RTE internal queues. ⌋*(SRS_Rte_00028, SRS_Rte_00131)*

If the transmission acknowledgement is enabled, the RTE has to notify component when the transmission is acknowledged or a transmission error occurs. [SWS_Rte_01080]

If a provide port typed by a sender-receiver interface has multiple require ports connected (i.e. it has multiple receivers), then the RTE shall ensure that writes to all receivers are independent. [SWS_Rte_01082]

Requirement [SWS_Rte_01082] ensures that an error detected by the RTE when writing to one receiver, e.g. an overflow in one component's queue, does not prevent the transmission of this message to other components.

If a provide port typed by a sender-receiver interface has multiple require ports connected (i.e. it has multiple receivers), then the RTE shall return `RTE_E_OK` only if no error at all occurred. [SWS_Rte_08413]

[SWS_Rte_08415] ⌈ In case of multiple faults during a call of `Rte_Send` the resulting return value shall be derived according to the following priority rules (highest priority first):

1. `RTE_E_SEG_FAULT`
2. `RTE_E_LIMIT` (only in case of Intra-ECU communication)
3. `RTE_E_HARD_TRANSFORMER_ERROR`
4. `RTE_E_COM_STOPPED`
5. `RTE_E_SOFT_TRANSFORMER_ERROR`

⌋*(SRS_Rte_00028)*

5.6.6 Rte_Switch

Purpose: Initiate a mode switch. The `Rte_Switch` API call is used for 'explicit' sending of a `mode switch notification`.

Signature: **[SWS_Rte_02631]** ⌈

```
Std_ReturnType
Rte_[Byps_]Switch_<p>_<o>([IN Rte_Instance <instance>],
                          IN <mode>)
```

Where <p> is the port name and <o> the *ModeDeclarationGroupPrototype* within the ModeSwitchInterface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00143, SRS_Rte_00028, SRS_Rte_00131)*

Existence: **[SWS_Rte_02632]** ⌈The existence of a *ModeSwitchPoint* shall result in the generation of a Rte_Switch API. ⌋*(SRS_Rte_00051)*

[SWS_Rte_CONSTR_09017] Rte_Switch API may only be used by the runnable that describes its usage ⌈The Rte_Switch API may only be used by the runnable that contains the corresponding *ModeSwitchPoint* ⌋*()*

Description: The Rte_Switch triggers a mode switch for all connected require ModeDeclarationGroupPrototypes.

The Rte_Switch API call includes exactly one IN parameter for the next mode <mode>. The IN parameter <mode> is passed by value according to the ImplementationDataType on which the *ModeDeclarationGroup* is mapped. The type name shall be equal to the shortName of the ImplementationDataType.

Return Value: The return value is used to indicate errors detected by the RTE during execution of the Rte_Switch call.

- **[SWS_Rte_02674]** ⌈RTE_E_OK – data passed to service successfully. ⌋*(SRS_Rte_00094)*
- **[SWS_Rte_02675]** ⌈RTE_E_LIMIT – a mode switch has been discarded by the receiving partition due to a full queue. ⌋*(SRS_Rte_00143)*

Notes: Rte_Switch is restricted to ECU local communication.

If a mode instance is currently involved in a transition then the Rte_Switch API will attempt to queue the request and return [SWS_Rte_02667]. However if no transition is in progress for the mode instance, the mode disablings and the activations of on-entry, on-transition, and on-exit ExecutableEntities for this mode instance are executed before the Rte_Switch API returns [SWS_Rte_02665].

Note that the mode switch might be discarded when the queue is full and a mode transition is in progress, see [SWS_Rte_02675].

5.6.7 Rte_Invalidate

Purpose: Invalidate a data element for an "explicit" sender-receiver transmission.

Signature: **[SWS_Rte_01206]** ⌈

```
Std_ReturnType
Rte_[Byps_]Invalidate_<p>_<o>(
    [IN Rte_Instance <instance>],
    [OUT Rte_TransformerError transformerError])
```

Where <p> is the port name and <o> the VariableDataPrototype within the sender-receiver interface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00078)*

Existence: **[SWS_Rte_01282]** ⌈ An Rte_Invalidate API shall be created for any VariableAccess in the dataSendPoint role that references a provided VariableDataPrototype which associated InvalidationPolicy is set to keep, replace or externalReplacement. ⌋*(SRS_Rte_00051, SRS_Rte_00078)*

[SWS_Rte_CONSTR_09018] Rte_Invalidate API may only be used by the runnable that describe its usage ⌈ The Rte_Invalidate API may only be used by the runnable that contains the corresponding VariableAccess in the dataSendPoint role ⌋*()*

[SWS_Rte_08582] ⌈ The optional OUT parameter transformerError of the API shall be generated if the PortPrototype of port <p> is referenced by a PortAPIOption which has the attribute errorHandling set to transformerErrorHandling. ⌋*(SRS_Rte_00249)*

Description: The Rte_Invalidate API takes the instance handle as input parameter. The return value is used to indicate the success, or otherwise, of the API call to the caller.

The OUT parameter transformerError contains the transformer error which occured during execution of the transformer chain. See chapter 4.10.5.

Return Value: The return value is used to indicate the "OK" status or errors detected by the RTE during execution of the Rte_Invalidate call.

- **[SWS_Rte_01207]** ⌈ RTE_E_OK – No error occurred. ⌋*(SRS_Rte_00094)*
- **[SWS_Rte_01339]** ⌈ RTE_E_COM_STOPPED – the RTE could not perform the operation because the communication service

is currently not available (inter ECU communication only). RTE shall return RTE_E_COM_STOPPED when:

- in case of COM the corresponding service returns COM_SERVICE_NOT_AVAILABLE
- in case of LdCom the corresponding LdCom_Transmit returns E_NOT_OK

⌋*(SRS_Rte_00094)*

- **[SWS_Rte_08576]** ⌈ RTE_E_HARD_TRANSFORMER_ERROR – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_08577]** ⌈ RTE_E_SOFT_TRANSFORMER_ERROR – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*

[SWS_Rte_08583] ⌈ In case of multiple faults during a call of Rte_Invalidate the resulting return value shall be derived according to the following priority rules (highest priority first): (1) RTE_E_HARD_TRANSFORMER_ERROR, (2) RTE_E_COM_STOPPED, (3) RTE_E_SOFT_TRANSFORMER_ERROR. ⌋*(SRS_Rte_00122)*

Notes: The API name includes an identifier <p>_<o> that is formed from the port and operation item names. See Section 5.2.6.4 for details on the naming convention.

The communication service configuration determines whether the signal receiver(s) receive an “invalid signal” notification or whether the invalidated signal is silently replaced by the signal’s initial value.

5.6.8 Rte_Feedback

Purpose: Provide access to acknowledgement notifications for explicit sender-receiver communication and to pass error notification to senders.

Signature: **[SWS_Rte_01083]** ⌈

```
Std_ReturnType
Rte_[Byps_]Feedback_<p>_<o>(
    [IN Rte_Instance <instance>])
```

Where <p> is the port name and <o> the VariableDataPrototype within the sender-receiver interface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00122)*

Existence: **[SWS_Rte_01283]** ⌈ Acknowledgement is enabled for a provided VariableDataPrototype by the existence of a TransmissionAcknowledgementRequest in the SenderComSpec. ⌋ *(SRS_Rte_00051, SRS_Rte_00122)*

[SWS_Rte_01284] ⌈ A blocking Rte_Feedback API shall be generated for a provided VariableDataPrototype if acknowledgement is enabled and a WaitPoint references a DataSendCompletedEvent that in turn references the VariableAccess which in turn references the VariableDataPrototype. ⌋ *(SRS_Rte_00051, SRS_Rte_00122)*

[SWS_Rte_07850] ⌈ A blocking Rte_Feedback API shall block when a transmission of the related VariableDataPrototype is ongoing. ⌋ *(SRS_Rte_00051, SRS_Rte_00122)*

[SWS_Rte_07851] ⌈ A blocking Rte_Feedback API shall return:

- if the sender port is not connected or
- if the calling runnable runs in an exclusive area or
- if no transmission of the related VariableDataPrototype is ongoing or
- when the wait point timeout occurs or
- when the related DataSendCompletedEvent is triggered.

⌋ *(SRS_Rte_00051, SRS_Rte_00122)*

[SWS_Rte_01285] ⌈ A non-blocking Rte_Feedback API shall be generated for a provided VariableDataPrototype if acknowledgement is enabled and a VariableAccess in the dataSendPoint role references the VariableDataPrototype but no WaitPoint references the DataSendCompletedEvent that references the VariableAccess which in turn references the VariableDataPrototype. ⌋ *(SRS_Rte_00051, SRS_Rte_00122)*

Please note that a non-blocking Rte_Feedback API does not require the existence of a DataSendCompletedEvent. If the DataSendCompletedEvent exists it can be used to trigger the execution of a RunnableEntity in which the non-blocking Rte_Feedback API function may be called.

[SWS_Rte_01286] ⌈ If acknowledgement is enabled for a provided VariableDataPrototype and a DataSendCompletedEvent references a runnable entity as well as the VariableAccess which in turn references the VariableDataPrototype, the runnable entity shall be activated when the transmission acknowledgement occurs or when a timeout was detected by the RTE. [SWS_Rte_01137]. ⌋ *(SRS_Rte_00051, SRS_Rte_00122)*

Requirement [SWS_Rte_01286] merely affects when the runnable is activated – an API call should still be created, according to requirement [SWS_Rte_01285] to actually read the data.

[SWS_Rte_01287] ⌈ A DataSendCompletedEvent that references a RunnableEntity and is referenced by a WaitPoint shall be an invalid configuration which is rejected by the RTE generator. ⌋ *(SRS_Rte_00051, SRS_Rte_00122, SRS_Rte_00018)*

[SWS_Rte_CONSTR_09019] Rte_Feedback API may only be used by the runnable that describe its usage ⌈ A blocking Rte_Feedback API may only be used by the runnable that contains the corresponding WaitPoint ⌋*()*

[SWS_Rte_07634] ⌈ A call to Rte_Feedback shall not change the status returned by Rte_Feedback. ⌋*(SRS_Rte_00122)*

The Rte_Feedback API return value is only changed when a new transmission is requested (Rte_Send or Rte_Write) or when the notification from COM is received.

[SWS_Rte_07635] ⌈ After a Rte_Send or Rte_Write transmission request, only the first notification from COM shall be taken into account for a given Signal or SignalGroup. ⌋*(SRS_Rte_00122)*

[SWS_Rte_07635] is needed in case of cyclic transmission which could result in multiple transmissions with different status.

Description: The Rte_Feedback API takes no parameters other than the instance handle – the return value is used to indicate the acknowledgement status to the caller.

The Rte_Feedback API applies only to explicit sender-receiver communication.

Return Value: The return value is used to indicate the status of the transmission and errors detected by the RTE.

- **[SWS_Rte_01084]** ⌈ RTE_E_NO_DATA – No acknowledgments or error notifications were received from COM when the Rte_Feedback API was called (non-blocking call) or when the WaitPoint timeout expired (blocking call). ⌋*(SRS_Rte_00094, SRS_Rte_00122)*
- RTE_E_COM_STOPPED – returned in one of these cases:
  - **[SWS_Rte_07636]** ⌈ (Inter-ECU communication only) The last transmission was rejected (when the Rte_Send or Rte_Write API was called), with an RTE_E_COM_STOPPED return code. ⌋*(SRS_Rte_00094, SRS_Rte_00122)*

- **[SWS_Rte_03774]** ⌈ (Inter-ECU communication only) An error notification from COM was received before any timeout notification. ⌋*(SRS_Rte_00094, SRS_Rte_00122)*

- **[SWS_Rte_07637]** ⌈ `RTE_E_TIMEOUT` – (Inter-ECU and Inter-Partition only) A timeout notification was received from COM or IOC before any error notification. ⌋*(SRS_Rte_00094, SRS_Rte_00122)*
- **[SWS_Rte_01086]** ⌈ `RTE_E_TRANSMIT_ACK` – In case of inter-ECU communication, a transmission acknowledgment was received from COM; or in case of intra-ECU communication, even if a queue overflow occurred. ⌋*(SRS_Rte_00094, SRS_Rte_00122)*
- `RTE_E_UNCONNECTED` – Indicates that the sender port is not connected [SWS_Rte_01344].
- **[SWS_Rte_02740]** ⌈ `RTE_E_IN_EXCLUSIVE_AREA` – Used only for the blocking API. `RTE_E_IN_EXCLUSIVE_AREA` indicates that the runnable can not enter wait, as one of the `ExecutableEntity`s in the call stack of this task is currently in an exclusive area, see [SWS_Rte_02739]. - In a properly configured system, this error should not occur. The check can be disabled according to [SWS_Rte_08318]. ⌋*(SRS_Rte_00092, SRS_Rte_00046, SRS_Rte_00032)*
- **[SWS_Rte_08578]** ⌈ `RTE_E_HARD_TRANSFORMER_ERROR` – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_08579]** ⌈ `RTE_E_SOFT_TRANSFORMER_ERROR` – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_08318]** ⌈ If `RteInExclusiveAreaCheckEnabled` is set to *false* the RTE generator shall omit the check and return of [SWS_Rte_02740]. ⌋*(SRS_Rte_00092, SRS_Rte_00046, SRS_Rte_00032)*

The `RTE_E_NO_DATA`, `RTE_E_TRANSMIT_ACK` and `RTE_E_UNCONNECTED` return values are not considered to be an error but rather indicates correct operation of the API call.

[SWS_Rte_07652] ⌈ The initial return value of the `Rte_Feedback` API, before any attempt to write some data shall be `RTE_E_TRANSMIT_ACK`. ⌋*(SRS_Rte_00094, SRS_Rte_00122, SRS_Rte_00128, SRS_Rte_00185)*

[SWS_Rte_08075] ⌈ In case of multiple faults during a call of Rte_Feedback the resulting return value shall be derived according to the following priority rules (highest priority first): (1) RTE_E_UNCONNECTED, (2) RTE_E_IN_EXCLUSIVE_AREA, (3) RTE_E_TIMEOUT, (4) RTE_E_HARD_TRANSFORMER_ERROR, (5) RTE_E_COM_STOPPED, (6) RTE_E_NO_DATA, (7) RTE_E_SOFT_TRANSFORMER_ERROR, (8) RTE_E_TRANSMIT_ACK. ⌋*(SRS_Rte_00122)*

Notes: If multiple transmissions on the same port/element are outstanding it is not possible to determine which is acknowledged first. If this is important, transmissions should be call serialized with the next occurring only when the previous transmission has been acknowledged or has timed out.

A transmission acknowledgment (or error and timeout) notification is not always provided by COM (the bus or PDU Router may not support transmission acknowledgment for this PDU, or COM may not be configured to perform transmission deadline monitoring).

In case of a blocking Rte_Feedback the value of the WaitPoint timeout depends on the timeout defined at the COM level.

5.6.9 Rte_SwitchAck

Purpose: Provide access to mode switch completed acknowledgements and error notifications to mode managers.

Signature: **[SWS_Rte_02725]** ⌈

```
Std_ReturnType
Rte_[Byps_]SwitchAck_<p>_<o>(
    [IN Rte_Instance <instance>])
```

Where <p> is the port name and <o> the ModeDeclarationGroupPrototype within the ModeSwitchInterface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00122)*

Existence: **[SWS_Rte_02676]** ⌈ Acknowledgement is enabled for a provided ModeDeclarationGroupPrototype by the existence of a ModeSwitchedAckRequest in the ModeSwitchSenderComSpec. ⌋*(SRS_Rte_00051, SRS_Rte_00122)*

[SWS_Rte_02677] ⌈ A blocking Rte_SwitchAck API shall be generated for a provided ModeDeclarationGroupPrototype if acknowledgement is enabled and a WaitPoint references a ModeSwitchedAckEvent that in turn references the ModeDeclarationGroupPrototype. ⌋*(SRS_Rte_00051, SRS_Rte_00122)*

[SWS_Rte_07846] ⌈ A blocking Rte_SwitchAck API shall block when a mode switch in the related mode machine instance is ongoing. ⌋*(SRS_Rte_00122, SRS_Rte_00092)*

[SWS_Rte_07847] ⌈ A blocking Rte_SwitchAck API shall return:

- if the mode machine instance behaves as unconnected or
- if the calling runnable runs in an exclusive area or
- if no mode switch in the related mode machine instance is ongoing or
- when the wait point timeout occurs or
- when the related ModeSwitchedAckEvent is triggered.

⌋*(SRS_Rte_00122, SRS_Rte_00092, SRS_Rte_00139)*

[SWS_Rte_02678] ⌈ A non-blocking Rte_SwitchAck API shall be generated for a provided ModeDeclarationGroupPrototype if acknowledgement is enabled but no WaitPoint references a ModeSwitchedAckEvent that references the ModeDeclarationGroupPrototype.

Please note that a non-blocking API does not require the existence of a ModeSwitchedAckEvent. If the ModeSwitchedAckEvent exists it can be used to trigger the execution of a RunnableEntity in which the non-blocking API function may be called. ⌋*(SRS_Rte_00051, SRS_Rte_00122)*

[SWS_Rte_CONSTR_09020] The blocking Rte_SwitchAck API may only be used by the runnable that describes its usage. ⌈ A blocking Rte_SwitchAck API must only be used by the runnable that contains the corresponding WaitPoint ⌋*()*

Description: The Rte_SwitchAck API takes no parameters other than the instance handle – the return value is used to indicate the acknowledgement status to the caller.

Return Value: The return value is used to indicate the status of a mode switch and errors detected by the RTE.

- **[SWS_Rte_02727]** ⌈ RTE_E_NO_DATA – (non-blocking read) The mode switch is still in progress. ⌋*(SRS_Rte_00094, SRS_Rte_00122)*

- **[SWS_Rte_02728]** ⌈ RTE_E_TIMEOUT – The configured timeout exceeds before the mode transition was completed. ⌋ *(SRS_Rte_00094, SRS_Rte_00210)*
- **[SWS_Rte_03853]** ⌈ RTE_E_TIMEOUT – Any mode users partition is stopped or restarting or has been restarted while the mode switch was requested. ⌋*(SRS_Rte_00094, SRS_Rte_00210)*
- **[SWS_Rte_02729]** ⌈ RTE_E_TRANSMIT_ACK – The mode switch has been completed (see [SWS_Rte_02587]). ⌋ *(SRS_Rte_00094, SRS_Rte_00122)*
- **[SWS_Rte_07659]** ⌈ RTE_E_UNCONNECTED – Indicates that the mode provider port is not connected. ⌋*(SRS_Rte_00094, SRS_Rte_00122, SRS_Rte_00139)*
- **[SWS_Rte_02741]** ⌈ RTE_E_IN_EXCLUSIVE_AREA – Used only for the blocking API. RTE_E_IN_EXCLUSIVE_AREA indicates that the runnable can not enter wait, as one of the ExecutableEntitys in the call stack of this task is currently in an exclusive area, see [SWS_Rte_02739]. - In a properly configured system, this error should not occur. The check can be disabled according to [SWS_Rte_08319]. ⌋*(SRS_Rte_00092, SRS_Rte_00046, SRS_Rte_00032)*
- **[SWS_Rte_08319]** ⌈ If RteInExclusiveAreaCheckEnabled is set to *false* the RTE generator shall omit the check and return of [SWS_Rte_02741]. ⌋*(SRS_Rte_00092, SRS_Rte_00046, SRS_Rte_00032)*

The RTE_E_TRANSMIT_ACK return value is not considered to be an error but rather indicates correct operation of the API call.

When RTE_E_NO_DATA occurs, a component is free to re-invoke Rte_SwitchAck and thus repeat the attempt to read the status of the mode switch.

[SWS_Rte_07848] ⌈ The initial return value of the Rte_SwitchAck API before any attempt to switch a mode shall be RTE_E_TRANSMIT_ACK. ⌋*(SRS_Rte_00094, SRS_Rte_00122)*

[SWS_Rte_07849] ⌈ In case of multiple faults during a call of Rte_SwitchAck the resulting return value shall be derived according to the following priority rules (highest priority first): (1) RTE_E_UNCONNECTED, (2) RTE_E_IN_EXCLUSIVE_AREA, (3) RTE_E_TIMEOUT, (4) RTE_E_NO_DATA, (5) RTE_E_TRANSMIT_ACK. ⌋*(SRS_Rte_00094, SRS_Rte_00122)*

Notes: If multiple mode switches of the same mode machine instance are outstanding, it is not possible to determine which is acknowledged first. If this is important, switches should be serialized with the next switch occurring only when the previous switch has been acknowledged. The queue length should be 1.

5.6.10 Rte_Read

Purpose: Performs an "explicit" read on a sender-receiver communication data element with "data" semantics (swImplPolicy != queued). By compatibility, the port may also have a ParameterInterface or a NvDataInterface. The Rte_Read API is used for explicit read by argument.

Signature: **[SWS_Rte_01091]** ⌈

```
Std_ReturnType
Rte_[Byps_]Read_<p>_<o>(
     [IN Rte_Instance <instance>],
     OUT <data>,
     [OUT Rte_TransformerError transformerError])
```

Where <p> is the port name and <o> the VariableDataPrototype within the sender-receiver interface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00141, SRS_Rte_00028, SRS_Rte_00131)*

Existence: **[SWS_Rte_01289]** ⌈ A non-blocking Rte_Read API shall be generated if a VariableAccess in the dataReceivePointByArgument role references a required VariableDataPrototype with 'data' semantics. ⌋*(SRS_Rte_00051)*

[SWS_Rte_07396] ⌈ The RTE shall ensure that direct explicit read accesses will not deliver undefined data item values. In case there may be an explicit read access before the first data reception an initial value shall be provided as the result of this explicit read access. ⌋*(SRS_Rte_00051, SRS_Rte_00183)*

A WaitPoint cannot reference a DataReceivedEvent that in turn references a required VariableDataPrototype with 'data' semantics shall be considered an invalid configuration (see [SWS_Rte_03018]). Hence there are no blocking Rte_Read API.

[SWS_Rte_CONSTR_09021] Rte_Read API may only be used by the runnable that describe its usage ⌈ The Rte_Read API may only be used by the runnable that contains the corresponding VariableAccess in the dataReceivePointByArgument role ⌋*()*

[SWS_Rte_01313] ⌈ A DataReceivedEvent that references a runnable entity and is referenced by a WaitPoint shall be an invalid configuration. ⌋*(SRS_Rte_00051, SRS_Rte_00018)*

The RTE generator shall take into account the kind of provide port which might not be just a variable but also a Parameter (fixed, const or standard), a standard sender (i.e. a variable) or a NV data. The table 4.7 gives an overview of compatibility rules.

[SWS_Rte_08563] ⌈ The optional OUT parameter transformerError of the API shall be generated if the PortPrototype of port <p> is referenced by a PortAPIOption which has the attribute errorHandling set to transformerErrorHandling. ⌋*(SRS_Rte_00249)*

Description: The Rte_Read API call includes the OUT parameter <data> to pass back the received data.

The pointer to the OUT parameter <data> must remain valid until the API call returns.

The OUT parameter transformerError contains the transformer error which occured during execution of the transformer chain. See chapter 4.10.5.

Return Value: The return value is used to indicate errors detected by the RTE during execution of the Rte_Read API call or errors detected by the communication system.

- **[SWS_Rte_01093]** ⌈ RTE_E_OK – data read successfully. ⌋*(SRS_Rte_00094)*
- **[SWS_Rte_02626]** ⌈ RTE_E_INVALID – data element invalid. ⌋*(SRS_Rte_00078)*
- **[SWS_Rte_02703]** ⌈ RTE_E_MAX_AGE_EXCEEDED – data element outdated. This Overlayed Error can be combined with any other error code. ⌋*(SRS_Rte_00147)*
- **[SWS_Rte_07643]** ⌈ RTE_E_NEVER_RECEIVED – No data received since system start or partition restart. ⌋*(SRS_Rte_00184, SRS_Rte_00224)*
- **[SWS_Rte_01371]** ⌈ RTE_E_OUT_OF_RANGE – data element out of range. ⌋*(SRS_Rte_00180)*
- **[SWS_Rte_01391]** ⌈ RTE_E_COM_BUSY – The read request is rejected due to a currently ongoing reception. No received data can be provided. ⌋*(SRS_Rte_00246)*

  Note: API call can be retried after the currently ongoing request has finished.

- **[SWS_Rte_06830]** ⌈ RTE_E_COM_STOPPED – The RTE could not perform the operation because the COM service is currently not available (inter ECU communication only). RTE shall return RTE_E_COM_STOPPED when the corresponding COM service returns COM_SERVICE_NOT_AVAILABLE. In case of stopped I-PDUS the last known value (or init value) is given back as data. ⌋*(SRS_Rte_00094)*
- RTE_E_UNCONNECTED – Indicates that the receiver port is not connected [SWS_Rte_01330].
- **[SWS_Rte_08548]** ⌈ RTE_E_HARD_TRANSFORMER_ERROR – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_08554]** ⌈ RTE_E_SOFT_TRANSFORMER_ERROR – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*

[SWS_Rte_08592] ⌈ In case of multiple faults during a call of Rte_Read the resulting return value shall be derived according to the following priority rules (highest priority first):

1. RTE_E_UNCONNECTED
2. RTE_E_COM_STOPPED
3. RTE_E_NEVER_RECEIVED
4. RTE_E_COM_BUSY
5. RTE_E_HARD_TRANSFORMER_ERROR
6. RTE_E_INVALID
7. RTE_E_OUT_OF_RANGE
8. RTE_E_SOFT_TRANSFORMER_ERROR

⌋*(SRS_Rte_00028)*

Please note that RTE_E_MAX_AGE_EXCEEDED is an overlay error and could be combined with any other error. Nevertheless in case of RTE_E_UNCONNECTED or RTE_E_COM_STOPPED time out monitoring is NOT active which in turn excludes the coincidence of RTE_E_MAX_AGE_EXCEEDED.

Notes: The API name includes an identifier <p>_<o> that indicates the read access point name and is formed from the port and operation item names. See section 5.2.6.4 for details on the naming convention.

5.6.11 Rte_DRead

Purpose: Performs an "explicit" read on a sender-receiver communication data element with "data" semantics (swImplPolicy != queued). By compatibility, the port may also have a ParameterInterface or a NvDataInterface. The Rte_DRead API is used for explicit read by value.

Signature: **[SWS_Rte_07394]** ⌈

```
<return>
Rte_[Byps_]DRead_<p>_<o>([IN Rte_Instance <instance>],
          [OUT Rte_TransformerError transformerError])
```

Where <p> is the port name and <o> the VariableDataPrototype within the sender-receiver interface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00141, SRS_Rte_00028, SRS_Rte_00131, SRS_Rte_00183)*

Existence: **[SWS_Rte_07395]** ⌈ A non-blocking Rte_DRead API shall be generated if a VariableAccess in the dataReceivePointByValue role references a required VariableDataPrototype with 'data' semantics. This requirement is applicable only for primitive data types. ⌋*(SRS_Rte_00051, SRS_Rte_00183)*

The RTE shall ensure that direct explicit read accesses will not deliver undefined data item values. In case there may be an explicit read access before the first data reception an initial value has to be provided as the result of this explicit read access. [SWS_Rte_07396]

A WaitPoint cannot reference a DataReceivedEvent that in turn references a required VariableDataPrototype with 'data' semantics. Such a configuration has to be considered as invalid (see [SWS_Rte_03018]). Hence there are no blocking Rte_DRead API.

[SWS_Rte_CONSTR_09022] Rte_DRead API may only be used by the runnable that describe its usage ⌈ The Rte_DRead API may only be used by the runnable that contains the corresponding VariableAccess in the dataReceivePointByValue role ⌋*()*

A DataReceivedEvent that references a runnable entity and is referenced by a WaitPoint shall be an invalid configuration. [SWS_Rte_01313]

The RTE generator shall take into account the kind of provide port which might not be just a variable but also a Parameter (fixed, const or standard), a standard sender (i.e. a variable) or a NV data. The table 4.7 gives an overview of compatibility rules.

[SWS_Rte_08565] ⌈ The optional OUT parameter transformerError of the API shall be generated if the PortPrototype of port <p> is referenced by a PortAPIOption which has the attribute errorHandling set to transformerErrorHandling. ⌋ *(SRS_Rte_00249)*

Description: The Rte_DRead API returns the received data as a return value.

The OUT parameter transformerError contains the transformer error which occured during execution of the transformer chain. See chapter 4.10.5.

Return Value: The Rte_DRead return value provide access to the data value of the VariableDataPrototype.

The return type of Rte_DRead is dependent on the ImplementationDataType of the VariableDataPrototype. Thus the component does not need to use type casting to convert access to the VariableDataPrototype data.

For details of the <return> value definition see section 5.2.6.6.

Please note that the Rte_DRead API only supports VariableDataPrototypes typed by a Primitive Implementation Data Type or Redefinition Implementation Data Type redefining a Primitive Implementation Data Type.

Notes: The API name includes an identifier <p>_<o> that indicates the read access point name and is formed from the port and operation item names. See section 5.2.6.4 for details on the naming convention.

5.6.12 Rte_Receive

Purpose: Performs an “explicit” read on a sender-receiver communication data element with “event” semantics (swImplPolicy = queued).

[SWS_Rte_01092] ⌈

```
Std_ReturnType
Rte_[Byps_]Receive_<p>_<o>([IN Rte_Instance <instance>],
        OUT <data>,
        [OUT Rte_TransformerError transformerError])
```

Where <p> is the port name and <o> the data element within the sender-receiver interface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋ *(SRS_BSW_00310, SRS_Rte_00141, SRS_Rte_00028, SRS_Rte_00131)*

Existence: **[SWS_Rte_01288]** ⌈ A non-blocking Rte_Receive API shall be generated if a VariableAccess in the dataReceivePointByArgument role references a required VariableDataPrototype with 'event' semantics. ⌋*(SRS_Rte_00051)*

[SWS_Rte_07638] ⌈ The RTE Generator shall reject configurations were a VariableDataPrototype with 'event' semantics is referenced by a VariableAccess in the dataReceivePointByValue role. ⌋*(SRS_Rte_00018)*

[SWS_Rte_01290] ⌈ A blocking Rte_Receive API shall be generated if a VariableAccess in the dataReceivePointByArgument role references a required VariableDataPrototype with 'event' semantics that is, in turn, referenced by a DataReceivedEvent and the DataReceivedEvent is referenced by a WaitPoint. ⌋*(SRS_Rte_00051)*

[SWS_Rte_CONSTR_09023] Rte_Receive API may only be used by the runnable that describe its usage ⌈ The Rte_Receive API may only be used by the runnable that contains the corresponding VariableAccess in the dataReceivePointByArgument role ⌋*()*

A DataReceivedEvent that references a runnable entity and is referenced by a WaitPoint has to be treated as an invalid configuration. [SWS_Rte_01313]

[SWS_Rte_08564] ⌈ The optional OUT parameter transformerError of the API shall be generated if the PortPrototype of port <p> is referenced by a PortAPIOption which has the attribute errorHandling set to transformerErrorHandling. ⌋ *(SRS_Rte_00249)*

Description: The Rte_Receive API call includes the OUT parameter <data> to pass back the received data element.

The pointers to the OUT parameters must remain valid until the API call returns.

[SWS_Rte_07673] ⌈ In case return value is RTE_E_NO_DATA, RTE_E_TIMEOUT, RTE_E_UNCONNECTED or RTE_E_IN_EXCLUSIVE_AREA, the OUT parameters shall remain unchanged. ⌋*(SRS_Rte_00094, SRS_Rte_00141)*

The OUT parameter transformerError contains the transformer error which occured during execution of the transformer chain. See chapter 4.10.5.

Return Value: The return value is used to indicate errors detected by the RTE during execution of the Rte_Receive API call or errors detected by the communication system.

- **[SWS_Rte_02598]** ⌈ RTE_E_OK – data read successfully. ⌋ *(SRS_Rte_00094)*
- **[SWS_Rte_01094]** ⌈ RTE_E_NO_DATA – (explicit non-blocking read) no events were received and no other error occurred when the read was attempted. ⌋*(SRS_Rte_00094)*
- **[SWS_Rte_01095]** ⌈ RTE_E_TIMEOUT – (explicit blocking read) no events were received and no other error occurred when the read was attempted. ⌋*(SRS_Rte_00094, SRS_Rte_00069)*
- **[SWS_Rte_02572]** ⌈ RTE_E_LOST_DATA – Indicates that some incoming data has been lost due to an overflow of the receive queue or due to an error of the underlying communication layers. This is not an error of the data returned in the parameters. This Overlayed Error can be combined with any other error. ⌋ *(SRS_Rte_00107, SRS_Rte_00110, SRS_Rte_00094)*
- RTE_E_UNCONNECTED – Indicates that the receiver port is not connected [SWS_Rte_01331].

  Unlike RTE_E_NO_DATA, there is no need to retry receiving an event in this case.
- **[SWS_Rte_02743]** ⌈ RTE_E_IN_EXCLUSIVE_AREA – Used only for the blocking API. RTE_E_IN_EXCLUSIVE_AREA indicates that the runnable can not enter wait, as one of the ExecutableEntitys in the call stack of this task is currently in an exclusive area, see [SWS_Rte_02739]. - In a properly configured system, this error should not occur. The check can be disabled according to [SWS_Rte_08320]. ⌋*(SRS_Rte_00092, SRS_Rte_00046, SRS_Rte_00032)*
- **[SWS_Rte_08320]** ⌈ If RteInExclusiveAreaCheckEnabled is set to *false* the RTE generator shall omit the check and return of [SWS_Rte_02743]. ⌋*(SRS_Rte_00092, SRS_Rte_00046, SRS_Rte_00032)*
- **[SWS_Rte_08549]** ⌈ RTE_E_HARD_TRANSFORMER_ERROR – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_08552]** ⌈ RTE_E_SOFT_TRANSFORMER_ERROR – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*

The RTE_E_NO_DATA, RTE_E_TIMEOUT and RTE_E_UNCONNECTED return values are not considered to be errors but rather indicate correct operation of the API call.

[SWS_Rte_08593] ⌈ In case of multiple faults during a call of Rte_Receive the resulting return value shall be derived according to the following priority rules (highest priority first):

1. RTE_E_UNCONNECTED
2. RTE_E_IN_EXCLUSIVE_AREA
3. RTE_E_TIMEOUT
4. RTE_E_HARD_TRANSFORMER_ERROR
5. RTE_E_SOFT_TRANSFORMER_ERROR
6. RTE_E_NO_DATA

⌋*(SRS_Rte_00028)*

Please note that RTE_E_LOST_DATA is an overlay error and could be combined with any other error. Nevertheless in case of RTE_E_UNCONNECTED its not possible to lose data which in turn excludes the coincidence of RTE_E_LOST_DATA.

Notes: The API name includes an identifier <p>_<o> that indicates the read access point name and is formed from the port and operation item names. See Section 5.2.6.4 for details on the naming convention.

5.6.13 Rte_Call

Purpose: Initiate a client-server communication.

Signature: **[SWS_Rte_01102]** ⌈

```
Std_ReturnType
Rte_[Byps_]Call_<p>_<o>([IN Rte_Instance <instance>],
        [IN|IN/OUT|OUT] <data_1>...
        [IN|IN/OUT|OUT] <data_n>,
        [OUT Rte_TransformerError transformerError])
```

Where <p> is the port name and <o> the operation within the client-server interface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋ *(SRS_BSW_00310, SRS_Rte_00029)*

Existence: **[SWS_Rte_01293]** ⌈ A synchronous Rte_Call API shall be generated if a SynchronousServerCallPoint references a required ClientServerOperation. ⌋*(SRS_Rte_00051, SRS_Rte_00111)*

[SWS_Rte_01294] ⌈ An asynchronous Rte_Call API shall be generated if an AsynchronousServerCallPoint references a required ClientServerOperation. ⌋*(SRS_Rte_00051, SRS_Rte_00111)*

A configuration that includes both synchronous and asynchronous ServerCallPoints for a given ClientServerOperation is invalid ([SWS_Rte_03014]).

[SWS_Rte_CONSTR_09024] Rte_Call API may only be used by the runnable that describe its usage ⌈ The Rte_Call API may only be used by the runnable that contains the corresponding ServerCallPoint ⌋*()*

[SWS_Rte_08566] ⌈ The optional OUT parameter transformerError of the API shall be generated if the PortPrototype of port <p> is referenced by a PortAPIOption which has the attribute errorHandling set to transformerErrorHandling. ⌋*(SRS_Rte_00249)*

Description: Client function to initiate client-server communication. The Rte_Call API is used for both synchronous and asynchronous calls.

The Rte_Call API includes zero or more IN, IN/OUT and OUT parameters.

[SWS_Rte_06639] ⌈ IN/OUT parameters are passed by value when they are "Primitive Implementation Data Type"s and the call is asynchronous. ⌋*(SRS_Rte_00051, SRS_Rte_00111)*

Rational: In case of an asynchronous call, the IN/OUT parameters are only IN parameters.

The IN, IN/OUT and OUT parameters are passed by value or reference according to the ImplementationDataType as described in the section 5.2.6.5.

The pointers to all parameters passed by reference must remain valid until the API call returns.

The OUT parameter transformerError contains the transformer error which occured during execution of the transformer chain. See chapter 4.10.5.

Return Value: **[SWS_Rte_01103]** ⌈ The return value shall be used to indicate infrastructure errors detected by the RTE during execution of the Rte_Call call and, for synchronous communication, infrastructure and application errors during execution of the server. ⌋*(SRS_Rte_00094, SRS_Rte_00123, SRS_Rte_00124)*

- **[SWS_Rte_01104]** ⌈ RTE_E_OK – The API call completed successfully. ⌋*(SRS_Rte_00094)*

Note: This means that RTE_E_OK is returned when neither an infrastructure error nor an overlay error occurred at the invocation of the server runnable and the invoked server runnable was returning a value equal to E_OK.

- **[SWS_Rte_01105]** ⌈ RTE_E_LIMIT – The client has multiple outstanding asynchronous client-server invocations of the same operation in the same port. The server invocation shall be discarded, the buffers of the return parameters shall not be modified (see also [SWS_Rte_02658]). ⌋*(SRS_Rte_00094, SRS_Rte_00079)*

- **[SWS_Rte_08727]** ⌈ RTE_E_TRANSFORMER_LIMIT – The RTE is not able to allocate the buffer needed to transform the data. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*

- **[SWS_Rte_08728]** ⌈ RTE_E_HARD_TRANSFORMER_ERROR – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*

- **[SWS_Rte_08555]** ⌈ RTE_E_SOFT_TRANSFORMER_ERROR – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*

- **[SWS_Rte_01106]** ⌈ RTE_E_COM_STOPPED – the RTE could not perform the operation because the communication service is currently not available (inter ECU communication only). RTE shall return RTE_E_COM_STOPPED when:

  – in case of COM the corresponding service returns COM_SERVICE_NOT_AVAILABLE

  – in case of LdCom the corresponding LdCom_Transmit returns E_NOT_OK

  The buffers of the return parameters shall not be modified. ⌋*(SRS_Rte_00094)*

- **[SWS_Rte_01107]** ⌈ RTE_E_TIMEOUT – (synchronous inter-task and inter-ECU only) No reply was received within the configured timeout. The buffers of the return parameters shall not be modified. ⌋*(SRS_Rte_00094, SRS_Rte_00069)*

- RTE_E_UNCONNECTED – Indicates that the client port is not connected [SWS_Rte_01334].

- **[SWS_Rte_02744]** ⌈ RTE_E_IN_EXCLUSIVE_AREA – Used only for the blocking API. RTE_E_IN_EXCLUSIVE_AREA indicates that the runnable can not enter wait, as one of the ExecutableEntitys in the call stack of this task is currently in an exclusive area, see [SWS_Rte_02739]. - In a properly configured system, this error should not occur. The check can be disabled according to [SWS_Rte_08321]. ⌋*(SRS_Rte_00092, SRS_Rte_00046, SRS_Rte_00032)*

- **[SWS_Rte_08321]** ⌈ If RteInExclusiveAreaCheckEnabled is set to *false* the RTE generator shall omit the check and return of [SWS_Rte_02744]. ⌋*(SRS_Rte_00092, SRS_Rte_00046, SRS_Rte_00032)*

- **[SWS_Rte_02755]** ⌈ RTE_E_SEG_FAULT – a segmentation violation is detected in the handed over parameters to the RTE API as required in [SWS_Rte_02752] and [SWS_Rte_02753]. No transmission is executed. ⌋*(SRS_Rte_00210)*

- **[SWS_Rte_02577]** ⌈ The application error (synchronous client-server) from a server shall only be returned if none of the above infrastructure errors (other than RTE_E_OK) have occurred. ⌋*(SRS_Rte_00123)*

- **[SWS_Rte_01392]** ⌈ RTE_E_COM_BUSY – The transmission is rejected due to a currently ongoing transmission. The transmission is not executed. ⌋*(SRS_Rte_00246)*

- **[SWS_Rte_04553]** ⌈ RTE_E_TIMEOUT – if the call is ignored according to [SWS_Rte_02535] ⌋*()*

  Note: API call can be retried after the currently ongoing request has finished.

[SWS_Rte_08594] ⌈ In case of multiple faults during a call of Rte_Call the resulting return value shall be derived according to the following priority rules (highest priority first):

1. RTE_E_UNCONNECTED
2. RTE_E_IN_EXCLUSIVE_AREA
3. RTE_E_LIMIT
4. RTE_E_SEG_FAULT
5. RTE_E_TRANSFORMER_LIMIT
6. RTE_E_HARD_TRANSFORMER_ERROR
7. RTE_E_COM_STOPPED / RTE_E_COM_BUSY
8. RTE_E_TIMEOUT

9. "application error"
10. RTE_E_SOFT_TRANSFORMER_ERROR

⌋(*SRS_Rte_00028*)

Note that the RTE_E_OK return value indicates that the Rte_Call API call completed successfully. In case of a synchronous client server call it also indicates successful processing of the request by the server.

An asynchronous server invocation is considered to be outstanding, if alternatively

1. no timeout has occurred, an AsynchronousServerCallResultPoint exists, and the client has not retrieved the result successfully yet.
2. no timeout has occurred, no AsynchronousServerCallResultPoint exists, and the server has not finished to process the last request of the client yet.
3. a timeout has been detected by the RTE in inter-ECU and inter-partition communication.
4. the server runnable has terminated after a timeout was detected in intra-ECU communication.

When the RTE_E_TIMEOUT error occurs, RTE shall discard any subsequent responses to that request, (see [SWS_Rte_02657]).

Notes: **[SWS_Rte_01109]** ⌈ The interface operation's OUT parameters shall be omitted for an *asynchronous* call. ⌋(*SRS_Rte_00029, SRS_Rte_00079*)

In case of asynchronous communication:

- the Rte_Call only includes IN and IN/OUT parameters.
- the Rte_Result only includes IN/OUT and OUT parameters to collect the result of the server call.
- the IN/OUT parameters provided during the Rte_Call can be a different addresse than the IN/OUT parameter passed during the Rte_Result.

5.6.14 Rte_Result

Purpose: Get the result of an asynchronous client-server call.

Signature: **[SWS_Rte_01111]** ⌈

```
Std_ReturnType
Rte_[Byps_]Result_<p>_<o>([IN Rte_Instance <instance>],
        [IN/OUT|OUT <param 1>]...
        [IN/OUT|OUT <param n>],
        [OUT Rte_TransformerError transformerError])
```

Where `<p>` is the port name and `<o>` the operation within the client-server interface categorizing the port. `[Byps_]` is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋ *(SRS_BSW_00310)*

The signature can include zero or more IN/OUT and OUT parameters depending on the signature of the operation in the client-server interface.

Existence: **[SWS_Rte_01296]** ⌈ A non-blocking `Rte_Result` API shall be generated if an `AsynchronousServerCallResultPoint` exists for the specific `RunnableEntity` and this `AsynchronousServerCallResultPoint` references an `AsynchronousServerCallPoint` which according to [SWS_Rte_01294] leads to the generation of an asynchronous `Rte_Call` API but no `WaitPoint` (of the `RunnableEntity`) references an `AsynchronousServerCallReturnsEvent` that references the `AsynchronousServerCallResultPoint`. ⌋*(SRS_Rte_00051)*

Please note that a non-blocking `Rte_Result` API does not require the existence of a `AsynchronousServerCallReturnsEvent`. If the `AsynchronousServerCallReturnsEvent` exists it can be used to trigger the execution of a `RunnableEntity` in which the non-blocking `Rte_Result` API function may be called.

[SWS_Rte_01297] ⌈ A blocking `Rte_Result` API shall be generated if an `AsynchronousServerCallResultPoint` exists for the specific `RunnableEntity` and this `AsynchronousServerCallResultPoint` references an `AsynchronousServerCallPoint` which according to [SWS_Rte_01294] leads to the generation of an asynchronous `Rte_Call` API and a `WaitPoint` (of the `RunnableEntity`) references an `AsynchronousServerCallReturnsEvent` that references the `AsynchronousServerCallResultPoint`. ⌋*(SRS_Rte_00051)*

[SWS_Rte_CONSTR_09025] Blocking `Rte_Result` API may only be used by the runnable that describe the `WaitPoint` ⌈ The blocking `Rte_Result` API may only be used by the runnable that contains the corresponding `WaitPoint` ⌋*()*

[SWS_Rte_01298] ⌈ If an `AsynchronousServerCallReturnsEvent` references a `RunnableEntity` and a required

ClientServerOperation, the RunnableEntity shall be activated when the operation's result is available or when a timeout was detected by the RTE [SWS_Rte_01133]. ⌋(SRS_Rte_00051)

Requirement [SWS_Rte_01298] merely affects when the runnable is activated – an API call should still be created to actually read the reply based on requirement [SWS_Rte_01296].

[SWS_Rte_01312] ⌈ An AsynchronousServerCallReturnsEvent that references a runnable entity and is referenced by a WaitPoint is invalid. ⌋(SRS_Rte_00051)

[SWS_Rte_08567] ⌈ The optional OUT parameter transformerError of the API shall be generated if the PortPrototype of port <p> is referenced by a PortAPIOption which has the attribute errorHandling set to transformerErrorHandling. ⌋ (SRS_Rte_00249)

Description: The Rte_Result API is used by a client to collect the result of an *asynchronous* client-server communication.

The Rte_Result API includes zero or more IN/OUT and OUT parameters to pass back results.

The pointers to all parameters passed by reference must remain valid until the API call returns.

The OUT parameter transformerError contains the transformer error which occured during execution of the transformer chain. See chapter 4.10.5.

Return Value: The return value is used to indicate errors from either the Rte_Result call itself or communication errors detected before the API call was made.

- **[SWS_Rte_01112]** ⌈ RTE_E_OK – The API call completed successfully. ⌋(SRS_Rte_00094)

  Note: This means that RTE_E_OK is returned when neither an infrastructure error nor an overlay error occurred at the invocation of the server runnable and the invoked server runnable was returning a value equal to E_OK.

- **[SWS_Rte_08591]** ⌈ RTE_E_TRANSFORMER_LIMIT – The RTE is not able to allocate the buffer needed to transform the data. ⌋ (SRS_Rte_00094, SRS_Rte_00091)

- **[SWS_Rte_08729]** ⌈ RTE_E_HARD_TRANSFORMER_ERROR – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋(SRS_Rte_00094, SRS_Rte_00091)

- **[SWS_Rte_08556]** ⌈ RTE_E_SOFT_TRANSFORMER_ERROR – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_01113]** ⌈ RTE_E_NO_DATA – (non-blocking read) The server's result is not available but no other error occurred within the API call or the server was not called since Rte_Start or the restart of the Partition. The buffers for the IN/OUT and OUT parameters shall not be modified. ⌋*(SRS_Rte_00094)*
- **[SWS_Rte_08301]** ⌈ RTE_E_NO_DATA – (non-blocking read) The previous Rte_Call returned an RTE_E_SEG_FAULT, RTE_E_TRANSFORMER_LIMIT, RTE_E_HARD_TRANSFORMER_ERROR. ⌋*(SRS_Rte_00094)*
- **[SWS_Rte_01114]** ⌈ RTE_E_TIMEOUT – The server's result is not available within the specified timeout but no other error occurred within the API call. The buffers for the IN/OUT and OUT parameters shall not be modified. ⌋*(SRS_Rte_00094, SRS_Rte_00069)*
- **[SWS_Rte_03606]** ⌈ RTE_E_COM_STOPPED – the RTE could not perform the operation because the COM service is currently not available (inter ECU communication only). RTE shall return RTE_E_COM_STOPPED when the corresponding COM service returns COM_SERVICE_NOT_AVAILABLE. The server's result has *not* been successfully retrieved from the communication service. The buffers of the return parameters shall not be modified. ⌋*(SRS_Rte_00094)*
- RTE_E_UNCONNECTED – Indicates that the client port is not connected [SWS_Rte_01333].
- **[SWS_Rte_02745]** ⌈ RTE_E_IN_EXCLUSIVE_AREA – Used only for the blocking API. RTE_E_IN_EXCLUSIVE_AREA indicates that the runnable can not enter wait, as one of the ExecutableEntitys in the call stack of this task is currently in an exclusive area, see [SWS_Rte_02739]. - In a properly configured system, this error should not occur. The check can be disabled according to [SWS_Rte_08322]. ⌋*(SRS_Rte_00092, SRS_Rte_00046, SRS_Rte_00032)*
- **[SWS_Rte_08322]** ⌈ If RteInExclusiveAreaCheckEnabled is set to *false* the RTE generator shall omit the check and return of [SWS_Rte_02745]. ⌋*(SRS_Rte_00092, SRS_Rte_00046, SRS_Rte_00032)*

  [SWS_Rte_02746] ⌈ Rte_Result shall not return RTE_E_IN_EXCLUSIVE_AREA, if the wait is resolved by a mapping of the server runnable to a task with higher priority on the same core. ⌋(*SRS_Rte_00092, SRS_Rte_00046, SRS_Rte_00032*)

- **[SWS_Rte_08302]** ⌈RTE_E_SEG_FAULT – a segmentation violation is detected in the handed over parameters to the RTE API as required in [SWS_Rte_02752] and [SWS_Rte_02753]. No transmission is executed. ⌋(*SRS_Rte_00094*)
- **[SWS_Rte_01393]** ⌈RTE_E_COM_BUSY – The query for the result is rejected due to a currently ongoing reception. No result data can be provided. ⌋(*SRS_Rte_00246*)
- **[SWS_Rte_04554]** ⌈ RTE_E_TIMEOUT – if the call is ignored according to [SWS_Rte_02535] ⌋*()*

  Note: API call can be retried after the currently ongoing request has finished.
- **[SWS_Rte_02578]** ⌈Application Errors – The error code of the server shall only be returned, if none of the above infrastructure errors or indications have occurred. ⌋(*SRS_Rte_00094, SRS_Rte_00123*)

[SWS_Rte_08595] ⌈ In case of multiple faults during a call of Rte_Result the resulting return value shall be derived according to the following priority rules (highest priority first):

1. RTE_E_UNCONNECTED
2. RTE_E_IN_EXCLUSIVE_AREA
3. RTE_E_SEG_FAULT
4. RTE_E_COM_STOPPED / RTE_E_COM_BUSY / RTE_E_TIMEOUT
5. RTE_E_TRANSFORMER_LIMIT
6. RTE_E_HARD_TRANSFORMER_ERROR
7. "application error"
8. RTE_E_SOFT_TRANSFORMER_ERROR

⌋(*SRS_Rte_00028*)

The RTE_E_NO_DATA, RTE_E_TIMEOUT, and RTE_E_UNCONNECTED return values are not considered to be errors but rather indicate correct operation of the API call.

When the RTE_E_TIMEOUT error occurs, RTE has to discard any subsequent responses to that request, (see [SWS_Rte_02657]).

When RTE_E_NO_DATA occurs, a component is free to invoke Rte_Result again and thus repeat the attempt to read the server's result.

Notes: The API name includes an identifier <p>_<o> that indicates the read access point name and is formed from the port and operation item names. See Section 5.2.6.4 for details on the naming convention.

If a AsynchronousServerCallPoint exists which is not referenced by a WaitPoint, a non-blocking Rte_Result API shall be generated. In this case Rte_Result has to return RTE_E_NO_DATA until the timeout expires and RTE_E_TIMEOUT afterwards.

5.6.15 Rte_Pim

Purpose: Provide access to the defined per-instance memory (section) of a software component.

Signature: **[SWS_Rte_01118]** ⌈

```
<type>/<return reference>
Rte_[Byps_]Pim_<name>([IN Rte_Instance <instance>])
```

Where <name> is the (short) name of the per-instance name. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00075)*

Existence: **[SWS_Rte_01299]** ⌈ An Rte_Pim API shall be created for each defined PerInstanceMemory or arTypedPerInstanceMemory within the AUTOSAR software-component (description). ⌋*(SRS_Rte_00051)*

Description: The Rte_Pim API provides access to the per-instance memory (section) defined in the context of a SwcInternalBehavior of a software-component description.

Return Value: **[SWS_Rte_01119]** ⌈ The API returns a typed reference (in C a typed pointer) to the per-instance memory. ⌋*(SRS_Rte_00051, SRS_Rte_00075)*

Notes: For a 'C' typed PerInstanceMemory, the name of the return type <type> has to be defined in the type attribute of the PerInstanceMemory. The type itself is defined using the typeDefinition attribute of the PerInstanceMemory. It is assumed that this attribute contains a string that represents a C type definition (typedef) in valid C syntax (see [SWS_Rte_02304] and [SWS_Rte_07133]). For an arTypedPerInstanceMemory the `<return reference>` is defined by the associated `AutosarDataType` (see [SWS_Rte_07161]). For details of the `<return reference>` definition see section 5.2.6.7.

5.6.16 Rte_CData

Purpose: Provide access to the calibration parameter an AUTOSAR software-component defined internally. The `ParameterDataPrototype` in the role `perInstanceParameter` or `sharedParameter` is used to define software component internal calibration parameters. Internal because the `ParameterDataPrototype` cannot be reused outside the software-component. Access is read-only. It can be configured for each calibration parameter individually if it is shared by all instances of an AUTOSAR software-component or if each instance has an own data value associated with it.

Signature: **[SWS_Rte_01252]** ⌈

```
<return>
Rte_[Byps_]CData_<name>([IN Rte_Instance <instance>])
```

Where `<name>` is the calibration parameter name. `[Byps_]` is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00155)*

Existence: **[SWS_Rte_01300]** ⌈ An `Rte_CData` API shall be generated if a `ParameterAccess` references a `ParameterDataPrototype` in the role `perInstanceParameter` or `sharedParameter` within the `SwcInternalBehavior` of an AUTOSAR software-component. ⌋ *(SRS_Rte_00051, SRS_Rte_00155)*

Description: The `Rte_CData` API provides access to the defined calibration parameter within a software-component. The actual data values for a software-component instance may be set after component compilation.

Return Value: The `Rte_CData` return value provide access to the data value of the `ParameterDataPrototype` in the role `perInstanceParameter` or `sharedParameter`.

The return type of `Rte_CData` is dependent on the `ImplementationDataType` of the `ParameterDataPrototype` and can either be a value or a pointer to the location where the value can be accessed. Thus the component does not need to use type casting to convert access to the `ParameterDataPrototype` data.

For details of the `<return>` value definition see section 5.2.6.6.

[SWS_Rte_03927] ⌈ If a ParameterDataPrototype is aggregated by an SwcInternalBehavior in the role of sharedParameter, the return value of the corresponding Rte_CData API shall provide access to the calibration parameter value common to all instances of the AtomicSwComponentType. ⌋*(SRS_Rte_00051, SRS_Rte_00155)*

[SWS_Rte_03952] ⌈ If a ParameterDataPrototype is aggregated by an SwcInternalBehavior in the role of perInstanceParameter, the return value of the corresponding Rte_CData API shall provide access to the calibration parameter value specific to the instance of the AtomicSwComponentType. ⌋*(SRS_Rte_00051, SRS_Rte_00155)*

Notes: None.

5.6.17 Rte_Prm

Purpose: Provide access to the parameters defined by an AUTOSAR ParameterSwComponentType. Access is read-only.

Signature: **[SWS_Rte_03928]** ⌈

```
<return>
Rte_[Byps_]Prm_<p>_<o>([IN Rte_Instance <instance>])
```

Where <p> is the port name and <o> is the name of the ParameterDataPrototype within the ParameterInterface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00155)*

Existence: **[SWS_Rte_03929]** ⌈ A Rte_Prm API shall be generated if a ParameterAccess references a ParameterDataPrototype in a require PortPrototype. ⌋*(SRS_BSW_00310, SRS_Rte_00155)*

Description: The Rte_Prm API provides access to the defined parameter within a ParameterSwComponentType.

In the case of a standard parameter (swImplPolicy = standard), i.e. a calibration, the actual data values for a ParameterSwComponentType instance may be set after ParameterSwComponentType compilation.

In the case of fixed parameter or constant parameter, the value is set during compilation time.

Return Value: **[SWS_Rte_03930]** ⌈ For primitive data types, the Rte_Prm API shall return the parameter value. For composite data types, the Rte_Prm

API shall return a reference (in C, a pointer) to the parameter, which shall be const. With fixed parameters, only primitive data is possible.

The return type of Rte_Prm is specified by the ImplementationDataType associated to the ParameterDataPrototype. Thus the component does not need to use type casting to access the calibration parameter. ⌋*(SRS_Rte_00051, SRS_Rte_00155, SRS_Rte_00171)* The Rte_Prm return value provide access to the data value of the ParameterDataPrototype.

The return type of Rte_Prm is dependent on the ImplementationDataType of the ParameterDataPrototype and can either be a value or a pointer to the location where the value can be accessed. Thus the component does not need to use type casting to convert access to the ParameterDataPrototype data.

For details of the <return> value definition see section 5.2.6.6.

Notes: The Rte_Prm API should not be used within a pre-compilation directive, e.g. #if. For such case, the coder should use the Rte_SysCon definitions which are dedicated to variant handling.

5.6.18 Rte_IRead

Purpose: Provide **read** access to the VariableDataPrototype referenced by VariableAccess in the dataReadAccess role.

Signature: **[SWS_Rte_03741]** ⌈

```
<return>
Rte_[Byps_]IRead_<re>_<p>_<o>(
    [IN Rte_Instance <instance>])
```

Where <re> is the runnable entity name, <p> the port name and <o> the VariableDataPrototype name. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00128)*

Existence: **[SWS_Rte_01301]** ⌈ An Rte_IRead API shall be created for a required VariableDataPrototype if the RunnableEntity has a VariableAccess in the dataReadAccess role referring to this VariableDataPrototype. ⌋*(SRS_Rte_00051)*

[SWS_Rte_CONSTR_09083] Rte_IRead API may only be used by the runnable that describe its usage ⌈ The Rte_IRead API may only be used by the runnable that contains the corresponding VariableAccess in the dataReadAccess role. ⌋*()*

Description: The Rte_IRead API provides access to the VariableDataPrototypes declared as accessed by a runnable using VariableAccesses in the dataReadAccess role. As the APIcan also be used in context of category 1A runnables an implementation has to ensure finite and constant execution times.

No error information is provided by this API. If required, the error status can be picked up with a separate API, see 5.6.22

The data value can always be read. To provide the required consistency the API provides access to a *copy* of the data data element for which it's guaranteed that it never changes during the actual execution of the runnable entity.

Implicit data read access by a SW-C should always return defined data.

[SWS_Rte_01268] ⌈ The RTE shall ensure that implicit read accesses will not deliver undefined data item values. ⌋ *(SRS_Rte_00108, SRS_Rte_00051, SRS_Rte_00128)*

[SWS_Rte_01394] ⌈ In case read access is not possible due to a currently ongoing reception the invalidValue shall be provided as the result of this implicit read access. ⌋ *(SRS_Rte_00246)*

In case where there may be an implicit read access before the first data reception an initial value has to be provided as the result of this implicit read access.

Return Value: The Rte_IRead return value provide access to the data value of the VariableDataPrototype.

The return type of Rte_IRead is dependent on the ImplementationDataType of the VariableDataPrototype and can either be a value or a pointer to the location where the value can be accessed. Thus the component does not need to use type casting to convert access to the VariableDataPrototype data.

For details of the <return> value definition see section 5.2.6.6.

Notes: None.

5.6.19 Rte_IWrite

Purpose: Provide **write** access to the VariableDataPrototypes referenced by VariableAccesses in the dataWriteAccess role.

Signature: **[SWS_Rte_03744]** ⌈

```
void
Rte_[Byps_]IWrite_<re>_<p>_<o>(
```

```
[IN Rte_Instance <instance>],
IN <data>)
```

Where <re> is the runnable entity name, <p> the port name and <o> the VariableDataPrototype name. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2).
⌋*(SRS_BSW_00310, SRS_Rte_00129)*

Existence: **[SWS_Rte_01302]** ⌈ An Rte_IWrite API shall be created for a provided VariableDataPrototype if the RunnableEntity has a VariableAccess in the dataWriteAccess role referring to this VariableDataPrototype. ⌋*(SRS_Rte_00051)*

[SWS_Rte_CONSTR_09084] Rte_IWrite API may only be used by the runnable that describe its usage ⌈ The Rte_IWrite API may only be used by the runnable that contains the corresponding VariableAccess in the dataWriteAccess role. ⌋*()*

Description: The Rte_IWrite API provides write access to the VariableDataPrototypes declared as accessed by a runnable using VariableAccesses in the dataWriteAccess role. The API function is guaranteed to be have constant execution time and therefore can also be used within category 1A runnable entities.

No access error information is required for the user – the value can always be written. To provide the required write-back semantics the RTE only makes written values available to other entities after the writing runnable entity has terminated.

[SWS_Rte_03746] ⌈ The Rte_IWrite API call includes the IN parameter <data> to pass the data element to write. ⌋*(SRS_Rte_00051, SRS_Rte_00129)*

The IN parameter <data> is passed by value or reference according to the ImplementationDataType as described in the section 5.2.6.5.

If the IN parameter <data> is passed by reference, the pointer must remain valid until the API call returns.

Return Value: None.

Notes: None.

5.6.20 Rte_IWriteRef

Purpose: Provide a reference to the VariableDataPrototype referenced by a VariableAccess in the dataWriteAccess role.

Signature: **[SWS_Rte_05509]** ⌈

```
<return reference>
Rte_[Byps_]IWriteRef_<re>_<p>_<o>(
    [IN Rte_Instance <instance>])
```

Where `<re>` is the runnable entity name, `<p>` the port name and `<o>` the `VariableDataPrototype` name. `[Byps_]` is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2).
⌋*(SRS_BSW_00310, SRS_Rte_00129)*

Existence: **[SWS_Rte_05510]** ⌈An `Rte_IWriteRef` API shall be created for a provided `VariableDataPrototype` if the `RunnableEntity` has a `VariableAccess` in the `dataWriteAccess` role referring to this `VariableDataPrototype`. ⌋*(SRS_Rte_00051)*

[SWS_Rte_CONSTR_09085] `Rte_IWriteRef` API may only be used by the runnable that describe its usage ⌈ The `Rte_IWriteRef` API may only be used by the runnable that contains the corresponding `VariableAccess` in the `dataWriteAccess` role. ⌋*()*

Description: The `Rte_IWriteRef` API returns a reference to the `VariableDataPrototype`s declared as accessed by a runnable using `VariableAccess`es in the `dataWriteAccess` role. The reference can be used by the runnable to directly update the corresponding data elements. This is especially useful for data elements of `Structure Implementation Data Type` or `Array Implementation Data Type`. The API function is guaranteed to be have constant execution time and therefore can also be used within category 1A runnable entities.

No error information is required for the user. To provide the required write-back semantics the RTE only makes written values available to other entities after the writing runnable entity has terminated.

[SWS_Rte_CONSTR_09026] `Rte_IWriteRef` may not return values written in previous executions ⌈ The reference returned by `Rte_IWriteRef` shall not be used by the runnables for reading the value previously written. ⌋*()*

The rationale for [SWS_Rte_CONSTR_09026] is that `Rte_IWriteRef` has a write semantic. Also, in case of an unconnected port, the written data shall be discarded (similarly to [SWS_Rte_01347]), and implementations may return a reference to the same buffer for all `Rte_IWriteRef` of unconnected provide ports.

Return Value: The `Rte_IWriteRef` return value provide access to the data write buffer of the `VariableDataPrototype`.

[SWS_Rte_05511] ⌈ Rte_IWriteRef returns a reference to the corresponding VariableDataPrototype. ⌋*(SRS_Rte_00051)*

The return reference type of Rte_IWriteRef is dependent on the ImplementationDataType of the VariableDataPrototype and is a pointer to the location where the value can be accessed. Thus the component does not need to use type casting to convert access to the VariableDataPrototype data.

For details of the <return reference> definition see section 5.2.6.7.

Notes: None.

5.6.21 Rte_IInvalidate

Purpose: Invalidate a VariableDataPrototype referenced by a VariableAccess in the dataWriteAccess role.

Signature: **[SWS_Rte_03800]** ⌈

```
void Rte_[Byps_]IInvalidate_<re>_<p>_<o>(
    [IN Rte_Instance <instance>])
```

Where <re> is the runnable entity name, <p> the port name and <o> the VariableDataPrototype name. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00078)*

Existence: **[SWS_Rte_03801]** ⌈ An Rte_IInvalidate API shall be created for a provided VariableDataPrototype if the RunnableEntity has VariableAccesses in the dataWriteAccess role referring to this VariableDataPrototype and the associated InvalidationPolicy of the VariableDataPrototype is set to keep, replace or externalReplacement. ⌋*(SRS_Rte_00051, SRS_Rte_00078)*

[SWS_Rte_CONSTR_09086] Rte_IInvalidate API may only be used by the runnable that is describing an write access to the data ⌈ The Rte_IInvalidate API may only be used by the runnable that contains the corresponding VariableAccess in the dataWriteAccess role to the VariableDataPrototype where the associated InvalidationPolicy of the VariableDataPrototype is set to keep or replace. ⌋*()*

Description: The Rte_IInvalidate API takes no parameters other than the instance handle – the return value is used to indicate the success, or otherwise, of the API call to the caller.

[SWS_Rte_03802] ⌈ In case of a primitive VariableDataPrototype the Rte_IInvalidate shall be implemented as a macro that writes the invalidValue to the buffer. ⌋*(SRS_Rte_00078)*

[SWS_Rte_05064] ⌈ In case of a composite VariableDataPrototype the Rte_IInvalidate shall be implemented as a macro that writes the invalidValue of every primitive part of the composition to the buffer. ⌋*(SRS_Rte_00078)*

[SWS_Rte_03778] ⌈ If Rte_IInvalidate is followed by an Rte_IWrite call for the same VariableDataPrototype or vice versa, the RTE shall use the last value written before the runnable entity terminates (last-is-best semantics). ⌋*(SRS_Rte_00078)*

[SWS_Rte_03778] states that an Rte_IWrite overrules an Rte_IInvalidate call if it occurs after the Rte_IInvalidate, since Rte_IWrite overwrites the contents of the internal buffer for the data element prototype before it is made known to other runnable entities.

Return Value: None.

Notes: The communication service configuration determines whether the signal receiver(s) receive an “invalid signal” notification or whether the invalidated signal is silently replaced by the signal’s initial value.

5.6.22 Rte_IStatus

Purpose: Provide the error status of a VariableDataPrototype referenced by a VariableAccess in the dataReadAccess role.

Signature: **[SWS_Rte_02599]** ⌈

```
Std_ReturnType
Rte_[Byps_]IStatus_<re>_<p>_<o>(
    [IN Rte_Instance <instance>],
    [OUT Rte_TransformerError transformerError])
```

Where `<re>` is the runnable entity name, `<p>` the port name and `<o>` the VariableDataPrototype name. `[Byps_]` is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_Rte_00147, SRS_Rte_00078)*

Existence: **[SWS_Rte_02600]** ⌈ An Rte_IStatus API shall be created for a required VariableDataPrototype if a RunnableEntity has a VariableAccess in the dataReadAccess role referring to this VariableDataPrototype, and

- if at the RPortPrototype or PRPortPrototype a NonqueuedReceiverComSpec with either
  - the attribute aliveTimeout set to a value greater than zero **and/or**
  - the attribute handleNeverReceived set to TRUE **and/or**
  - the attribute handleOutOfRange not set to none **and/or**
  - the attribute handleDataStatus set to TRUE

  and/or
- if at the SenderReceiverInterface classifying the RPortPrototype or PRPortPrototype an InvalidationPolicy set to keep

is specified for this VariableDataPrototype. ⌋*(SRS_Rte_00147, SRS_Rte_00078)*

[SWS_Rte_CONSTR_09027] Rte_IStatus API shall only be used by a RunnableEntity describing an read access to the related data ⌈ The Rte_IStatus API shall only be used by a RunnableEntity that has a VariableAccess in the dataReadAccess role referring to the VariableDataPrototype to which the status belongs. ⌋*()*

[SWS_Rte_08568] ⌈ The optional OUT parameter transformerError of the API shall be generated if the PortPrototype of port <p> is referenced by a PortAPIOption which has the attribute errorHandling set to transformerErrorHandling. ⌋*(SRS_Rte_00249)*

Description: The Rte_IStatus API provides access to the current status of the data elements declared as accessed by a runnable using a VariableAccess in the dataReadAccess role. The API function is guaranteed to be have constant execution time and therefore can also be used within category 1A runnable entities.

To provide the required consistency access by a runnable is to a *copy* of the status together with the data that is guaranteed never to be modified by the RTE during the lifetime of the runnable entity.

The OUT parameter transformerError contains the transformer error which occured during execution of the transformer chain. See chapter 4.10.5.

Return Value: The return value is used to indicate errors detected by the communication system.

- **[SWS_Rte_02602]** ⌈ RTE_E_OK – no errors. ⌋ *(SRS_Rte_00094)*
- **[SWS_Rte_02603]** ⌈ RTE_E_INVALID – data element invalid. ⌋ *(SRS_Rte_00078)*
- **[SWS_Rte_02604]** ⌈ RTE_E_MAX_AGE_EXCEEDED – data element outdated. This Overlayed Error can be combined with any other error code. ⌋ *(SRS_Rte_00147)*
- **[SWS_Rte_07644]** ⌈ RTE_E_NEVER_RECEIVED – No data received since system start or partition restart. ⌋ *(SRS_Rte_00184, SRS_Rte_00224)*
- **[SWS_Rte_01372]** ⌈ RTE_E_OUT_OF_RANGE – data element out of range. ⌋ *(SRS_Rte_00180)*
- **[SWS_Rte_06828]** ⌈ RTE_E_COM_STOPPED – the RTE could not perform the operation because the communication service is currently not available (inter ECU communication only). RTE shall return RTE_E_COM_STOPPED when:
  - in case of COM the corresponding service returns COM_SERVICE_NOT_AVAILABLE
  - in case of LdCom the corresponding LdCom_Transmit returns E_NOT_OK

  In case of stopped I-PDUS the last known value (or init value) is given back as data by the according Rte_IRead API. ⌋ *(SRS_Rte_00094)*
- RTE_E_UNCONNECTED – Indicates that the receiver port is not connected [SWS_Rte_03785].
- **[SWS_Rte_08572]** ⌈ RTE_E_HARD_TRANSFORMER_ERROR – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋ *(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_08573]** ⌈ RTE_E_SOFT_TRANSFORMER_ERROR – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋ *(SRS_Rte_00094, SRS_Rte_00091)*

Notes: **[SWS_Rte_06829]** ⌈ In case of multiple faults during reception of the related data the resulting return value of Rte_IStatus shall be derived according to the following priority rules (highest priority first):

1. RTE_E_UNCONNECTED
2. RTE_E_COM_STOPPED

3. RTE_E_NEVER_RECEIVED
4. RTE_E_HARD_TRANSFORMER_ERROR
5. RTE_E_INVALID
6. RTE_E_OUT_OF_RANGE
7. RTE_E_SOFT_TRANSFORMER_ERROR

⌋*(SRS_Rte_00147, SRS_Rte_00078, SRS_Rte_00184, SRS_Rte_00180)*

Please note that RTE_E_MAX_AGE_EXCEEDED is an overlay error and could be combined with any other error. Nevertheless in case of RTE_E_UNCONNECTED or RTE_E_COM_STOPPED time out monitoring is NOT active which in turn excludes the coincidence of RTE_E_MAX_AGE_EXCEEDED.

5.6.23 Rte_IrvIRead

Purpose: Provide **read** access to the *InterRunnableVariables with implicit* behavior of an AUTOSAR SW-C.

Signature: **[SWS_Rte_03550]** ⌈

```
<return> Rte_[Byps_]IrvIRead_<re>_<o>(
    [IN RTE_Instance <instance>])
```

Where <re> is the name of the runnable entity the API might be used in, <o> is the name of the VariableDataPrototype in role implicitInterRunnableVariable. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00142)*

Existence: **[SWS_Rte_01303]** ⌈ An Rte_IrvIRead API shall be created for each VariableAccess in role readLocalVariable to an implicitInterRunnableVariable. ⌋*(SRS_Rte_00051, SRS_Rte_00142)*

[SWS_Rte_CONSTR_09087] Rte_IrvIRead API may only be used by the runnable that describe its usage ⌈ The Rte_IrvIRead API may only be used by the runnable that contains the corresponding VariableAccess in the readLocalVariable role. ⌋*()*

Description: The Rte_IrvIRead API provides read access to the defined InterRunnableVariables with *implicit* behavior within a component description.

The return value is used to deliver the requested data value. The return value is not required to pass error information to the user because no inter-ECU communication is involved and there will always be a readable value present.

Return Value: The Rte_IrvIRead return value provide access to the data value of the InterRunnableVariable.

The return type of Rte_IrvIRead is dependent on the ImplementationDataType of the InterRunnableVariable and can either be a value or a pointer to the location where the value can be accessed. Thus the component does not need to use type casting to convert access to the InterRunnableVariable data.

For details of the <return> value definition see section 5.2.6.6.

Notes: The runnable entity name in the signature allows runnable context specific optimizations.

The concept of InterRunnableVariables is explained in section 4.2.5.6. More details about InterRunnableVariables with *implicit* behavior is explained in section 4.2.5.6.1.

5.6.24 Rte_IrvIWrite

Purpose: Provide **write** access to the *InterRunnableVariables with implicit behavior* of an AUTOSAR SW-C.

Signature: **[SWS_Rte_03553]** ⌈

```
void Rte_[Byps_]IrvIWrite_<re>_<o>(
     [IN RTE_Instance <instance>],
     IN <data>)
```

Where <re> is the name of the RunnableEntity the API might be used in, <o> is the name of the VariableDataPrototype in the role implicitInterRunnableVariable to access and <data> is the placeholder for the data the InterRunnableVariable shall be set to. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00142)*

Existence: **[SWS_Rte_01304]** ⌈ An Rte_IrvIWrite API shall be created for each VariableAccess in role writtenLocalVariable to an implicitInterRunnableVariable. ⌋*(SRS_Rte_00142, SRS_Rte_00051)*

[SWS_Rte_CONSTR_09088] Rte_IrvIWrite API may only be used by the runnable that describe its usage ⌈ The

Rte_IrvIWrite API may only be used by the runnable that contains the corresponding VariableAccess in the writtenLocalVariable role. ⌋()

Description: The Rte_IrvIWrite API provides write access to the InterRunnableVariables with *implicit* behavior within a component description. The runnable entity name in the signature allows runnable context specific optimizations.

The data given by Rte_IrvIWrite is dependent on the InterRunnableVariable data type. Thus the component does not need to use type casting to write the InterRunnableVariable.

The return value is unused. The return value is not required to pass error information to the user because no inter-ECU communication is involved and the value can always be written.

The IN parameter <data> is passed by value or reference according to the ImplementationDataType as described in the section 5.2.6.5.

Return Value: None.

Notes: The runnable entity name in the signature allows runnable context specific optimizations.

The concept of InterRunnableVariables is explained in section 4.2.5.6. Further details about InterRunnableVariables with *implicit* behavior are explained in Section 4.2.5.6.1.

5.6.25 Rte_IrvIWriteRef

Purpose: Provide a reference to the VariableDataPrototype defined with the implicitInterRunnableVariable role referenced by a VariableAccess in the writtenLocalVariable role.

Signature: **[SWS_Rte_06207]** ⌈

```
<return reference> Rte_[Byps_]IrvIWriteRef_<re>_<o>(
    [IN RTE_Instance <instance>])
```

Where <re> is the name of the RunnableEntity the API might be used in, <o> is the name of the VariableDataPrototype in the role implicitInterRunnableVariable to access. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00142)*

Existence: **[SWS_Rte_06208]** ⌈ An Rte_IrvIWriteRef API shall be created for each VariableAccess in role writtenLocalVariable to an implicitInterRunnableVariable. ⌋(SRS_Rte_00142, SRS_Rte_00051)

[SWS_Rte_CONSTR_09092] Rte_IrvIWriteRef API may only be used by the runnable that describe its usage ⌈ The Rte_IrvIWriteRef API may only be used by the runnable that contains the corresponding VariableAccess in the writtenLocalVariable role. ⌋()

Description: The Rte_IrvIWriteRef API returns a reference to the VariableDataPrototypes declared as accessed by a runnable using VariableAccesss in the writtenLocalVariable role. The reference can be used by the runnable to directly update the corresponding data elements. This is especially useful for data elements of Structure Implementation Data Type or Array Implementation Data Type. The API function is guaranteed to have constant execution time and therefore can also be used within category 1A runnable entities.

No error information is required for the user. To provide the required write-back semantics the RTE only makes written values available to other entities after the writing runnable entity has terminated.

[SWS_Rte_CONSTR_09093] Rte_IrvIWriteRef may not return values written in previous executions ⌈ The reference returned by Rte_IrvIWriteRef shall not be used by the runnables for reading the value previously written. ⌋()

Return Value: The Rte_IrvIWriteRef return value provides access to the data write buffer of the VariableDataPrototype.

[SWS_Rte_06209] ⌈ Rte_IrvIWriteRef returns a reference to the corresponding VariableDataPrototype. ⌋(SRS_Rte_00051)

The return reference type of Rte_IrvIWriteRef is dependent on the ImplementationDataType of the VariableDataPrototype and is a pointer to the location where the value can be accessed. Thus the component does not need to use type casting to convert access to the VariableDataPrototype data. For details of the <return reference> definition see section 5.2.6.7.

Notes: None.

5.6.26 Rte_IrvRead

Purpose: Provide **read** access to the *InterRunnableVariables with explicit behavior* of an AUTOSAR SW-C.

Signature: **[SWS_Rte_03560]** ⌈
primitive type signature:

```
<return> Rte_[Byps_]IrvRead_<re>_<o>(
    [IN RTE_Instance <instance>])
```

complex type signature:

```
void Rte_[Byps_]IrvRead_<re>_<o>(
    [IN RTE_Instance <instance>],
    OUT <data>)
```

Where `<re>` is the name of the runnable entity the API might be used in, `<o>` is the name of the InterRunnableVariables. `[Byps_]` is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2).

The complex type signature is used, if the `ImplementationDataType` of the `InterRunnableVariable` resolves to `Array Implementation Data Type` or `Structure Implementation Data Type`, otherwise the primitive type signature is used. ⌋ *(SRS_BSW_00310, SRS_Rte_00142)*

Existence: **[SWS_Rte_01305]** ⌈ An `Rte_IrvRead` API shall be created for each read InterRunnableVariable using explicit access. ⌋ *(SRS_Rte_00142, SRS_Rte_00051)*

[SWS_Rte_CONSTR_09089] `Rte_IrvRead` API may only be used by the runnable that describe its usage ⌈ The `Rte_IrvRead` API may only be used by the runnable that contains the corresponding `VariableAccess` in the `readLocalVariable` role. ⌋ *()*

Description: The `Rte_IrvRead` API provides read access to the defined InterRunnableVariables with *explicit* behavior within a component description.

The return value is not required to pass error information to the user because no inter-ECU communication is involved and there will always be a readable value present.

For the primitive type signature, the return value is used to deliver the requested data value. For the complex type signature, the return value is void.

For the complex type signature, the `Rte_IrvRead` API call includes the OUT parameter `<data>` to pass back the received data. The OUT parameter `<data>` is typed as reference (pointer) to the type of the InterRunnableVariable. The pointer to the OUT parameter `<data>` must remain valid until the API call returns.

Return Value: The `Rte_IrvRead` return value provide access to the data value of the InterRunnableVariable.

The return type of Rte_IrvRead is dependent on the ImplementationDataType of the InterRunnableVariable. Thus the component does not need to use type casting to convert access to the InterRunnableVariable data.

For details of the <return> value definition see section 5.2.6.6.

Please note that the Rte_IrvRead API Signature only has a return value if the InterRunnableVariable is typed by a Primitive Implementation Data Type or Redefinition Implementation Data Type redefining a Primitive Implementation Data Type.

[SWS_Rte_03562] ⌈ For the primitive type signature, the Rte_IrvRead call shall return the value of the accessed InterRunnableVariable. ⌋*(SRS_Rte_00142, SRS_Rte_00051)*

For complex type signature, the Rte_IrvRead call does not return any value (void).

Notes: The runnable entity name in the signature allows runnable context specific optimizations.

The concept of InterRunnableVariables is explained in section 4.2.5.6. Further details about InterRunnableVariables with *explicit* behavior are explained in Section 4.2.5.6.2.

5.6.27 Rte_IrvWrite

Purpose: Provide **write** access to the *InterRunnableVariables with explicit behavior* of an AUTOSAR SW-C.

Signature: **[SWS_Rte_03565]** ⌈

```
void Rte_[Byps_]IrvWrite_<re>_<o>(
     [IN RTE_Instance <instance>],
     IN <data>)
```

Where <re> is the name of the runnable entity the API might be used in, <o> is the name of the InterRunnableVariable to access and <data> is the placeholder for the data the InterRunnableVariable shall be set to. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00142)*

Existence: **[SWS_Rte_01306]** ⌈ An Rte_IrvWrite API shall be created for each written InterRunnableVariable using explicit access. ⌋*(SRS_Rte_00142, SRS_Rte_00051)*

[SWS_Rte_CONSTR_09090] Rte_IrvWrite API may only be used by the runnable that describe its usage ⌈ The Rte_IrvWrite API may only be used by the runnable that contains the corresponding VariableAccess in the writtenLocalVariable role. ⌋*()*

Description: The Rte_IrvWrite API provides write access to the InterRunnableVariables with *explicit* behavior within a component description.

The return value is unused. The return value is not required to pass error information to the user because no inter-ECU communication is involved and the value can always be written.

[SWS_Rte_03567] ⌈ The Rte_IrvWrite API call include the IN parameter <data> to pass the data element to write. ⌋ *(SRS_Rte_00142, SRS_Rte_00051)*

The IN parameter <data> is passed by value or reference according to the ImplementationDataType as described in the section 5.2.6.5.

If the IN parameter <data> is passed by reference, the pointer must remain valid until the API call returns.

Return Value: None.

Notes: The runnable entity name in the signature allows runnable context specific optimizations.

The concept of InterRunnableVariables is explained in section 4.2.5.6. Further details about InterRunnableVariables with *explicit* behavior are explained in Section 4.2.5.6.2.

5.6.28 Rte_Enter

Purpose: Enter an exclusive area.

Signature: **[SWS_Rte_01120]** ⌈

```
void
Rte_[Byps_]Enter_[<re_>]<name>(
    [IN Rte_Instance <instance>])
```

Where <re> is the runnable entity name, <name> is the exclusive area name. The sub part in squared brackets [<re>_] is emitted if the attribute SwcExclusiveAreaPolicy.apiPrinciple is set to "perExecutable". [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00046, SRS_Rte_00115)*

Existence: **[SWS_Rte_01307]** ⌈ An Rte_Enter API shall be created for each ExclusiveArea that is declared and which has an *canEnterExclusiveArea* association. ⌋*(SRS_Rte_00115, SRS_Rte_00051)*

Description: The Rte_Enter API call is invoked by an AUTOSAR software-component to define the start of an exclusive area.

Return Value: None.

Notes: The RTE is not required to support nested invocations of Rte_Enter for the same exclusive area.

[SWS_Rte_01122] ⌈ The RTE shall permit calls to Rte_Enter and Rte_Exit to be nested as long as different exclusive areas are exited in the reverse order they were entered. ⌋*(SRS_Rte_00046, SRS_Rte_00032, SRS_Rte_00115)*

[SWS_Rte_CONSTR_09028] Rte_Enter and Rte_Exit API may only be used by runnables describing its usage ⌈ The Rte_Enter and Rte_Exit API may only be used by *Runnable Entities* that contain a corresponding *canEnterExclusiveArea* association ⌋*()*

[SWS_Rte_CONSTR_09029] Nested call of Rte_Enter and Rte_Exit is restricted ⌈ The Rte_Enter and Rte_Exit API may only be called nested if different exclusive areas are invoked; in this case exclusive areas shall exited in the reverse order they were entered. ⌋*()*

Within the AUTOSAR OS an attempt to lock a resource cannot fail because the lock is already held. The lock attempt can only fail due to configuration errors (e.g. caller not declared as accessing the resource) or invalid handle. Therefore the return type from this function is void.

5.6.29 Rte_Exit

Purpose: Leave an exclusive area.

Signature: **[SWS_Rte_01123]** ⌈

```
void
Rte_[Byps_]Exit_[<re_>]<name>(
    [IN Rte_Instance <instance>])
```

Where <re> is the runnable entity name, <name> is the exclusive area name. The sub part in squared brackets [<re>_] is emitted if the attribute SwcExclusiveAreaPolicy.apiPrinciple is set to "perExecutable". [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00046, SRS_Rte_00051)*

Existence: **[SWS_Rte_01308]** ⌈ An Rte_Exit API shall be created for each ExclusiveArea that is declared and which has an *canEnterExclusiveArea* association. ⌋*(SRS_Rte_00115, SRS_Rte_00051)*

Description: The Rte_Exit API call is invoked by an AUTOSAR software-component to define the end of an exclusive area.

Return Value: None.

Notes: The RTE is not required to support nested invocations of Rte_Exit for the same exclusive area.

Requirement [SWS_Rte_01122] permits calls to Rte_Enter and Rte_Exit to be nested as long as different exclusive areas are exited in the reverse order they were entered.

5.6.30 Rte_Mode

There exist two versions of the Rte_Mode API. Depending on the attribute enhancedModeApi in the *software component description* there shall be provided different versions of this API (see also 5.6.31).

Purpose: Provides the currently active mode of a mode switch port.

Signature: **[SWS_Rte_02628]** ⌈

```
<return>
Rte_[Byps_]Mode_<p>_<o>([IN Rte_Instance <instance>])
```

Where <p> is the port name, and <o> the ModeDeclarationGroupPrototype name within the ModeSwitchInterface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_Rte_00144)*

Existence: **[SWS_Rte_02629]** ⌈ If a ModeAccessPoint exists and if the attribute enhancedModeApi of the ModeSwitchSenderComSpec resp. ModeSwitchReceiverComSpec is set to *false* or does not exist a Rte_Mode API according to [SWS_Rte_02628] shall be generated. ⌋*(SRS_Rte_00147, SRS_Rte_00078)*

[SWS_Rte_CONSTR_09030] Rte_Mode API may only be used by the runnable that describe its usage ⌈ The Rte_Mode API may only be used by the runnable that contains the corresponding ModeAccessPoint ⌋*()*

Description: The Rte_Mode API tells the AUTOSAR software-component which mode of a ModeDeclarationGroup of a given port is currently active. This is the information that the RTE uses for the mode disabling dependency's. A new mode will not be indicated immediately after the reception of a mode switch notification from a mode manager, see section 4.4.4. During mode transitions, i.e. during the execution of runnables that are triggered on exiting one mode or on entering the next mode, overlapping mode disablings of two modes are active. In this case, the Rte_Mode will return RTE_TRANSITION_<ModeDeclarationGroup>.

The Rte_Mode will return the same mode for all mode switch ports that are connected to the same mode switch port of the mode manager (see [SWS_Rte_02630]).

It is supported to have ModeAccessPoint(s) referring the provide mode switch ports of the mode manager to provide access for the mode manager on the information that the RTE uses for the mode disabling dependency's.

Return Value: The return type of Rte_Mode is dependent on the ImplementationDataType of the ModeDeclarationGroup. It shall return the value of the ModeDeclarationGroupPrototype. The type name shall be equal to the shortName of the ImplementationDataType.

The return value of the Rte_Mode is used to inform the caller about the current mode of the mode machine instance. The Rte_Mode API shall return the following values:

[SWS_Rte_07666] ⌈ During a transition of the mode machine instance, Rte_Mode shall return RTE_TRANSITION_<ModeDeclarationGroup>, where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup. ⌋*(SRS_Rte_00144)*

[SWS_Rte_02660] ⌈ When the mode machine instance is in a defined mode, Rte_Mode shall return RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration>, where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup and <ModeDeclaration> is the short name of the currently active ModeDeclaration. ⌋*(SRS_Rte_00144)*

[SWS_Rte_06742] ⌈ The API Rte_Mode shall return the value RTE_TRANSITION_<ModeDeclarationGroup> for a mode machine instance assigned to the RTE ([SWS_Rte_07533]) until the RTE has been initialized and where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup. ⌋ *(SRS_Rte_00144)*

[SWS_Rte_06781] ⌈ If modeManagerErrorBehavior.errorReactionPolicy is set to defaultMode the API Rte_Mode shall return the value RTE_TRANSITION_<ModeDeclarationGroup> for a mode machine instance while the partition of the mode users is stopped or restarting and until the RTE dequeues the next mode switch notifications.
<ModeDeclarationGroup> is the short name of the ModeDeclarationGroup. ⌋*(SRS_Rte_00144)* This indicates a transition and therefore the behavior is identical as during the initialization of the RTE (see [SRS_Rte_00144]).

[SWS_Rte_06782] ⌈ If the modeManagerErrorBehavior.errorReactionPolicy is set to lastMode, the API enhanced Rte_Mode shall return the value RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration> of the last mode for a mode machine instance while the partition of the mode users is stopped or restarting and until the RTE dequeues the next mode switch notifications.
<ModeDeclarationGroup> is the short name of the ModeDeclarationGroup. ⌋*(SRS_Rte_00144)* This indicates a stable mode during the re-initialization of the partition until the RTE is capable to dequeue the first mode switch notification after the partition restart.

[SWS_Rte_06743] ⌈ The Rte_Mode API shall return the values according [SWS_Rte_07666] and [SWS_Rte_02660] for a common mode machine instance already after initialization of the *Basic Software Scheduler*. ⌋*(SRS_Rte_00144)*

In inter partition mode management, RTE on the mode manager sided partition might not have direct access to the state variables of the mode machine instance.

[SWS_Rte_02732] ⌈ In inter partition mode management, the return value of the Rte_Mode API to the mode manager shall be consistent with the start of a transition by the Rte_Switch API and the inter partition communication of the ModeSwitchedAckEvent. ⌋*(SRS_Rte_00144, SRS_Rte_00210)*

Notes: The Rte_Mode API may already indicate the next ModeDeclaration, before the mode manager has picked up the ModeSwitchedAckEvent with the Rte_SwitchAck. This is not in contradiction to [SWS_Rte_02732].

[SWS_Rte_06744] ⌈ The RTE shall support calls of Rte_Mode after initialization of the *Basic Software Scheduler* but before the RTE is initialized. ⌋*(SRS_Rte_00144)*

5.6.31 Enhanced Rte_Mode

Purpose: Provides the currently active mode of a mode switch port. If the mode machine instance is in transition additionally the values of the previous and the next mode are provided.

Signature: **[SWS_Rte_08500]** ⌈

```
<return>
Rte_[Byps_]Mode_<p>_<o>([IN Rte_Instance <instance>,]
                        OUT <previousmode>,
                        OUT <nextmode>)
```

Where `<p>` is the port name, and `<o>` the ModeDeclarationGroupPrototype name within the ModeSwitchInterface categorizing the port. `[Byps_]` is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_Rte_00144)*

Existence: **[SWS_Rte_08501]** ⌈ The existence of a ModeAccessPoint given that the attribute *enhancedModeApi* of the ModeSwitchSenderComSpec resp. ModeSwitchReceiverComSpec is set to *true* shall result in the generation of a Rte_Mode API according to [SWS_Rte_08500]. ⌋*(SRS_Rte_00147, SRS_Rte_00078)*

[SWS_Rte_CONSTR_09031] Rte_Mode API may only be used by the runnable that describe its usage ⌈ The Rte_Mode API may only be used by the runnable that contains the corresponding ModeAccessPoint ⌋*()*

Description: The Rte_Mode API tells the AUTOSAR software-component which mode of a ModeDeclarationGroup of a given port is currently active. This is the information that the RTE uses for the mode disabling dependency's. A new mode will not be indicated immediately after the reception of a mode switch notification from a mode manager, see section 4.4.4. During mode transitions, i.e. during the execution of runnables that are triggered on exiting one mode or on entering the next mode, overlapping mode disablings of two modes are active. In this case, the Rte_Mode will return `RTE_TRANSITION_<ModeDeclarationGroup>`. The parameter `<previousmode>` than contains the mode currently being left,the parameter `<nextmode>` the mode being entered.

The Rte_Mode will return the same mode for all mode switch ports that are connected to the same mode switch port of the mode manager (see [SWS_Rte_02630]).

It is supported to have ModeAccessPoint(s) referring the provided mode switch ports of the mode manager to provide access for the mode manager on the information that the RTE uses for the mode disabling dependency's.

Return Value: The return type of Rte_Mode is dependent on the ImplementationDataType of the ModeDeclarationGroup. It shall return the value of the ModeDeclarationGroupPrototype. The type name shall be equal to the shortName of the ImplementationDataType. The return value of the Rte_Mode and the parameters <previousmode> and <nextmode> are used to inform the caller about the current mode of the mode machine instance.

[SWS_Rte_08504] ⌈ During a transition of a mode machine instance Rte_Mode shall return the following values

- the return value shall be RTE_TRANSITION_<ModeDeclarationGroup>,
- <previousmode> shall contain the value of the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration> of the mode being left,
- <nextmode> shall contain the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration> of the mode being entered,

where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup and <ModeDeclaration> is the short name of the ModeDeclaration. ⌋*(SRS_Rte_00144, SRS_Rte_00210)*

[SWS_Rte_08505] ⌈ When the mode machine instance is in a defined mode, Rte_Mode shall return the following values

- the return value shall contain the value of RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration>,
- <previousmode> shall contain the value of the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration>
- <nextmode> shall contain the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration>

where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup and <ModeDeclaration> is the short name of the currently active ModeDeclaration. ⌋*(SRS_Rte_00144)*

[SWS_Rte_06745] ⌈ The API enhanced Rte_Mode shall return the following values for a mode machine instance assigned to the RTE ([SWS_Rte_07533]) until the RTE has been initialized:

- the return value shall be RTE_TRANSITION_<ModeDeclarationGroup>,
- <previousmode> shall contain the value of the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration> of the initialMode of the ModeDeclarationGroup

- <nextmode> shall contain the value of the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration> of the initialMode of the ModeDeclarationGroup

where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup. ⌋*(SRS_Rte_00144)*

[SWS_Rte_06783] ⌈ If modeManagerErrorBehavior.errorReactionPolicy is set to defaultMode the API enhanced Rte_Mode shall return the following values for a mode machine instance while the partition of the mode users is stopped or restarting and until the RTE dequeues the next mode switch notifications.

- the return value shall be RTE_TRANSITION_<ModeDeclarationGroup>,
- <previousmode> shall contain the value of the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration> of the modeUserErrorBehavior.defaultMode of the ModeDeclarationGroup
- <nextmode> shall contain the value of the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration> of the modeUserErrorBehavior.defaultMode of the ModeDeclarationGroup

where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup. ⌋*(SRS_Rte_00144)* This indicates a transition from and to the defaultMode. If the defaultMode is identical to the initialMode the behavior is identical as during the initialization of the RTE (see [SRS_Rte_00144]).

[SWS_Rte_06784] ⌈ If the modeManagerErrorBehavior.errorReactionPolicy is set to lastMode, the API enhanced Rte_Mode shall return the following values for a mode machine instance while the partition of the mode users is stopped or restarting and until the RTE dequeues the next mode switch notifications.

- the return value shall be RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration> of the last mode,
- <previousmode> shall contain the value of the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration> of the last mode
- <nextmode> shall contain the value of the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration> of the last mode

where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup. ⌋(SRS_Rte_00144) This indicates a stable mode during the re-initialization of the partition until the RTE is capable to dequeue the first mode switch notification after the partition restart.

[SWS_Rte_06746] ⌈ The enhanced Rte_Mode API shall return the values according [SWS_Rte_08504] and [SWS_Rte_08505] for a common mode machine instance already after initialization of the *Basic Software Scheduler*. ⌋*(SRS_Rte_00144)*

In inter partition mode management, RTE on the mode manager sided partition might not have direct access to the state variables of the mode machine instance.

[SWS_Rte_08506] ⌈ In inter partition mode management, the return value and the contents of the parameters <previousmode> and <nextmode> of the Rte_Mode API to the mode manager shall be consistent with the start of a transition by the Rte_Switch API and the inter partition communication of the ModeSwitchedAckEvent. ⌋*(SRS_Rte_00144, SRS_Rte_00210)*

Notes: The Rte_Mode API may already indicate the next ModeDeclaration, before the mode manager has picked up the ModeSwitchedAckEvent with the Rte_SwitchAck. This is not in contradiction to [SWS_Rte_02732].

[SWS_Rte_06747] ⌈ The RTE shall support calls of the enhanced Rte_Mode after initialization of the *Basic Software Scheduler* but before the RTE is initialized. ⌋*(SRS_Rte_00144)*

5.6.32 Rte_Trigger

Purpose: Raise an external trigger of a trigger port.

Signature: **[SWS_Rte_07200]** ⌈
signature without queuing support:

```
void Rte_[Byps_]Trigger_<p>_<o>(
    [IN Rte_Instance <instance>],
    [OUT Rte_TransformerError transformerError])
```

signature with queuing support:

```
Std_ReturnType Rte_[Byps_]Trigger_<p>_<o>(
    [IN Rte_Instance <instance>])
```

Where <p> is the port name and <o> the Trigger within the trigger interface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2).

The signature for queuing support shall be generated by the RTE generator if the swImplPolicy of the associated Trigger is set to queued. ⌋(*SRS_Rte_00162*)

Data Transformation of external triggers is only supported for external triggers without queueing support.

Existence: **[SWS_Rte_07201]** ⌈ The existence of an ExternalTriggeringPoint shall result in the generation of a Rte_Trigger API. ⌋(*SRS_Rte_00162*)

[SWS_Rte_05300] ⌈ The optional OUT parameter transformerError of the API shall be generated if the PortPrototype of port <p> is referenced by a PortAPIOption which has the attribute errorHandling set to transformerErrorHandling. ⌋(*SRS_Rte_00249*)

[SWS_Rte_CONSTR_09032] Rte_Trigger API may only be used by the runnable that describe its usage ⌈ The Rte_Trigger API may only be used by the runnable that contains the corresponding ExternalTriggeringPoint. ⌋*()*

Description: The Rte_Trigger API triggers an execution for all runnables whose ExternalTriggerOccurredEvent is associated to the Trigger. The OUT parameter transformerError contains the transformer error which occurred during execution of the transformer chain. See chapter 4.10.5.

Return Value: None in case of signature without queuing support.

[SWS_Rte_06720] ⌈ The Rte_Trigger API shall return the following values:

- RTE_E_OK if the trigger was successfully queued or if no queue is configured
- RTE_E_LIMIT if the trigger was not queued because the maximum queue size is already reached.

in the case of signature with queuing support. ⌋(*SRS_Rte_00235*)

5.6.33 Rte_IrTrigger

Purpose: Raise an internal trigger to activate Runnable entities of the same software component instance.

Signature: **[SWS_Rte_07203]** ⌈

signature without queuing support:

```
void Rte_[Byps_]IrTrigger_<re>_<o>(
    [IN Rte_Instance <instance>])
```

signature with queuing support:

```
Std_ReturnType Rte_[Byps_]IrTrigger_<re>_<o>(
    [IN Rte_Instance <instance>])
```

Where `<re>` is the name of the runnable entity the API might be used in and `<o>` is the name of the `InternalTriggeringPoint`. `[Byps_]` is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2).

The signature for queuing support shall be generated by the RTE generator if the `swImplPolicy` of the associated `InternalTriggeringPoint` is set to `queued`. ⌋*(SRS_Rte_00163)*

Existence: **[SWS_Rte_07204]** ⌈ The existence of an `InternalTriggeringPoint` shall result in the generation of a `Rte_IrTrigger` API. ⌋*(SRS_Rte_00163)*

[SWS_Rte_CONSTR_09033] `Rte_IrTrigger` API may only be used by the runnable that describe its usage ⌈ The `Rte_IrTrigger` API may only be used by the runnable that contains the corresponding `InternalTriggeringPoint`. ⌋*()*

Description: The `Rte_IrTrigger` triggers an execution for all runnables whose `InternalTriggerOccurredEvent` is associated to the `InternalTriggeringPoint`.

Return Value: None in case of signature without queuing support.

[SWS_Rte_06721] ⌈ The `Rte_Trigger` API shall return the following values:

- `RTE_E_OK` if the trigger was successfully queued or if no queue is configured
- `RTE_E_LIMIT` if the trigger was not queued because the maximum queue size is already reached.

in the case of signature with queuing support. ⌋*(SRS_Rte_00235)*

Notes: None.

5.6.34 Rte_IFeedback

Purpose: Provide access to acknowledgement notifications for implicit sender receiver communication and to pass error notification to senders.

Signature:

[SWS_Rte_07367] ⌈

```
Std_ReturnType
Rte_[Byps_]IFeedback_<re>_<p>_<o> (
    [IN RTE_Instance <instance>])
```

Where <re> is the runnable entity name, <p> the port name and <o> the VariableDataPrototype within the sender-receiver interface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00122, SRS_Rte_00129, SRS_Rte_00185)*

Existence:

Note: according to [SWS_Rte_01283], acknowledgment is enabled for a provided VariableDataPrototype by the existence of a TransmissionAcknowledgementRequest in the SenderComSpec.

[SWS_Rte_07646] ⌈ An Rte_IFeedback API shall be created for a provided VariableDataPrototype if acknowledgment is enabled and the RunnableEntity has a VariableAccess in the dataWriteAccess role referring to this VariableDataPrototype. ⌋*(SRS_Rte_00122, SRS_Rte_00129, SRS_Rte_00185)*

[SWS_Rte_07647] ⌈ An Rte_IFeedback API shall be created for a provided VariableDataPrototype if acknowledgment is enabled and a DataWriteCompletedEvent references the RunnableEntity as well as the VariableAccess which in turn references the VariableDataPrototype. ⌋*(SRS_Rte_00122, SRS_Rte_00129, SRS_Rte_00185)*

[SWS_Rte_07648] ⌈ If acknowledgment is enabled for a provided VariableDataPrototype and a DataWriteCompletedEvent references a runnable entity as well as the VariableAccess which in turn references the VariableDataPrototype, the runnable entity shall be activated when the transmission acknowledgment occurs or when a timeout was detected by the RTE. See [SWS_Rte_07379]. ⌋*(SRS_Rte_00122, SRS_Rte_00129, SRS_Rte_00185)*

[SWS_Rte_CONSTR_09000] Rte_IFeedback API may only be used by the RunnableEntitys that describe its usage ⌈ The Rte_IFeedback API shall only be used by a RunnableEntity that either has a VariableAccess in the dataWriteAccess role referring to the VariableDataPrototype or is triggered by a DataWriteCompletedEvent referring to the VariableAccess which in turn references the VariableDataPrototype. ⌋*()*

Description:

The Rte_IFeedback API takes no parameters other than the instance handle – the return value is used to indicate the acknowledgment status to the caller.

The Rte_IFeedback API applies only to implicit sender-receiver communication.

The Rte_IFeedback API provides access to the transmission feedback of the data elements, declared as sent by a runnable using a VariableAccess in the dataWriteAccess role, and sent after the previous invocation of the runnable. The API function is guaranteed to be have constant execution time and therefore can also be used within category 1A runnable entities.

The required consistency access by a runnable can be provided by copying of the status before the execution of the runnable so that it cannot be modified by the RTE during the lifetime of the runnable entity.

Return Value: The return value is used to indicate the "status" status and errors detected by the RTE during execution of the Rte_IFeedback call.

- **[SWS_Rte_07374]** ⌈ RTE_E_NO_DATA – No acknowledgments or error notifications were received from COM when the runnable entity was started. ⌋*(SRS_Rte_00094, SRS_Rte_00122, SRS_Rte_00129, SRS_Rte_00185)*
- **[SWS_Rte_07375]** ⌈ RTE_E_COM_STOPPED – (Inter-ECU communication only) The last transmission was rejected (when the local buffer was sent), with an RTE_E_COM_STOPPED return code or an error notification was received from COM before any timeout notification. ⌋*(SRS_Rte_00094, SRS_Rte_00122, SRS_Rte_00129, SRS_Rte_00185)*
- **[SWS_Rte_07650]** ⌈ RTE_E_TIMEOUT – (Inter-ECU only) A timeout notification was received from COM before any error notification. ⌋*(SRS_Rte_00094, SRS_Rte_00122, SRS_Rte_00129, SRS_Rte_00185)*
- **[SWS_Rte_07376]** ⌈ RTE_E_TRANSMIT_ACK – A transmission acknowledgment was received. This error code is valid for both inter-ECU and intra-ECU communication. ⌋*(SRS_Rte_00094, SRS_Rte_00122, SRS_Rte_00129, SRS_Rte_00185)*
- **[SWS_Rte_07660]** ⌈ RTE_E_UNCONNECTED – Indicates that the sender port is not connected. ⌋*(SRS_Rte_00094, SRS_Rte_00122, SRS_Rte_00129, SRS_Rte_00185, SRS_Rte_00139)*
- **[SWS_Rte_08580]** ⌈ RTE_E_HARD_TRANSFORMER_ERROR – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*

- **[SWS_Rte_08581]** ⌈ RTE_E_SOFT_TRANSFORMER_ERROR – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*

The RTE_E_NO_DATA, RTE_E_TRANSMIT_ACK and RTE_E_UNCONNECTED return values are not considered to be an error but rather indicates correct operation of the API call.

[SWS_Rte_07651] ⌈ The initial return value of the Rte_IFeedback API, when the runnable entity is executed before any attempt to write some data shall be RTE_E_TRANSMIT_ACK. ⌋*(SRS_Rte_00094, SRS_Rte_00122, SRS_Rte_00129, SRS_Rte_00185)*

[SWS_Rte_08074] ⌈ In case of multiple faults during a call of Rte_IFeedback the resulting return value shall be derived according to the following priority rules (highest priority first): (1) RTE_E_UNCONNECTED, (2) RTE_E_TIMEOUT, (3) RTE_E_HARD_TRANSFORMER_ERROR, (4) RTE_E_COM_STOPPED, (5) RTE_E_NO_DATA, (6) RTE_E_SOFT_TRANSFORMER_ERROR, (7) RTE_E_TRANSMIT_ACK. ⌋*(SRS_Rte_00122)*

Notes: See the notes for the Rte_Feedback API in section 5.6.8.

5.6.35 Rte_IsUpdated

Purpose: Provide access to the update flag for an explicit receiver.

Signature: **[SWS_Rte_07390]** ⌈

```
boolean Rte_[Byps_]IsUpdated_<p>_<o>(
    [IN RTE_Instance <instance>])
```

Where <p> is the port name and <o> the VariableDataPrototype within the sender-receiver interface categorizing the port. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_BSW_00310, SRS_Rte_00179)*

Existence: **[SWS_Rte_07391]** ⌈ An Rte_IsUpdated API shall be created for a required VariableDataPrototype if a RunnableEntity has a VariableAccess in the dataReceivePointByArgument or dataReceivePointByValue role referring to the VariableDataPrototype and the enableUpdate attribute is enabled in the NonqueuedReceiverComSpec of the VariableDataPrototype. ⌋*(SRS_Rte_00179)*

[SWS_Rte_CONSTR_09034] Rte_IsUpdated API may only be used by the runnable that describe the access to the corresponding data ⌈ The Rte_IsUpdated API may only be used by the runnable that contains the corresponding VariableAccess in the dataReceivePointByArgument or dataReceivePointByValue role. ⌋*()*

Description: The Rte_IsUpdated API takes no parameters other than the instance handle – the return value is used to indicate if the VariableDataPrototype has been updated or not.

The Rte_IsUpdated API applies only to sender-receiver communication.

Return Value: The return value is used to indicate if the VariableDataPrototype has been updated or not.

- **[SWS_Rte_07392]** ⌈ TRUE – Data element updated since last read. ⌋*(SRS_Rte_00094, SRS_Rte_00179)*
- **[SWS_Rte_07393]** ⌈ FALSE – Data element not updated since last read. ⌋*(SRS_Rte_00094, SRS_Rte_00179)*

Notes: None.

5.6.36 Rte_PBCon

Purpose: Provide access to the individual post-build artifacts of a VariationPointProxy for SWCs of a system containing different variants.

Signature: **[SWS_Rte_08066]** ⌈

```
<return>
Rte_[Byps_]PBCon_<vpp> ()
```

Where <vpp> is the shortName of the VariationPointProxy. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_Rte_00191)*

Existence: **[SWS_Rte_08067]** ⌈ A Rte_PBCon API shall be generated, if a PostBuildVariantCriterion or at least one PostBuildVariantCondition is defined for the VariationPointProxy. ⌋*(SRS_Rte_00191)*

Description: Depending on the category of the VariationPointProxy (see Software Component Template [2]), the Rte_PBCon API provides either access to the PostBuildVariantCriterion or to the result of the evaluation of the PostBuildVariantConditions against the PostBuildVariantCriterion.

Return Value: **[SWS_Rte_08068]** ⌈ For VariationPointProxys of category VALUE the return value of Rte_PBCon shall be an integer value yielding from the VariationPointProxy.postBuildValueAccess.

The return type of Rte_PBCon shall be in this case conform with the ImplementationDataType defined by VariationPointProxy.implementationDataType. ⌋*(SRS_Rte_00191)*

[SWS_Rte_08069] ⌈ For VariationPointProxys of category CONDITION the return value of Rte_PBCon shall be the result of the evaluated expression $PBExp$:$\bigwedge_{PBVarCon}$(VariationPointProxy.postBuildValueAccess = PostBuildVariantCondition.value), where *PBVarCon* is the set of all postBuildVariantConditions of the VariationPointProxy. If a pre-build condition is defined in addition the return value shall be the result of the evaluated expression $PPBExp$:VariationPointProxy.conditionAccess$\bigwedge PBExp$.

The return type of Rte_PBCon shall be in this case the Platform Type boolean. ⌋*(SRS_Rte_00191)*

Notes: **[SWS_Rte_08070]** ⌈ For VariationPointProxys of category CONDITION that are using both conditionAccess and postBuildVariantCondition the RTE shall ensure in Rte_PBCon that pre-build conditions have precedence over post-build conditions. ⌋*(SRS_Rte_00191)*

More details regarding Rte_PBCon API can be found in section 4.7.5.

5.6.37 Rte_IsAvailable

Purpose: Provide access to the availability information for an optional member of an ImplementationDataType of category STRUCTURE.

Signature: **[SWS_Rte_03611] DRAFT** ⌈

```
boolean
Rte_IsAvailable_<i>_<e>(IN <data>)
```

Where <i> is the shortName of the ImplementationDataType of category STRUCTURE and <e> the shortName of the ImplementationDataTypeElement. ⌋*(SRS_Rte_00261)*

Existence: **[SWS_Rte_03612] DRAFT** ⌈ An Rte_IsAvailable API shall be generated for an ImplementationDataTypeElement of an ImplementationDataType when the attribute isOptional of the ImplementationDataTypeElement is set to true. ⌋*(SRS_Rte_00261)*

Description: The Rte_IsAvailable API takes a concrete variable as input by reference (e.g. the returned data of Rte_Read). The variable must be of type <i>. The return value is used to indicate whether the optional member <e> is available within the variable of type <i>.

Return Value:
- **[SWS_Rte_03613] DRAFT** ⌈ TRUE – The optional member <i> is available. ⌋*(SRS_Rte_00261)*
- **[SWS_Rte_03614] DRAFT** ⌈ FALSE – The optional member <i> is not available. ⌋*(SRS_Rte_00261)*

Notes: None.

5.6.38 Rte_SetAvailable

Purpose: Sets the availability information for an optional member of an ImplementationDataType of category STRUCTURE.

Signature: **[SWS_Rte_03615] DRAFT** ⌈

```
void
Rte_SetAvailable_<i>_<e>(IN/OUT <data>, boolean available)
```

Where <i> is the shortName of the ImplementationDataType of category STRUCTURE and <e> the shortName of the ImplementationDataTypeElement. ⌋*(SRS_Rte_00261)*

Existence: **[SWS_Rte_03616] DRAFT** ⌈ An Rte_SetAvailable API shall be generated for an ImplementationDataTypeElement of an ImplementationDataType when the attribute isOptional of the ImplementationDataTypeElement is set to true. ⌋*(SRS_Rte_00261)*

Description: The Rte_SetAvailable API takes a concrete variable as input by reference (e.g. a variable which will be passed to an Rte_Write call). The variable must be of type <i>. The API sets the availability of the struct member <e> within the variable to the value defined by the available parameter.

Return Value: None.

Notes: None.

5.7 Runnable Entity Reference

An AUTOSAR component defines one or more "runnable entities". A runnable entity is a piece of code with a single entry point and an associate set of data. A software-component description provides definitions for each runnable entity within the software-component.

For components implemented using C or C++ the entry point of a runnable entity is implemented by a function with global scope defined within a software-component's source code. The following sections consider the function signature and prototype.

5.7.1 Signature

The definition of all runnable entities, whatever the RTEEvent that triggers their execution, follows the same basic form.

[SWS_Rte_01126] ⌈

```
<void|Std_ReturnType> [Byps_]<prefix><name>(
     [IN Rte_Instance <instance>],
     [IN Rte_ActivatingEvent_<name> <activation>],
     [role parameters])
```

Where <name> [8] is the symbol describing the runnable's entry point and <prefix> is the optional SymbolProps.symbol attribute of the AtomicSwComponentType owning the RunnableEntity, i.e. <prefix> will only appear if the attribute SymbolProps.symbol exists. The usage of Rte_ActivatingEvent is optional and defined in [SWS_Rte_08051]. The definition of the *role parameters* is defined in Section 5.7.3. [Byps_] is an optional infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_Rte_00031, SRS_Rte_00011, SRS_Rte_00238)*

Section 5.2.6.4 contains details on a recommended naming conventions for runnable entities based on the RTEEvent that triggers the runnable entity. The recommended naming convention makes explicit the functions that implement runnable entities as well as clearly associating the runnable entity and the applicable data element or operation.

5.7.2 Entry Point Prototype

The RTE determines the required role parameters, and hence the prototype of the entry point, for a runnable entity based on information in the input information. The entry point defined in the component source *must* be compatible with the parameters passed by the RTE when the runnable entity is triggered by the RTE and therefore the RTE generator is required to emit a prototype for the function.

[SWS_Rte_01132] ⌈ The RTE generator shall emit a prototype for the runnable entity's entry point in the *Application Header File*, if the RunnableEntity is triggered by an RTEEvent and no SwcBswRunnableMapping exists for it. ⌋*(SRS_Rte_00087, SRS_Rte_00051, SRS_Rte_00031)*

[8] Runnable entities have two "names" associated with them in the AUTOSAR Software Component Template; the runnable's identifier and the entry point's symbol. The identifier is used to reference the runnable entity within the input data and the symbol used within code to identify the runnable's implementation. In the context of a prototype for a runnable entity, "name" is the runnable entity's entry point symbol.

The prototype for a function implementing the entry point of a runnable entity is emitted for both “RTE Contract” and “RTE Generation” phases. The function name for the prototype is the runnable entity’s entry point. The prototype of the entry point function includes the runnable entity’s instance handle and its role parameters, see Listing 5.1.

[SWS_Rte_07194] ⌈ The RTE Generator shall wrap each RunnableEntity’s *Entry Point Prototype* in the *Application Header File* with the *Memory Mapping* and *Compiler Abstraction* macros.

```
#define [Byps_]<c>_START_SEC_<sadm>
#include "[Byps_]<c>_MemMap.h"

FUNC(<void|Std_ReturnType>, <c>_<sadm>)  [Byps_]<prefix><name> (
                             [IN Rte_Instance <instance>],
                             [IN Rte_ActivatingEvent_<name> <activation>],
                             [role parameters]);

#define [Byps_]<c>_STOP_SEC_<sadm>
#include "[Byps_]<c>_MemMap.h"
```

where <c> is the shortName of the software component type,

<sadm> is the shortName of the referred swAddrMethod.

<prefix> is the optional SymbolProps.symbol attribute of the AtomicSwComponentType owning the RunnableEntity, i.e. <prefix> will only appear if the attribute SymbolProps.symbol exists.

<name> is the attribute symbol describing the RunnableEntity’s entry point.

The usage of Rte_ActivatingEvent is optional and defined in [SWS_Rte_08051]. The definition of the *role parameters* is defined in Section 5.7.3. The Memory Mapping macros could wrap several *Entry Point Prototype* if these are referring to the same swAddrMethod. If RunnableEntity does not refer a swAddrMethod the <sadm> is set to default CODE. [Byps_] is an optionnal infix used when component wrapper method for bypass support is enabled for the related software component type (See chapter 4.9.2). ⌋*(SRS_Rte_00148, SRS_Rte_00149, SRS_Rte_00238, SRS_Rte_00011)*

[SWS_Rte_06531] ⌈ The RTE Generator shall wrap each *Entry Point Prototype* in the *Application Header File* of a variant existent RunnableEntity if the variability shall be implemented. ⌋*(SRS_Rte_00201)*

```
#if (<condition>)

<Entry Point Prototype>

#endif
```

where condition is the *Condition Value Macro* of the VariationPoint relevant for the variant existence of the RunnableEntity (see table 4.20), Entry Point Prototype is the code according an invariant *Entry Point Prototype* (see also [SWS_Rte_01131], [SWS_Rte_07177], [SWS_Rte_02512], [SWS_Rte_01133], [SWS_Rte_01359], [SWS_Rte_01166], [SWS_Rte_01135], [SWS_Rte_01137], [SWS_Rte_07207], [SWS_Rte_07208], [SWS_Rte_07379]).

[SWS_Rte_01016] ⌈ The function implementing the entry point of a runnable entity shall define an instance handle as the first formal parameter if and only if the software component's supportsMultipleInstantiation attribute is set to TRUE. ⌋ *(SRS_Rte_00011, SRS_Rte_00031)*

The RTE will ensure that when the runnable entity is triggered the instance handle parameter indicates the correct component instance. The remaining parameters passed to the runnable entity depend on the RTEEvent that triggers execution of the runnable entity.

Due to the global name space of a C Linker Locater symbols of RunnableEntitys have to be unique in the ECU. When AtomicSwComponentTypes of several vendors are integrated in the same ECU name clashes might occur if the same symbol is accidentally used twice. To ease the dissolving of name clashes the RTE supports an abstraction of the RunnableEntity symbol in the implementation of the software component.

[SWS_Rte_06713] ⌈ The RTE generator shall emit for each RunnableEntity a define for a symbolic name of the RunnableEntity.

```
#define RTE_RUNNABLE_<name> <prefix><symbol>
```

where <name> is the shortName of the RunnableEntity,

<prefix> is the optional SymbolProps.symbol attribute of the AtomicSwComponentType owning the RunnableEntity.

<symbol> is the attribute symbol describing the RunnableEntity's entry point.

⌋ *(SRS_Rte_00087, SRS_Rte_00051, SRS_Rte_00031)*

This symbolic name of the RunnableEntity can be used as follows in the software component implementation.

Example 5.30

For software component "'HugeSwc"' with a runnable "'FOO"' where the SymbolProps.symbol is set to "'TinySwc"' the *Application Header File* contains the definition:

```
/* Application Header File of HugeSwc*/
#define RTE_RUNNABLE_FOO TinySwcfoo
```

This can be used in the software components c file for the definition of the runnable:

```
/* software component c file */
RTE_RUNNABLE_FOO()
{
  /* The algorithm of foo */
  return;
}
```

A change of the SymbolProps.symbol valued would have no effect on the c implementation of the software component but it would change the contract and the used labels in a object code delivery.

In case that the RunnableEntity is mapped to BswModuleEntity the RTE Generator has to additionally respect the definitions in 6.3.2.3.4.

5.7.3 Role Parameters

The *role parameters* are optional and their presence and types depend on the RTE-Event that triggers the execution of the runnable entity. The role parameters that are necessary for each triggering RTEEvent are defined in Section 5.7.5.

[SWS_Rte_06703] ⌈ The RTE Generator shall name role parameters according to the value of the symbol attribute of RunnableEntityArguments if RunnableEntityArguments are defined for the related RunnableEntity and if no mapping to a BswModuleEntry is defined. ⌋*(SRS_Rte_00087)*

[SWS_Rte_06704] ⌈ The RTE Generator shall name role parameters according to the shortName of the SwServiceArgs of the mapped BswModuleEntry if a mapping of the RunnableEntity to a BswModuleEntry is defined. ⌋*(SRS_Rte_00087)*

Please note that RunnableEntityArguments defined for a RunnableEntity which is mapped to a BswModuleEntry are irrelevant.

[SWS_Rte_06705] ⌈ The RTE Generator shall generate nameless role parameters if neither RunnableEntityArguments nor a mapping to a BswModuleEntry is defined for the RunnableEntity. ⌋*(SRS_Rte_00087)*

Further details about the mapping of RunnableEntitys and BswModuleEntry can be found section "‘Synchronization with a Corresponding SWC"’ of the document [9]

5.7.4 Return Value

A function in C or C++ is required to have a return type. The RTE only uses the function return value to return application error codes of a server operation.

[SWS_Rte_01130] ⌈ A function implementing a runnable entity entry point shall only have the return type Std_ReturnType, if the runnable entity represents a server operation and the AUTOSAR interface description of that client server communication lists potential application errors. All other functions implementing a runnable entity entry point shall have a return type of void. ⌋*(SRS_Rte_00124, SRS_Rte_00031)*

Note: If the potential application errors include RTE_E_OK, this shall also lead to a return type of Std_ReturnType.

[SWS_Rte_CONSTR_09045] The upper two bits of the of the server return value are reserved ⌈ Only the least significant six bit of the return value of a server runnable shall be used by the application to indicate an error. The upper two bit shall be zero. ⌋ *()*

See also [SWS_Rte_02573].

5.7.5 Triggering Events

The RTE is the *sole* entity that can trigger the execution of a runnable entity. The RTE triggers runnable entities in response to different `RTEEvent`s.

The most basic `RTEEvent` that can trigger a runnable entity is the `TimingEvent` that causes a runnable entity to be periodically triggered by the RTE. In contrast, the remaining `RTEEvent`s that can trigger runnable entities all occur as a result of communication activity or as a result of mode switches.

The following subsections describe the conditions that can trigger execution of a runnable entity. For each triggering event the signature of the function (the “entry point”) that implements the runnable entity is defined. The signature definition includes two classes of parameters for each function;

1. The instance handle – the parameter type is always `Rte_Instance`. ([SWS_Rte_01016])
2. The role parameters – used to pass information required by the runnable entity as a consequence of the triggering condition. The presence (and number) of role parameters depends solely on the triggering condition.

5.7.5.1 TimingEvent

Purpose: Trigger a runnable entity periodically at a rate defined within the software-component description.

Signature: **[SWS_Rte_01131]** ⌈

```
void <name>([IN Rte_Instance <instance>])
```

⌋*(SRS_Rte_00072)*

5.7.5.2 BackgroundEvent

Purpose: A recurring `RTEEvent` which is used to perform background activities. It is similar to a `TimingEvent` but has no fixed time period and is activated only with low priority.

Signature: **[SWS_Rte_07177]** ⌈

```
void <name>([IN Rte_Instance <instance>])
```

⌋(*SRS_Rte_00072*)

5.7.5.3 SwcModeSwitchEvent

Purpose: Trigger of a runnable entity as a result of a mode switch. See also sections 4.4.4 and 4.4.7 for reference.

Signature: **[SWS_Rte_02512]** ⌈

```
void <name>([IN Rte_Instance <instance>])
```

⌋(*SRS_Rte_00072, SRS_Rte_00143*)

5.7.5.4 AsynchronousServerCallReturnsEvent

Purpose: Triggers a runnable entity used to "collect" the result and status information of an asynchronous client-server operation.

Signature: **[SWS_Rte_01133]** ⌈

```
void <name>([IN Rte_Instance <instance>])
```

⌋(*SRS_Rte_00072, SRS_Rte_00029, SRS_Rte_00079*)

Notes: The runnable entity triggered by an `AsynchronousServerCallReturnsEvent` `RTEEvent` should use the `Rte_Result` API to actually receive the result and the status of the server operation.

5.7.5.5 DataReceiveErrorEvent

Purpose: Triggers a runnable entity used to "collect" the error status of a `data element` with "data" semantics on the receiver side.

Signature: **[SWS_Rte_01359]** ⌈

```
void <name>([IN Rte_Instance <instance>])
```

⌋(*SRS_Rte_00072, SRS_Rte_00029, SRS_Rte_00079*)

Notes: The runnable entity triggered by a `DataReceiveErrorEvent` `RTEEvent` should use the `Rte_IStatus` API to actually read the status.

5.7.5.6 OperationInvokedEvent

Purpose: An `RTEEvent` that causes the RTE to trigger a runnable entity whose entry point provides an implementation for a client-server operation.

This event occurs in response to a received request from a client to execute the operation.

Signature: **[SWS_Rte_01166]** ⌈

```
<void|Std_ReturnType> <name>
        ([IN Rte_Instance <instance>],
        [IN              <portDefArg 1>, ...
         IN              <portDefArg n>],
        [IN|INOUT|OUT] <param 1>, ...
        [IN|INOUT|OUT] <param n>,
        [IN Rte_TransformerError transformerError])
```

Where `<portDefArg 1>, ..., <portDefArg n>` represent the port-defined argument values (see Section 4.3.2.4) and `<param 1>, ... <param n>` indicates the operation IN, INOUT and OUT parameters. ⌋*(SRS_Rte_00029, SRS_Rte_00079, SRS_Rte_00072, SRS_Rte_00152)*

The data type of each port defined argument is taken from the software component template, as defined in `valueType`.

Note that the port-defined argument values are optional, depending upon the server's internal behavior.

[SWS_Rte_07023] ⌈ The operation parameters `<param 1>, ... <param n>` are the specified `ArgumentDataPrototype`s of the `ClientServerOperation` that is associated with the `OperationInvokedEvent`. The operation parameters shall be ordered according to the `ClientServerOperation`'s ordered list of the `ArgumentDataPrototype`s. ⌋*(SRS_Rte_00029, SRS_Rte_00079, SRS_Rte_00072)*

[SWS_Rte_07024] ⌈ If the `ServerArgumentImplPolicy` is set to `useArgumentType` the data type of the `<param>` is derived from the `ArgumentDataPrototype`'s `ImplementationDataType`. ⌋*(SRS_Rte_00029, SRS_Rte_00079, SRS_Rte_00072)*

In case of [SWS_Rte_07024] the `RunnableEntity`s parameter are equally typed as the parameter for the `Rte_Call` API described in section 5.2.6.5

[SWS_Rte_08569] ⌈ The optional IN parameter `transformerError` of the API shall be generated if the `PortPrototype` of port `<p>` is referenced by a `PortAPIOption` which has the attribute `errorHandling` set to `transformerErrorHandling`. ⌋*(SRS_Rte_00249)*

The IN parameter `transformerError` contains the transformer error which occured during execution of the transformer chain. See chapter 4.10.5. Because the runnable can only be triggered if the error is no hard error, the error given here is always a soft error.

Hard errors are notified via TransformerHardErrorEvents.

[SWS_Rte_07026] ⌈ The RTE-Generator shall reject configurations violating [constr_1297]. ⌋*(SRS_Rte_00029, SRS_Rte_00079, SRS_Rte_00072, SRS_Rte_00018)*

[SWS_Rte_07027] ⌈ If the ServerArgumentImplPolicy is set to useVoid the data type of the <param> is set to void * for any kind of data type. ⌋*(SRS_Rte_00029, SRS_Rte_00079, SRS_Rte_00072)*

It is considered an invalid configuration if ServerArgumentImplPolicy uses void in case of primitive IN arguments. See [constr_1286] in Software Component Template specification.

[SWS_Rte_08800] ⌈ The RTE-Generator shall reject configurations violating [constr_1286]. ⌋*(SRS_Rte_00079, SRS_Rte_00018)*

Return Value: If the AUTOSAR interface description of the client server communication lists possible error codes, these are returned by the function using the return type Std_ReturnType. If no error codes are defined for this interface, the return type shall be void (see [SWS_Rte_01130]).

This means that even if a runnable entity implementing a server "only" returns E_OK, application errors have to be defined. Else the return types do not match.

5.7.5.7 DataReceivedEvent

Purpose: A runnable entity triggered by the RTE to receive and process a signal received on a sender-receiver interface.

Signature: **[SWS_Rte_01135]** ⌈

```
void <name>([IN Rte_Instance <instance>])
```

⌋*(SRS_Rte_00072, SRS_Rte_00028, SRS_Rte_00131, SRS_Rte_00107)*

Notes: The data or event is not passed as an additional parameter. Instead, the previously described reception API should be used to access the data/event. This approach permits the same signature for runnables that are triggered by time (TimingEvent) or data reception.

Caution: For intra-ECU communication, the DataReceivedEvent is fired after each completed write operation to the shared data. In case of implicit access, write operation is considered to be completed when the runnable ends. While for inter-ECU communication, the DataReceivedEvent is fired by the RTE after a callback from COM or LdCom due to data reception. Over a physical network, 'data' is commonly transmitted periodically and hence not only will the latency and jitter of DataReceivedEvents vary depending on whether a configuration uses intra or inter-ECU communication, but also the number and frequency of these RTEEvents may change significantly. This means that a TimingEvent should be used to periodically activation of a runnable rather than relying on the periodic transmission of data.

5.7.5.8 DataSendCompletedEvent

Purpose: A runnable entity triggered by the RTE to receive and process transmit acknowledgment notifications.

Signature: **[SWS_Rte_01137]** ⌈

```
void <name>([IN Rte_Instance <instance>])
```

⌋(*SRS_Rte_00072, SRS_Rte_00122, SRS_Rte_00107*)

Notes: The runnable entity triggered by a DataSendCompletedEvent RTEEvent should use the Rte_Feedback API to actually receive the status of the acknowledgment.

5.7.5.9 ModeSwitchedAckEvent

Purpose: A runnable entity triggered by the RTE to receive and process mode switched acknowledgment notifications.

Signature: **[SWS_Rte_02758]** ⌈

```
void <name>([IN Rte_Instance <instance>])
```

⌋(*SRS_Rte_00072, SRS_Rte_00122, SRS_Rte_00107*)

Notes: The runnable entity triggered by an ModeSwitchedAckEvent should use the Rte_SwitchAck API to actually receive the status of the acknowledgment.

5.7.5.10 SwcModeManagerErrorEvent

Purpose: A runnable entity triggered by the RTE to react on errors occurring during mode handling.

Signature: **[SWS_Rte_06771]** ⌈

```
void <name>([IN Rte_Instance <instance>])
```

⌋(*SRS_Rte_00072, SRS_Rte_00122, SRS_Rte_00107*)

Notes: –

5.7.5.11 ExternalTriggerOccurredEvent

Purpose: A runnable entity triggered by the RTE at the occurrence of an external event.

Signature: **[SWS_Rte_07207]** ⌈

```
void <name>([IN Rte_Instance <instance>],
    [IN Rte_TransformerError transformerError])
```

⌋*(SRS_Rte_00162, SRS_Rte_00072)*

[SWS_Rte_05301] ⌈ The optional IN parameter `transformerError` of the API shall be generated if the `PortPrototype` of port `<p>` is referenced by a `PortAPIOption` which has the attribute `errorHandling` set to `transformerErrorHandling`. ⌋*(SRS_Rte_00249)*

The IN parameter `transformerError` contains the transformer error which occurred during execution of the transformer chain. See chapter 4.10.5. Because the `RunnableEntity` can only be triggered if the error is no hard error, the error given here is always a soft error. Hard errors are notified via `TransformerHardErrorEvent`s.

Notes: –

5.7.5.12 InternalTriggerOccurredEvent

Purpose: A runnable entity triggered by the RTE by an inter runnable trigger.

Signature: **[SWS_Rte_07208]** ⌈

```
void <name>([IN Rte_Instance <instance>])
```

⌋*(SRS_Rte_00163, SRS_Rte_00072)*

Notes: –

5.7.5.13 DataWriteCompletedEvent

Purpose: A runnable entity triggered by the RTE to receive and process transmit acknowledgment notifications for implicit communication.

Signature: **[SWS_Rte_07379]** ⌈

```
void <name>([IN Rte_Instance <instance>])
```

⌋*(SRS_Rte_00072, SRS_Rte_00122, SRS_Rte_00185)*

Notes: The runnable entity triggered by a `DataWriteCompletedEvent` `RTEEvent` should use the `Rte_IFeedback` API to actually receive the status of the acknowledgment.

5.7.5.14 InitEvent

Purpose: A runnable entity triggered by the RTE for initialization.

Signature: **[SWS_Rte_06748]** ⌈

```
void <name>([IN Rte_Instance <instance>])
```

⌋*(SRS_Rte_00072, SRS_Rte_00240)*

Notes: The runnable entity triggered by an `InitEvent` `RTEEvent` is supposed to be used for initialization purposes, i.e. for starting and restarting a partition. It is not guaranteed that all `RunnableEntity`s referenced by this `InitEvent` are executed before the 'regular' `RunnableEntity`s are executed for the first time.

5.7.5.15 TransformerErrorEvent

Purpose: A `RunnableEntity` triggered by the RTE because a transformation error occurred during the transformation of a server runnable's arguments or during the transformation of an external trigger event (external trigger sink).

Signature: **[SWS_Rte_08791]** ⌈

```
void <name>([IN Rte_Instance <instance>],
        IN Rte_TransformerError transformerError)
```

⌋*(SRS_Rte_00072, SRS_Rte_00249)*

Notes: The `RunnableEntity` triggered by a `TransformerHardErrorEvent` `RTEEvent` is supposed to be used for reaction on a hard transformer error on the server side of a client/server comumunication or in the external trigger sink. The IN parameter `transformerError` contains the transformer error which occured during execution of the transformer chain. See chapter 4.10.5.

5.7.6 Reentrancy

A runnable entity is declared within a software-component type. The RTE ensures that concurrent activation of same instance of a runnable entity is only allowed if the runnables attribute "canBeInvokedConcurrently" is set to TRUE (see Section 4.2.6).

When a software-component is multiple instantiated each separate instance has its own instance of the runnable entities in the software-component. Whilst instances of a software-component are independent, the runnable entities instances share the same code ([SWS_Rte_03015]).

Example 5.31

Consider a component `c1` with runnable entity `re1` and entry point `ep` that is instantiated twice on the same ECU.

The two instances of `c1` each has a separate *instance* of `re1`. Software-component instances are scheduled independently and therefore each instance of `re1` could be concurrently executing `ep`.

The potential for concurrent execution of runnable entities when multiple instances of a software-component are created means that each entry point should be reentrant.

5.8 RTE Lifecycle API Reference

This section documents the API functions used to start and stop the RTE. RTE Lifecycle API functions are not invoked from AUTOSAR software-components – instead they are invoked from other basic software module(s).

5.8.1 Rte_Start

The API `Rte_Start` initializes the RTE itself.

Service name:	Rte_Start	

Syntax:	`Std_ReturnType Rte_Start(`
	`void`
	`)`	

Service ID[hex]:	0x70	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant	
Parameters (in):	None	
Parameters (inout):	None	
Parameters (out):	None	
Return value:	Std_ReturnType	RTE_E_OK: No error occurred. RTE_E_LIMIT: An internal limit has been exceeded. The allocation of a required resource has failed.
Description:	Rte_Start is intended to allocate and initialize system resources and communication resources used by the RTE.	
Available via:	Rte.h	

Table 5.6: Rte_Start

5.8.1.1 Signature

[SWS_Rte_02569] ⌈
```
Std_ReturnType Rte_Start(void)
```
⌋*(SRS_BSW_00310, SRS_Rte_00116)*

5.8.1.2 Existence

[SWS_Rte_01309] ⌈The Rte_Start API is always created. ⌋*(SRS_Rte_00051)*

5.8.1.3 Description

[SWS_Rte_CONSTR_09035] Rte_Start shall be called only once ⌈Rte_Start shall be called only once by the EcuStateManager from trusted OS context on a core after the basic software modules required by RTE are initialized. ⌋*()*

These modules include:

- OS
- COM
- memory services

The Rte_Start API shall not be invoked from AUTOSAR software components.

[SWS_Rte_CONSTR_09036] Rte_Start API may only be used after call of SchM_Init ⌈The Rte_Start API may only be used after the *Basic Software Scheduler* is initialized (after termination of the SchM_Init). ⌋*()*

[SWS_Rte_CONSTR_09037] Rte_Start API shall be called on every core ⌈The Rte_Start API shall be called on every core that hosts AUTOSAR software-components of the ECU. ⌋*()*

[SWS_Rte_02585] ⌈Rte_Start shall return within finite execution time – it must not enter an infinite loop. ⌋*(SRS_Rte_00116)*

Rte_Start may be implemented as a function or a macro.

5.8.1.4 Return Value

If the allocation of a resource fails, Rte_Start shall return with an error.

- **[SWS_Rte_01261]** ⌈RTE_E_OK – No error occurred. ⌋*(SRS_Rte_00094)*
- **[SWS_Rte_01262]** ⌈RTE_E_LIMIT – An internal limit has been exceeded. The allocation of a required resource has failed. ⌋*(SRS_Rte_00094)*

5.8.1.5 Notes

Rte_Start is declared in the lifecycle header file Rte_Main.h. The initialization of AUTOSAR software-components takes place after the termination of Rte_Start and is triggered by a mode change event on entering run state.

5.8.2 Rte_Stop

The API Rte_Stop finalizes the RTE itself.

Service name:	Rte_Stop	

Syntax:	`Std_ReturnType Rte_Stop(`
	`void`
	`)`	

Service ID[hex]:	0x71	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant	
Parameters (in):	None	
Parameters (inout):	None	
Parameters (out):	None	
Return value:	Std_ReturnType	RTE_E_OK: No error occurred. RTE_E_LIMIT: A resource could not be released.
Description:	Rte_Stop is used to finalize the RTE on the core it is called. This service releases all system and communication resources allocated by the RTE on that core.	
Available via:	Rte.h	

Table 5.7: Rte_Stop

5.8.2.1 Signature

[SWS_Rte_02570] ⌈

```
Std_ReturnType Rte_Stop(void)
```

⌋*(SRS_Rte_00116)*

5.8.2.2 Existence

[SWS_Rte_01310] ⌈ The Rte_Stop API is always created. ⌋*(SRS_Rte_00051)*

5.8.2.3 Description

[SWS_Rte_CONSTR_09038] Rte_Stop shall be called before BSW shutdown ⌈ Rte_Stop shall be called by the EcuStateManager before the basic software modules required by RTE are shut down. ⌋*()*

These modules include:

- OS
- COM
- memory services

Rte_Stop shall be called from trusted context and not by an AUTOSAR software component.

[SWS_Rte_02584] ⌈ Rte_Stop shall return within finite execution time. ⌋ *(SRS_Rte_00116)*

Rte_Stop may be implemented as a function or a macro.

5.8.2.4 Return Value

- **[SWS_Rte_01259]** ⌈ RTE_E_OK – No error occurred. ⌋ *(SRS_Rte_00094)*
- **[SWS_Rte_01260]** ⌈ RTE_E_LIMIT – a resource could not be released. ⌋ *(SRS_Rte_00094)*

5.8.2.5 Notes

Rte_Stop is declared in the lifecycle header file Rte_Main.h.

5.8.3 Rte_PartitionTerminated

The API Rte_PartitionTerminated indicates to the RTE that a partition is going to be terminated, and the communication with the Partition shall be ignored.

Service name:	Rte_PartitionTerminated_<PID>

Syntax:	`void Rte_PartitionTerminated_<PID>(`
	`void`
	`)`

Service ID[hex]:	0x72
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_PartitionTerminated is intended to notify the RTE that a given partition is terminated or is being restarted.
Available via:	Rte.h

Table 5.8: Rte_PartitionTerminated

5.8.3.1 Signature

[SWS_Rte_07330] ⌈

```
void Rte_PartitionTerminated_<PID>(void)
```

⌋*(SRS_Rte_00223)*

Where `<PID>` is the name of the `EcucPartition` according to the ECU Configuration Description [5].

5.8.3.2 Existence

[SWS_Rte_07331] ⌈ An `Rte_PartitionTerminated` API shall be created for every `Partition`. ⌋*(SRS_Rte_00223)*

5.8.3.3 Description

[SWS_Rte_CONSTR_09039] `Rte_PartitionTerminated` shall be called only once ⌈ `Rte_PartitionTerminated` shall be called only once by the ProtectionHook. ⌋*()*

`Rte_PartitionTerminated` may be implemented as a function or a macro.

[SWS_Rte_07334] ⌈ The treatments in `Rte_PartitionTerminated` shall be restricted to the ones allowed in the context of a ProtectionHook. ⌋*(SRS_Rte_00223)*

Since `Rte_PartitionTerminated` is called from the ProtectionHook context, it should be as fast as possible. Moreover, it cannot be assumed any more that partition local data including RTE data is consistent. Therefore, actions should be limited to setting a flag. Actual cleanup needs to be deferred to another task.

The notification provided by `Rte_PartitionTerminated` can be used later by the RTE to immediately return an error status when SW-Cs of other partitions tries to communicate with the stopped partition. See [SWS_Rte_02710] and [SWS_Rte_02709].

[SWS_Rte_07335] ⌈ Terminating an already terminated Partition shall be ignored. ⌋*(SRS_Rte_00223)*

5.8.3.4 Return Value

None.

5.8.3.5 Notes

`Rte_PartitionTerminated` is declared in the lifecycle header file `Rte_Main.h`.

5.8.4 Rte_PartitionRestarting

The API Rte_PartitionRestarting indicates to the RTE that a Partition is going to be restarted and that the communication with the Partition shall be ignored.

Service name:	Rte_PartitionRestarting_<PID>

Syntax:	`void Rte_PartitionRestarting_<PID>(`
	`void`
	`)`

Service ID[hex]:	0x73
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_PartitionRestarting is intended to notify the RTE that a given partition is being restarted. As Rte_PartitionTerminated, Rte_PartitionRestarting indicates that the communication with the partition shall be ignored, but in case of Rte_PartitionRestarting, the partition may be restarted later in the ECU lifecycle.
Available via:	Rte.h

Table 5.9: Rte_PartitionRestarting

5.8.4.1 Signature

[SWS_Rte_07620] ⌈

```
void Rte_PartitionRestarting_<PID>(void)
```

Where <PID> is the name of the EcucPartition according to the ECU Configuration Description [5]. ⌋*(SRS_Rte_00223)*

5.8.4.2 Existence

[SWS_Rte_07619] ⌈ An Rte_PartitionRestarting API shall be created for any Partition which can be restarted (i.e. a Partition whose PartitionCanBeRestarted parameter is enabled). ⌋*(SRS_Rte_00223)*

5.8.4.3 Description

[SWS_Rte_CONSTR_09040] Rte_PartitionRestarting shall be called only onc ⌈ Rte_PartitionRestarting shall be called only once by the ProtectionHook. ⌋*()*

Rte_PartitionRestarting may be implemented as a function or a macro.

[SWS_Rte_07617] ⌈ The treatments in Rte_PartitionRestarting shall be restricted to the ones allowed in the context of a ProtectionHook. ⌋*(SRS_Rte_00223)*

Since Rte_PartitionRestarting is called from the ProtectionHook context, it should be as fast as possible. It should be limited to setting a flag. Actual cleanup should be deferred to another task.

[SWS_Rte_07622] ⌈ Restarting an already terminated Partition or restarting a Partition during an ongoing restart shall be ignored. ⌋*(SRS_Rte_00223)*

5.8.4.4 Return Value

None.

5.8.4.5 Notes

Rte_PartitionRestarting is declared in the lifecycle header file Rte_Main.h.

5.8.5 Rte_RestartPartition

The API Rte_RestartPartition initializes the RTE resources allocated for a partition.

Service name:	Rte_RestartPartition_<PID>	
Syntax:	`Std_ReturnType Rte_RestartPartition_<PID>( void )`	
Service ID[hex]:	0x74	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant	
Parameters (in):	None	
Parameters (inout):	None	
Parameters (out):	None	
Return value:	Std_ReturnType	RTE_E_OK: No error occurred. RTE_E_LIMIT: An internal limit has been exceeded. The allocation of a required resource has failed.
Description:	Rte_RestartPartition is intended to notify the RTE that a given partition will be restarted.	
Available via:	Rte.h	

Table 5.10: Rte_RestartPartition

5.8.5.1 Signature

[SWS_Rte_07188] ⌈

```
Std_ReturnType Rte_RestartPartition_<PID>(void)
```

Where <PID> is the name of the EcucPartition according to the ECU Configuration Description [5]. ⌋(*SRS_Rte_00224*)

5.8.5.2 Existence

[SWS_Rte_07336] ⌈ An Rte_RestartPartition API shall be created for any Partition which can be restarted (i.e. a Partition whose PartitionCanBeRestarted parameter is enabled). ⌋(*SRS_Rte_00224*)

5.8.5.3 Description

[SWS_Rte_CONSTR_09041] Rte_RestartPartition shall be called from RestartTask ⌈ Rte_RestartPartition shall be called only in the context of the RestartTask of the given partition. ⌋()

[SWS_Rte_07338] ⌈ Rte_RestartPartition shall return within finite execution time – it must not enter an infinite loop. ⌋(*SRS_Rte_00224*)

Rte_RestartPartition may be implemented as a function or a macro.

[SWS_Rte_07339] ⌈ The Rte_RestartPartition shall restore an initial RTE environment for the partition and re-activate communication with this partition. ⌋(*SRS_Rte_00224*)

This includes:

- signal initial values,
- modes,
- queued events,
- sequence counters.

[SWS_Rte_07340] ⌈ Rte_RestartPartition shall be ignored if the given partition was not stopped before (with Rte_PartitionTerminated or Rte_PartitionRestarting). ⌋(*SRS_Rte_00224*)

5.8.5.4 Return Value

If the allocation of a resource fails, Rte_RestartPartition shall return with an error.

- **[SWS_Rte_07341]** ⌈ RTE_E_OK – No error occurred. ⌋(*SRS_Rte_00224*)

- **[SWS_Rte_07342]** ⌈ RTE_E_LIMIT – An internal limit has been exceeded. The allocation of a required resource has failed. ⌋ *(SRS_Rte_00224)*

5.8.5.5 Notes

Rte_RestartPartition is declared in the lifecycle header file Rte_Main.h.

5.8.6 Rte_Init

The API Rte_Init schedules RunnableEntitys for initialization purpose.

Service name:	Rte_Init_<InitContainer>

Syntax:	`void Rte_Init_<InitContainer>(`
	`void`
	`)`

Service ID[hex]:	0x75
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Init is intended schedule RunnableEntitys for initialization purpose which are mapped to the related RteInitializationRunnableBatch container.
Available via:	Rte.h

Table 5.11: Rte_Init

5.8.6.1 Signature

[SWS_Rte_06749] ⌈

```
void Rte_Init_<InitContainer>(void)
```

Where <InitContainer> is the short name of the RteInitializationRunnableBatch container. ⌋ *(SRS_Rte_00240)*

5.8.6.2 Existence

[SWS_Rte_06750] ⌈ An Rte_Init API shall be created for each RteInitializationRunnableBatch container. ⌋ *(SRS_Rte_00240)*

5.8.6.3 Description

[SWS_Rte_06751] ⌈ An Rte_Init API shall invoke the RunnableEntitys which are associated with an RTEEvent mapped to the related RteInitialization-RunnableBatch container in the order defined by the RtePositionInTask parameters. ⌋*(SRS_Rte_00240)*

[SWS_Rte_06752] ⌈ Rte_Init shall return within finite execution time – it must not enter an infinite loop. ⌋*(SRS_Rte_00240)*

[SWS_Rte_06753] ⌈ Rte_Init shall be implemented as a function. ⌋*(SRS_Rte_00240)*

[SWS_Rte_CONSTR_09060] Rte_Init API may only be used after call of Rte_Start ⌈ The Rte_Init API may only be used after the *RTE* is initialized (after termination of the Rte_Start). ⌋*()*

5.8.6.4 Return Value

none

5.8.6.5 Notes

Rte_Init is declared in the lifecycle header file Rte_Main.h.

5.8.7 Rte_StartTiming

The API Rte_StartTiming starts the triggering of recurrent events.

Service name:	Rte_StartTiming

Syntax:	`void Rte_StartTiming(`
	`void`
	`)`

Service ID[hex]:	0x76
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_StartTiming API is intended to release the activation of RunnableEntitys triggered by TimingEvents and BackgroundEvents after the last call of a Rte_Init function.
Available via:	Rte.h

Table 5.12: Rte_StartTiming

5.8.7.1 Signature

[SWS_Rte_06754] ⌈

```
void Rte_StartTiming(void)
```

⌋*(SRS_Rte_00240)*

5.8.7.2 Existence

[SWS_Rte_06755] ⌈ An `Rte_StartTiming` API shall be created if any `Rte_Init` API is created. ⌋*(SRS_Rte_00240)*

5.8.7.3 Description

[SWS_Rte_06756] ⌈ `Rte_StartTiming` API shall release the activation of `RunnableEntity`s triggered by `TimingEvent`s and `BackgroundEvent`s. ⌋*(SRS_Rte_00240)*

See as well [SWS_Rte_06759] and [SWS_Rte_06760].

[SWS_Rte_06757] ⌈ `Rte_StartTiming` shall return within finite execution time – it must not enter an infinite loop. ⌋*(SRS_Rte_00240)*

[SWS_Rte_06758] ⌈ `Rte_StartTiming` shall be implemented as a function. ⌋*(SRS_Rte_00240)*

[SWS_Rte_CONSTR_09061] `Rte_StartTiming` API may only be used after call of `Rte_Start` ⌈ The `Rte_StartTiming` API may only be used after the *RTE* is initialized (after termination of the `Rte_Start`). ⌋*()*

5.8.7.4 Return Value

none

5.8.7.5 Notes

`Rte_StartTiming` is declared in the lifecycle header file `Rte_Main.h`.

5.9 RTE Call-backs Reference

This section documents the call-backs that are generated by the RTE that must be invoked by other components, such as the communication service, and therefore must have a well-defined name and semantics.

[SWS_Rte_01165] ⌈ A call-back implementation created by the RTE generator is not permitted to block. ⌋*(SRS_Rte_00022)*

Requirement [SWS_Rte_01165] serves to constrain RTE implementations so that all implementations can work with all basic software.

5.9.1 RTE-COM Message Naming Conventions

The COM signals used for communication are defined in the input information provided by Com.

[SWS_Rte_03007] ⌈ The RTE shall initiate an inter-ECU transmission using the COM API with the handle id of the corresponding COM signal for primitive data element `SenderReceiverToSignalMapping`. ⌋*(SRS_Rte_00019)*

[SWS_Rte_03008] ⌈ The RTE shall initiate an inter-ECU transmission using the COM API with the handle id of the corresponding COM signal group for composite data elements or operation arguments `SenderReceiverToSignalGroupMapping`. ⌋*(SRS_Rte_00019)*

5.9.2 Communication Service Call-backs

Purpose: Implement the call-back functions that AUTOSAR COM / LdCom invokes as a result of inter-ECU communication, where:

- A data item/event is ready for reception by a receiver.
- A transmission acknowledgment shall be routed to a sender.
- An operation shall be invoked by a server.
- The result of an operation is ready for reading by a client.

Signature: **[SWS_Rte_03000]** ⌈

```
void <CallbackRoutineName> (void);
```

⌋*(SRS_Rte_00019)*

Where `<CallbackRoutineName>` is the name of the call-back function.

Description: Prototypes for the call-back `<CallbackRoutineName>` provided by AUTOSAR COM / LdCom.

Return Value: No return value : `void`

In the following sections, the naming convention of `<CallBackRoutineName>` are defined:

5.9.2.1 Call-backs for communication over AUTOSAR COM

5.9.2.1.1 Rte_COMCbk_<sn>

Service name:	Rte_COMCbk_<sn>

Syntax:	`void Rte_COMCbk_<sn>(`
	`void`
	`)`

Service ID[hex]:	0x9f
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	This callback function indicates that the signal of the primitive data item/ event is ready for reception.
Available via:	Rte_Com.h

Table 5.13: Rte_COMCbk_sn

[SWS_Rte_03001] ⌈

```
void Rte_COMCbk_<sn>(void)
```

where `<sn>` is the name of the COM signal. ⌋*(SRS_Rte_00019)*

This callback function indicates that the signal of the primitive data item/event is ready for reception by a receiver.

Configured in Com: `ComNotification` [ECUC_Com_00498] as part of `ComSignal`

5.9.2.1.2 Rte_COMCbkTAck_<sn>

Service name:	Rte_COMCbkTAck_<sn>

Syntax:	`void Rte_COMCbkTAck_<sn>(`
	`void`
	`)`

Service ID[hex]:	0x90
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None

Description:	This callback function indicates that the signal of the primitive data item/ event is already handed over by COM to the PDU router.
Available via:	Rte_Com.h

Table 5.14: Rte_COMCbkTAck_sn

[SWS_Rte_03002] ⌈

`void Rte_COMCbkTAck_<sn>(void)`

where `<sn>` is the name of the COM signal. ⌋*(SRS_Rte_00019, SRS_Rte_00122)*

"TAck" is literal text indicating transmission acknowledgment. This callback function is used to route a transmission acknowledgment of a primitve data item/event to a sender.

Configured in Com: `ComNotification` [ECUC_Com_00498] as part of `ComSignal`

5.9.2.1.3 Rte_COMCbkTErr_<sn>

Service name:	Rte_COMCbkTErr_<sn>

Syntax:	`void Rte_COMCbkTErr_<sn>(`
	`void`
	`)`

Service ID[hex]:	0x91
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	This callback function indicates that an error occurred when the signal of the primitive data item/event was handed over by COM to the PDU router.
Available via:	Rte_Com.h

Table 5.15: Rte_COMCbkTErr_sn

[SWS_Rte_03775] ⌈

`void Rte_COMCbkTErr_<sn>(void)`

where `<sn>` is the name of the COM signal. ⌋*(SRS_Rte_00019, SRS_Rte_00122)*

"TErr" is literal text indicating transmission error. This callback function is used to route a transmission error notification of a primitve data item/event to a sender.

Configured in Com: `ComErrorNotification` [ECUC_Com_00499] as part of `ComSignal`

5.9.2.1.4 Rte_COMCbkInv_<sn>

Service name:	Rte_COMCbkInv_<sn>

Syntax:	`void Rte_COMCbkInv_<sn>(`
	`void`
	`)`

Service ID[hex]:	0x92
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	This callback function indicates that COM has received a signal and parsed it as "invalid".
Available via:	Rte_Com.h

Table 5.16: Rte_COMCbkInv_sn

[SWS_Rte_02612] ⌈

```
void Rte_COMCbkInv_<sn>(void)
```

where `<sn>` is the name of the COM signal. ⌋*(SRS_Rte_00019, SRS_Rte_00122)*

“Inv” is literal text indicating signal invalidation. This callback function is used to route a signal invalidation of a primitive data item to a receiver.

Configured in Com: `ComInvalidNotification` [ECUC_COM_00315] as part of `ComSignal`

5.9.2.1.5 Rte_COMCbkRxTOut_<sn>

Service name:	Rte_COMCbkRxTOut_<sn>

Syntax:	`void Rte_COMCbkRxTOut_<sn>(`
	`void`
	`)`

Service ID[hex]:	0x93
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	This callback function indicates that the aliveTimeout after the last successful reception of the signal of the primitive data item/event has expired (data element outdated).
Available via:	Rte_Com.h

Table 5.17: Rte_COMCbkRxTOut_sn

[SWS_Rte_02610] ⌈

```
void Rte_COMCbkRxTOut_<sn>(void)
```

where `<sn>` is the name of the COM signal. ⌋*(SRS_Rte_00019, SRS_Rte_00147)*

"RxTOut" is literal text indicating reception signal time out. This callback function is used to indicate that a signal of a primitve data item is outdated and no new data is available.

Configured in Com: `ComTimeoutNotification` [ECUC_Com_00552] as part of `ComSignal`

5.9.2.1.6 Rte_COMCbkTxTOut_<sn>

Service name:	Rte_COMCbkTxTOut_<sn>

Syntax:	`void Rte_COMCbkTxTOut_<sn>(`
	`void`
	`)`

Service ID[hex]:	0x94
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	This callback function indicates that the timeout of TransmissionAcknowledgementRequest for sending the signal of the primitive data item/event has expired.
Available via:	Rte_Com.h

Table 5.18: Rte_COMCbkTxTOut_sn

[SWS_Rte_05084] ⌈

```
void Rte_COMCbkTxTOut_<sn>(void)
```

where `<sn>` is the name of the COM signal. ⌋*(SRS_Rte_00019, SRS_Rte_00122)*

"TxTOut" is literal text indicating transmission failure and time out. This callback function is used to indicate that transmission has failed and timed out for a primitve data item.

Configured in Com: `ComTimeoutNotification` [ECUC_Com_00552] as part of `ComSignal`

5.9.2.1.7 Rte_COMCbk_<sg>

Service name:	Rte_COMCbk_<sg>

Syntax:	`void Rte_COMCbk_<sg>(`
	`void`
	`)`

Service ID[hex]:	0x95
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	This callback function indicates that the signals of the composite data item/event or the arguments of an operation are ready for reception.
Available via:	Rte_Com.h

Table 5.19: Rte_COMCbk_sg

[SWS_Rte_03004] ⌈

```
void Rte_COMCbk_<sg>(void)
```

where `<sg>` is the name of the COM signal group, which contains all the signals of the composite data item/event or an operation. ⌋*(SRS_Rte_00019)*

This callback function indicates that the signals of the composite data item/event or the arguments of an operation are ready for reception.

Configured in Com: `ComNotification` [ECUC_Com_00498] as part of `ComSignalGroup`

5.9.2.1.8 Rte_COMCbkTAck_<sg>

Service name:	Rte_COMCbkTAck_<sg>

Syntax:	`void Rte_COMCbkTAck_<sg>(`
	`void`
	`)`

Service ID[hex]:	0x96
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	This callback function indicates that the signals of the composite data item/event is already handed over by COM to the PDU router.
Available via:	Rte_Com.h

Table 5.20: Rte_COMCbkTAck_sg

[SWS_Rte_03005] ⌈

```
void Rte_COMCbkTAck_<sg>(void)
```

where `<sg>` is the name of the COM signal group, which contains all the signals of the composite data item/event or an operation. ⌋*(SRS_Rte_00019, SRS_Rte_00122)*

“TAck” is literal text indicating transmission acknowledgment. This callback function indicates that the signals of the composite data item/event is already handed over by COM to the PDU router.

Configured in Com: `ComNotification` [ECUC_Com_00498] as part of `ComSignalGroup`

5.9.2.1.9 Rte_COMCbkTErr_<sg>

Service name:	Rte_COMCbkTErr_<sg>

Syntax:	`void Rte_COMCbkTErr_<sg>(`
	`void`
	`)`

Service ID[hex]:	0x97
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	This callback function indicates that an error occurred when the signal of the composite data item/event was handed over by COM to the PDU router.
Available via:	Rte_Com.h

Table 5.21: Rte_COMCbkTErr_sg

[SWS_Rte_03776] ⌈

```
void Rte_COMCbkTErr_<sg>(void)
```

where `<sg>` is the name of the COM signal group, which contains all the signals of the composite data item/event or an operation. ⌋*(SRS_Rte_00019, SRS_Rte_00122)*

“TErr” is literal text indicating transmission error. This callback function indicates that an error occurred when the signal of the composite data item/event was handed over by COM to the PDU router.

Configured in Com: `ComErrorNotification` [ECUC_Com_00499] as part of `ComSignalGroup`

5.9.2.1.10 Rte_COMCbkInv_<sg>

Service name:	Rte_COMCbkInv_<sg>

Syntax:	`void Rte_COMCbkInv_<sg>(`
	`void`
	`)`

Service ID[hex]:	0x98
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	This callback function indicates that COM has received a signal group and parsed it as "invalid".
Available via:	Rte_Com.h

Table 5.22: Rte_COMCbkInv_sg

[SWS_Rte_05065] ⌈

```
void Rte_COMCbkInv_<sg>(void)
```

where `<sg>` is the name of the COM signal group, which contains all the signals of the composite data item/event or an operation. ⌋*(SRS_Rte_00019, SRS_Rte_00122)*

“Inv” is literal text indicating signal group invalidation. This callback function indicates that COM has received a signal group and parsed it as “invalid”.

Configured in Com: `ComInvalidNotification` [ECUC_Com_00315] as part of `ComSignalGroup`

5.9.2.1.11 Rte_COMCbkRxTOut_<sg>

Service name:	Rte_COMCbkRxTOut_<sg>

Syntax:	`void Rte_COMCbkRxTOut_<sg>(`
	`void`
	`)`

Service ID[hex]:	0x99
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	This callback function indicates that the aliveTimeout after the last successful reception of the signal group carrying the composite data item has expired (data element outdated).
Available via:	Rte_Com.h

Table 5.23: Rte_COMCbkRxTOut_sg

[SWS_Rte_02611] ⌈

`void Rte_COMCbkRxTOut_<sg>(void)`

where `<sg>` is the name of the COM signal group, which contains all the signals of the composite data item/event or an operation. ⌋*(SRS_Rte_00019, SRS_Rte_00147)*

“RxTOut” is literal text indicating reception signal time out. This callback function indicates that the `aliveTimeout` after the last successful reception of the signal group carrying the composite data item has expired (`data element outdated`).

Configured in Com: `ComTimeoutNotification` [ECUC_Com_00552] as part of `ComSignalGroup`

5.9.2.1.12 Rte_COMCbkTxTOut_<sg>

Service name:	Rte_COMCbkTxTOut_<sg>

Syntax:	`void Rte_COMCbkTxTOut_<sg>(`
	`void`
	`)`

Service ID[hex]:	0x9a
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	This callback function indicates that the timeout of TransmissionAcknowledgementRequest for sending the signal group of the composite data item/event has expired.
Available via:	Rte_Com.h

Table 5.24: Rte_COMCbkTxTOut_sg

[SWS_Rte_05085] ⌈

`void Rte_COMCbkTxTOut_<sg>(void)`

where `<sg>` is the name of the COM signal group, which contains all the signals of the composite data item/event or an operation. ⌋*(SRS_Rte_00019, SRS_Rte_00122)*

“TxTOut” is literal text indicating transmission failure and time out. This callback function indicates that the `timeout` of `TransmissionAcknowledgementRequest` for sending the signal group of the composite data item/event has expired.

Configured in Com: `ComTimeoutNotification` [ECUC_Com_00552] as part of `ComSignalGroup`

5.9.2.2 Call-backs for communication over AUTOSAR LdCom

[SWS_Rte_01412] ⌈ The RTE shall import the following type from `ComStack_Types.h`:

- `BufReq_ReturnType`
- `PduIdType`
- `PduInfoType`
- `PduLengthType`
- `RetryInfoType`

⌋*(SRS_BSW_00384)*

5.9.2.2.1 Rte_LdComCbkRxIndication_<sn>

Service name:	Rte_LdComCbkRxIndication_<sn>	

Syntax:	`void Rte_LdComCbkRxIndication_<sn>(`
	`const PduInfoType* PduInfoPtr`
	`)`	

Service ID[hex]:	0xA0	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant for same sn, otherwise Reentrant	
Parameters (in):	PduInfoPtr	Contains the length (SduLength) of the received PDU, a pointer to a buffer (SduDataPtr) containing the PDU, and the MetaData related to this PDU.
Parameters (inout):	None	
Parameters (out):	None	
Return value:	None	
Description:	Indication of a received PDU from a lower layer communication interface module.	
Available via:	Rte_LdCom.h	

Table 5.25: Rte_LdComCbkRxIndication_sn

[SWS_Rte_01395] ⌈

```
void Rte_LdComCbkRxIndication_<sn> (
        IN const PduInfoType* info
);
```

Where `<sn>` is a LdCom signal/I-PDU name. ⌋*(SRS_Rte_00246)*

It is configured in LdCom:
`LdComRxIndication` [ECUC_LdCom_00014] as part of `LdComIPdu`

5.9.2.2.2 Rte_LdComCbkStartOfReception_<sn>

Service name:	Rte_LdComCbkStartOfReception_<sn>	
Syntax:	`BufReq_ReturnType Rte_LdComCbkStartOfReception_<sn>( const PduInfoType* info, PduLengthType TpSduLength, PduLengthType* bufferSizePtr )`	
Service ID[hex]:	0xA1	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant for same sn, otherwise Reentrant	
Parameters (in):	info	Pointer to a PduInfoType structure containing the payload data (without protocol information) and payload length of the first frame or single frame of a transport protocol I-PDU reception, and the MetaData related to this PDU. If neither first/single frame data nor MetaData are available, this parameter is set to NULL_PTR.
	TpSduLength	Total length of the N-SDU to be received.
Parameters (inout):	None	
Parameters (out):	bufferSizePtr	Available receive buffer in the receiving module. This parameter will be used to compute the Block Size (BS) in the transport protocol module.
Return value:	BufReq_ReturnType	BUFREQ_OK: Connection has been accepted. bufferSizePtr indicates the available receive buffer; reception is continued. If no buffer of the requested size is available, a receive buffer size of 0 shall be indicated by bufferSizePtr. BUFREQ_E_NOT_OK: Connection has been rejected; reception is aborted. bufferSizePtr remains unchanged. BUFREQ_E_OVFL: No buffer of the required length can be provided; reception is aborted. bufferSizePtr remains unchanged.
Description:	This function is called at the start of receiving an N-SDU. The N-SDU might be fragmented into multiple N-PDUs (FF with one or more following CFs) or might consist of a single N-PDU (SF). The service shall provide the currently available maximum buffer size when invoked with TpSduLength equal to 0.	
Available via:	Rte_LdCom.h	

Table 5.26: Rte_LdComCbkStartOfReception_sn

[SWS_Rte_01396] ⌈

```
BufReq_ReturnType Rte_LdComCbkStartOfReception_<sn> (
IN const PduInfoType* SduInfoPtr,
IN PduLengthType SduLength,
OUT PduLengthType* RxBufferSizePtr
)
```

Where `<sn>` is a LdCom signal/I-PDU name. ⌋*(SRS_Rte_00246)*

It is configured in LdCom:
`LdComRxStartOfReception` [ECUC_LdCom_00015] as part of `LdComIPdu`

[SWS_Rte_01397] ⌈ The `Rte_LdComCbkStartOfReception_<sn>` Call back shall return `BUFREQ_OK` when connection has been accepted. `RxBufferSizePtr` indicates the available receive buffer. ⌋*(SRS_Rte_00246)*

[SWS_Rte_01398] ⌈ The `Rte_LdComCbkStartOfReception_<sn>` Call back shall return `BUFREQ_E_NOT_OK` when connection has been rejected. `RxBufferSizePtr` remains unchanged. ⌋*(SRS_Rte_00246)*

[SWS_Rte_01399] ⌈ The `Rte_LdComCbkStartOfReception_<sn>` Call back shall return `BUFREQ_E_OVFL` when configured buffer size as specified via `ComPduIdRef.PduLength` is smaller than `TpSduLength`. ⌋*(SRS_Rte_00246)*

5.9.2.2.3 Rte_LdComCbkCopyRxData_<sn>

Service name:	Rte_LdComCbkCopyRxData_<sn>	

Syntax:	`BufReq_ReturnType Rte_LdComCbkCopyRxData_<sn>(`
	`const PduInfoType* info,`
	`PduLengthType* bufferSizePtr`
	`)`	

Service ID[hex]:	0xA2	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant for same sn, otherwise Reentrant	
Parameters (in):	info	Provides the source buffer (SduDataPtr) and the number of bytes to be copied (SduLength). An SduLength of 0 can be used to query the current amount of available buffer in the upper layer module. In this case, the SduDataPtr may be a NULL_PTR.
Parameters (inout):	None	
Parameters (out):	bufferSizePtr	Available receive buffer after data has been copied.
Return value:	BufReq_ReturnType	BUFREQ_OK: Data copied successfully BUFREQ_E_NOT_OK: Data was not copied because an error occurred.
Description:	This function is called to provide the received data of an I-PDU segment (N-PDU) to the upper layer. Each call to this function provides the next part of the I-PDU data. The size of the remaining data is written to the position indicated by bufferSizePtr.	
Available via:	Rte_LdCom.h	

Table 5.27: Rte_LdComCbkCopyRxData_sn

[SWS_Rte_01400] ⌈

```
BufReq_ReturnType Rte_LdComCbkCopyRxData_<sn> (
IN const PduInfoType* SduInfoPtr,
OUT PduLengthType* RxBufferSizePtr
)
```

Where `<sn>` is a LdCom signal/I-PDU name. ⌋*(SRS_Rte_00246)*

It is configured in LdCom:
LdComRxCopyRxData [ECUC_LdCom_00013] as part of LdComIPdu

[SWS_Rte_01401] ⌈ The Rte_LdComCbkCopyRxData_<sn> Call back shall return BUFREQ_OK when data has been copied to the receive buffer completely as requested. ⌋*(SRS_Rte_00246)*

[SWS_Rte_01402] ⌈ The Rte_LdComCbkCopyRxData_<sn> Call back shall return BUFREQ_E_NOT_OK when data has not been copied. Request failed. ⌋ *(SRS_Rte_00246)*

5.9.2.2.4 Rte_LdComCbkTpRxIndication_<sn>

Service name:	Rte_LdComCbkTpRxIndication_<sn>	

Syntax:	`void Rte_LdComCbkTpRxIndication_<sn>(`
	`Std_ReturnType result`
	`)`	

Service ID[hex]:	0xA3	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant for same sn, otherwise Reentrant	
Parameters (in):	result	Result of the reception.
Parameters (inout):	None	
Parameters (out):	None	
Return value:	None	
Description:	Called after an I-PDU has been received via the TP API, the result indicates whether the transmission was successful or not.	
Available via:	Rte_LdCom.h	

Table 5.28: Rte_LdComCbkTpRxIndication_sn

[SWS_Rte_01403] ⌈

```
void Rte_LdComCbkTpRxIndication_<sn> (
IN Std_ReturnType Result
)
```

where <sn> is a LdCom signal/I-PDU name. ⌋*(SRS_Rte_00246)*

It is configured in LdCom:
LdComTpRxIndication [ECUC_LdCom_00016] as part of LdComIPdu

5.9.2.2.5 Rte_LdComCbkCopyTxData_<sn>

Service name:	Rte_LdComCbkCopyTxData_<sn>

Syntax:	`BufReq_ReturnType Rte_LdComCbkCopyTxData_<sn>(`
	`const PduInfoType* info,`
	`const RetryInfoType* retry,`
	`PduLengthType* availableDataPtr`
	`)`

Service ID[hex]:	0xA4	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant for same sn, otherwise Reentrant	
Parameters (in):	info	Provides the destination buffer (SduDataPtr) and the number of bytes to be copied (SduLength). If not enough transmit data is available, no data is copied by the upper layer module and BUFREQ_E_BUSY is returned. The lower layer module may retry the call. An SduLength of 0 can be used to indicate state changes in the retry parameter or to query the current amount of available data in the upper layer module. In this case, the SduDataPtr may be a NULL_PTR.
	retry	Will not be handled by LdCom and its upper layer.
Parameters (inout):	None	
Parameters (out):	availableDataPtr	Indicates the remaining number of bytes that are available in the upper layer module's Tx buffer. availableDataPtr can be used by TP modules that support dynamic payload lengths (e.g. FrIsoTp) to determine the size of the following CFs.
Return value:	BufReq_ReturnType	BUFREQ_OK: Data has been copied to the transmit buffer completely as requested. BUFREQ_E_BUSY: Request could not be fulfilled, because the required amount of Tx data is not available. The lower layer module may retry this call later on. No data has been copied. BUFREQ_E_NOT_OK: Data has not been copied. Request failed.
Description:	This function is called to acquire the transmit data of an I-PDU segment (N-PDU). Each call to this function provides the next part of the I-PDU data unless retry->TpDataState is TP_DATARETRY. In this case the function restarts to copy the data beginning at the offset from the current position indicated by retry->TxTpDataCnt. The size of the remaining data is written to the position indicated by availableDataPtr	
Available via:	Rte_LdCom.h	

Table 5.29: Rte_LdComCbkCopyTxData_sn

[SWS_Rte_01404] ⌈

```
BufReq_ReturnType Rte_LdComCbkCopyTxData_<sn> (
IN const PduInfoType* SduInfoPtr,
IN RetryInfoType* RetryInfoPtr,
OUT PduLengthType* TxDataCntPtr
)
```

Where `<sn>` is a LdCom signal/I-PDU name. ⌋*(SRS_Rte_00246)*

It is configured in LdCom:
`LdComTxCopyTxData` [ECUC_LdCom_00018] as part of `LdComIPdu`

[SWS_Rte_01405] ⌈ The `Rte_LdComCbkCopyTxData_<sn>` Call back shall return `BUFREQ_OK` when data has been copied to the receive buffer completely as requested.
⌋*(SRS_Rte_00246)*

[SWS_Rte_01406] ⌈ The `Rte_LdComCbkCopyTxData_<sn>` Call back shall return `BUFREQ_E_NOT_OK` when data has not been copied to the receive buffer completely as requested. ⌋*(SRS_Rte_00246)*

Possible Request failure are:

- in case the provided I-PDU ID is wrong
- in case the corresponding I-PDU is stopped
- in case the RetryInfoPtr->TpDataState is `TP_DATARETRY` and the offset RetryInfoPtr->TxTpDataCnt exceeds the current position

5.9.2.2.6 Rte_LdComCbkTpTxConfirmation_<sn>

Service name:	Rte_LdComCbkTpTxConfirmation_<sn>	

Syntax:	`void Rte_LdComCbkTpTxConfirmation_<sn>(`
	`Std_ReturnType result`
	`)`	

Service ID[hex]:	0xA5	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant for same sn, otherwise Reentrant	
Parameters (in):	result	E_OK - transmission successful E_NOT_OK - transmission not successful
Parameters (inout):	None	
Parameters (out):	None	
Return value:	None	
Description:	This function is called after a Signal has been transmitted via the TP-API on its network.	
Available via:	Rte_LdCom.h	

Table 5.30: Rte_LdComCbkTpTxConfirmation_sn

[SWS_Rte_01407] ⌈

```
void Rte_LdComCbkTpTxConfirmation_<sn> (
IN Std_ReturnType Result
)
```

where `<sn>` is a LdCom signal/I-PDU name. ⌋*(SRS_Rte_00246, SRS_Com_02044)*

It is configured in LdCom:
`LdComTpTxConfirmation` [ECUC_LdCom_00017] as part of `LdComIPdu`

5.9.2.2.7 Rte_LdComCbkTriggerTransmit_<sn>

Service name:	Rte_LdComCbkTriggerTransmit_<sn>	
Syntax:	`Std_ReturnType Rte_LdComCbkTriggerTransmit_<sn>( PduInfoType* PduInfoPtr )`	
Service ID[hex]:	0xA6	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant for same sn, otherwise Reentrant	
Parameters (in):	None	
Parameters (inout):	PduInfoPtr	Contains a pointer to a buffer (SduDataPtr) to where the SDU data shall be copied, and the available buffer size in SduLengh. On return, the service will indicate the length of the copied SDU data in SduLength.
Parameters (out):	None	
Return value:	Std_ReturnType	E_OK: SDU has been copied and SduLength indicates the number of copied bytes. E_NOT_OK: No SDU data has been copied. PduInfoPtr must not be used since it may contain a NULL pointer or point to invalid data.
Description:	Within this API, the upper layer module (called module) shall check whether the available data fits into the buffer size reported by PduInfoPtr->SduLength. If it fits, it shall copy its data into the buffer provided by PduInfoPtr->SduDataPtr and update the length of the actual copied data in PduInfoPtr->SduLength. If not, it returns E_NOT_OK without changing PduInfoPtr.	
Available via:	Rte_LdCom.h	

Table 5.31: Rte_LdComCbkTriggerTransmit_sn

[SWS_Rte_01408] ⌈

```
Std_ReturnType Rte_LdComCbkTriggerTransmit_<sn> (
PduInfoType* PduInfoPtr
)
```

where `<sn>` is a LdCom signal/I-PDU name. ⌋*(SRS_Rte_00246)*

It is configured in LdCom:
`LdComTxCopyTxData` [ECUC_LdCom_00018] as part of `LdComIPdu`

[SWS_Rte_01409] ⌈ The `Rte_LdComCbkTriggerTransmit_<sn>` Call back shall return `E_OK` when SDU has been copied. In this case `PduInfoPtr->SduLength` shall indicate the number of copied bytes. ⌋*(SRS_Rte_00246)*

[SWS_Rte_01410] ⌈ The `Rte_LdComCbkTriggerTransmit_<sn>` Call back shall return `E_NOT_OK` when No SDU data has been copied. ⌋*(SRS_Rte_00246)*

In case of failure, `PduInfoPtr` must not be used since it may contain a NULL pointer or point to invalid data.

5.9.2.2.8 Rte_LdComCbkTxConfirmation_<sn>

Service name:	Rte_LdComCbkTxConfirmation_<sn>	

Syntax:	`void Rte_LdComCbkTxConfirmation_<sn>(`
	`Std_ReturnType result`
	`)`	

Service ID[hex]:	0xA7	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant for same sn, otherwise Reentrant	
Parameters (in):	result	E_OK: The PDU was transmitted. E_NOT_OK: Transmission of the PDU failed.
Parameters (inout):	None	
Parameters (out):	None	
Return value:	None	
Description:	The lower layer communication interface module confirms the transmission of a PDU, or the failure to transmit a PDU.	
Available via:	Rte_LdCom.h	

Table 5.32: Rte_LdComCbkTxConfirmation_sn

[SWS_Rte_01411] ⌈

```
void Rte_LdComCbkTxConfirmation_<sn> (
Std_ReturnType result
)
```

where `<sn>` is a LdCom signal/I-PDU name. ⌋*(SRS_Rte_00246, SRS_Com_02044)*

It is configured in LdCom:
`LdComTxConfirmation` [ECUC_LdCom_00021] as part of `LdComIPdu`

5.9.3 NVM Service Call-backs

5.9.3.1 Rte_SetMirror

Service name:	Rte_SetMirror_<b>_<d>	

Syntax:	`Std_ReturnType Rte_SetMirror_<b>_<d>(`
	`const void* NVMBuffer`
	`)`	

Service ID[hex]:	0x9b	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant	
Parameters (in):	NVMBuffer	source buffer pointer
Parameters (inout):	None	
Parameters (out):	None	
Return value:	Std_ReturnType	E_OK: the copy is successful. E_NOT_OK: the copy could not be performed.
Description:	The Rte_SetMirror API copies the values of the VariableDataPrototypes contained in a NvBlockDescriptor from a NVM internal buffer to their locations in the RTE.	
Available via:	<application.h> or Rte_<Mip>.h	

Table 5.33: Rte_SetMirror

Rte_SetMirror warranties the consistency of the VariableDataPrototypes contained in a NvBlockSwComponentType, when the associated NVM block is read and copied to the VariableDataPrototypes storage locations.

[SWS_Rte_07310] ⌈

```
Std_ReturnType
Rte_SetMirror_<b>_<d> (const void *NVMBuffer)
```

where <b> is the SwComponentPrototype's name of the NvBlockSwComponentType and <d> is the NvBlockDescriptor name. ⌋*(SRS_Rte_00178)*

[SWS_Rte_07311] ⌈ An Rte_SetMirror API shall be created for each instance of a NvBlockDescriptor. ⌋*(SRS_Rte_00178)*

[SWS_Rte_07312] ⌈ The Rte_SetMirror API shall copy the specified buffer to the NvBlockDescriptor's ramBlock, according to the NvBlockDescriptor's NvBlockDataMapping. ⌋*(SRS_Rte_00177)*

The RTE is responsible for ensuring the data consistency, see section 4.2.5 In particular for the NvBlockDescriptor, the Sender-Receiver ports, the Rte_SetMirror, and Rte_GetMirror may access concurrently the same VariableDataPrototypes.

[SWS_Rte_07319] ⌈ The Rte_SetMirror API shall be callable before the Rte is started (with Rte_Start), and can rely on a running OS. ⌋*(SRS_Rte_00178)*

The NVM module uses the return value of the Rte_SetMirror API to check if the copy was successful. In case of failure, the NVM may retry later.

[SWS_Rte_07602] ⌈ The Rte_SetMirror API shall return E_OK if the copy is successful. ⌋*(SRS_Rte_00178)*

[SWS_Rte_07613] ⌈ The Rte_SetMirror API shall return E_NOT_OK if the copy could not be performed. ⌋*(SRS_Rte_00178)*

The NVM shall be configured to use this function when ReadBlock requests are processed (see NvmWriteRamBlockFromNvm in [21]).

5.9.3.2 Rte_GetMirror

Service name:	Rte_GetMirror_<b>_<d>

Syntax:	`Std_ReturnType Rte_GetMirror_<b>_<d>(`
	`void* NVMBuffer`
	`)`

Service ID[hex]:	0x9c
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant

Parameters (in):	None	
Parameters (inout):	None	
Parameters (out):	NVMBuffer	destination buffer pointer
Return value:	Std_ReturnType	E_OK: the copy is successful. E_NOT_OK: the copy could not be performed.
Description:	The Rte_GetMirror API copies the values of the VariableDataPrototypes contained in a NvBlockDescriptor to a specified NVM internal buffer.	
Available via:	<application.h> or Rte_<Mip>.h	

Table 5.34: Rte_GetMirror

Rte_GetMirror warranties the consistency of the VariableDataPrototypes contained in a NvBlockSwComponentType, when their values are written to the NVRAM device by the NVM.

[SWS_Rte_07315] ⌈

```
Std_ReturnType
Rte_GetMirror_<b>_<d> (void *NVMBuffer)
```

where <b> is the SwComponentPrototype's name of the NvBlockSwComponentType and <d> is the NvBlockDescriptor name. ⌋*(SRS_Rte_00178)*

[SWS_Rte_07316] ⌈ An Rte_GetMirror API shall be created for each instance of a NvBlockDescriptor. ⌋*(SRS_Rte_00178)*

The Rte_GetMirror API copies the values of the VariableDataPrototypes contained in a NvBlockDescriptor to a specified NVM internal buffer.

[SWS_Rte_07317] ⌈ The Rte_GetMirror API shall copy the NvBlockDescriptor's ramBlock to the specified buffer, according to the NvBlockDescriptor's NvBlockDataMapping. ⌋*(SRS_Rte_00177)*

The RTE is responsible for ensuring the data consistency, see section 4.2.5 In particular for the NvBlockDescriptor, the Sender-Receiver ports, the Rte_SetMirror, and Rte_GetMirror may access concurrently the same VariableDataPrototypes.

[SWS_Rte_07350] ⌈ The Rte_GetMirror API shall be callable after the Rte is stopped (with Rte_Stop), and can rely on a running OS. ⌋*(SRS_Rte_00178)*

The NVM module uses the return value of the Rte_GetMirror API to check if the copy was successful. In case of failure, the NVM may retry later.

[SWS_Rte_07601] ⌈ The Rte_GetMirror API shall return E_OK if the copy is successful. ⌋*(SRS_Rte_00178)*

[SWS_Rte_07614] ⌈ The Rte_GetMirror API shall return E_NOT_OK if the copy could not be performed. ⌋*(SRS_Rte_00178)*

The NVM shall be configured to use this function when WriteBlock requests are processed (see NvmWriteRamBlockToNvm in [21]).

5.9.3.3 Rte_NvMNotifyJobFinished

Service name:	Rte_NvMNotifyJobFinished_<b>_<d>	
Syntax:	Std_ReturnType Rte_NvMNotifyJobFinished_<b>_<d>(NvM_BlockRequestType BlockRequest, NvM_RequestResultType JobResult)	
Service ID[hex]:	0x9d	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant	
Parameters (in):	BlockRequest	The request type (read, write, ... etc.) of the previous processed block job
	JobResult	Covers the job result of the processed NvM job.
Parameters (inout):	None	
Parameters (out):	None	
Return value:	Std_ReturnType	The Rte_NvMNotifyJobFinished API shall return E_OK.
Description:	The Rte_NvMNotifyJobFinished receives the notification from the NvM when a job is finished and forward it to the SW-C.	
Available via:	Rte_NvM.h	

Table 5.35: Rte_NvMNotifyJobFinished

`Rte_NvMNotifyJobFinished` forwards notifications back to the SW-Cs.

[SWS_Rte_07623] ⌈

```
Std_ReturnType
Rte_NvMNotifyJobFinished_<b>_<d> (
    NvM_BlockRequestType BlockRequest,
    NvM_RequestResultType JobResult)
```

where `<b>` is the `SwComponentPrototype`'s name of the `NvBlockSwComponentType` and `<d>` is the `NvBlockDescriptor` name. ⌋*(SRS_Rte_00228)*

[SWS_Rte_07624] ⌈An `Rte_NvMNotifyJobFinished` API shall be created for each instance of a `NvBlockDescriptor`. ⌋*(SRS_Rte_00228)*

[SWS_Rte_07625] ⌈The `Rte_NvMNotifyJobFinished` API shall call the servers referenced by `RoleBasedPortAssignment` with a `NvMNotifyJobFinished` role which are aggregated to the `NvBlockDescriptor`. ⌋*(SRS_Rte_00228)*

[SWS_Rte_07671] ⌈The `Rte_NvMNotifyJobFinished` API shall return without any action when the RTE is not started, when the RTE is stopped, or when the partition containing the `NvBlockSwComponentType` is terminated or restarting. ⌋*(SRS_Rte_00228)*

[SWS_Rte_07626] ⌈The `Rte_NvMNotifyJobFinished` API shall return `E_OK`. ⌋*(SRS_Rte_00228)*

The NVM shall be configured to use this function (see `NvmSingleBlockCallback` in [21]).

5.9.3.4 Rte_NvMNotifyInitBlock

Service name:	Rte_NvMNotifyInitBlock_<b>_<d>	
Syntax:	`Std_ReturnType Rte_NvMNotifyInitBlock_<b>_<d>( NvM_InitBlockRequestType InitBlockRequest )`	
Service ID[hex]:	0x9e	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant	
Parameters (in):	InitBlockRequest	The request type (read, restore, ... etc.) of the currently processed block
Parameters (inout):	None	
Parameters (out):	None	
Return value:	Std_ReturnType	The Rte_NvMNotifyInitBlock API shall return E_OK.
Description:	The Rte_NvMNotifyInitBlock API receives the notification from the NvM when initialization of the mirror is requested.	
Available via:	Rte_NvM.h	

Table 5.36: Rte_NvMNotifyInitBlock

`Rte_NvMNotifyInitBlock` indicates to the SW-Cs that initialization of the Mirror is requested by the NvM.

[SWS_Rte_07627] ⌈

```
Std_ReturnType
Rte_NvMNotifyInitBlock_<b>_<d> (NvM_InitBlockRequestType InitBlockRequest)
```

where `<b>` is the `SwComponentPrototype`'s name of the `NvBlockSwComponentType` and `<d>` is the `NvBlockDescriptor` name. ⌋*(SRS_Rte_00228)*

[SWS_Rte_07628] ⌈ An `Rte_NvMNotifyInitBlock` API shall be created for each instance of a `NvBlockDescriptor`. ⌋*(SRS_Rte_00228)*

[SWS_Rte_07629] ⌈ If the `NvBlockDescriptor` is configured with a `romBlock initValue`, this `initValue` shall be copied into the `NvBlockDescriptor`'s mirror before calling any SW-C server. ⌋*(SRS_Rte_00228)*

[SWS_Rte_07630] ⌈ The `Rte_NvMNotifyInitBlock` API shall call the servers referenced by `RoleBasedPortAssignment` with a `NvMNotifyInitBlock` role which are aggregated to the `NvBlockDescriptor`. ⌋*(SRS_Rte_00228)*

[SWS_Rte_07672] ⌈ The `Rte_NvMNotifyInitBlock` API shall return without any action when the RTE is not started, when the RTE is stopped, or when the partition containing the `NvBlockSwComponentType` is terminated or restarting. ⌋ *(SRS_Rte_00228)*

Due to [SWS_Rte_07672], a block selected in the NVRAM Manager [21] as read during `NvM_ReadAll` should not be configured with its `NvmInitBlockCallback` set to a `Rte_NvMNotifyInitBlock` API.

[SWS_Rte_07631] ⌈ The `Rte_NvMNotifyInitBlock` API shall return `E_OK`. ⌋ *(SRS_Rte_00228)*

The NVM shall be configured to use this function (see `InitBlockCallbackFunction` in [21]).

5.10 Expected interfaces

5.10.1 Expected Interfaces from Com

The specification of the RTE requires the usage of the following COM API functions.

Com API function	Context
`Com_SendSignal`	to transmit a data element of primitive type using COM.
`Com_SendDynSignal`	to transmit a data element of primitive dynamic type uint8[n] using COM.
`Com_ReceiveSignal`	to retrieve the new value of a data element of primitive type from COM.
`Com_ReceiveDynSignal`	to retrieve the new value of a data element of primitive dynamic type uint[8] from COM.
`Com_SendSignalGroup`	to initiate sending of a data element of composite type using COM.
`Com_ReceiveSignalGroup`	to retrieve the new value of a data element of composite type from COM.
`Com_InvalidateSignal`	to invalidate a data element of primitive type using COM.
`Com_InvalidateSignalGroup`	to invalidate a whole signal group using COM.
`Com_SendSignalGroupArray`	to initiate sending of a data element of composite type using COM array based signal group API.
`Com_ReceiveSignalGroupArray`	to retrieve the new data element of composite type using COM array based signal group API.

Table 5.37: COM API functions used by the RTE

Please note that [SWS_Rte_02761] may require to access COM through the use of call trusted function in a partitioned system.

5.10.2 Expected Interfaces from LdCom

The specification of the RTE requires the usage of the following LdCom API functions.

LdCom API function	Context
`LdCom_Transmit`	to transmit a data element of primitive type or uint8[n] using LdCom API.

Table 5.38: LdCom API functions used by the RTE

Please note that [SWS_Rte_02761] may require to access LdCom through the use of call trusted function in a partitioned system.

5.10.3 Expected Interfaces from Os

The usage of APIs provided by the Os module [4] is up to the implementation of a specific RTE Generator, System description and Ecu configuration. In general a RTE may utilize any standardized API. Therefore no dedicated list of expected APIs is specified here.

In case of multi-core the RTE may utilize the *IOC*-Module [4] to implement the inter-core communication. The *IOC*-Module is specified to be part of the Os. Therefore no specific APIs are listed here.

5.10.4 Expected Interfaces for Data Transformation

The specification of the RTE requires the usage of the following Transformer API functions.

Transformer API function	Context
`<Mip>_<transformerId>`	API of a transformer on the sending/calling side of the communcation. The name pattern follows [SWS_Xfrm_00062].
`<Mip>_Inv_<transformerId>`	API of a transformer on the receiving/called side of the communcation. The name pattern follows [SWS_Xfrm_00062].

Table 5.39: Transformer API functions used by the RTE

Please note that the exact names of the API depend on the EcuC of the respective transformer module.

The EcuC of a transformer module contains a mapping from the transformer and `ISignal` or `ISignalGroup` with the to the `BswModuleEntry` which implements this specific transformer. (See [ECUC_Xfrm_00001].

This mapping can be used by the RTE to determine which `BswModuleEntry` shall be executed by the RTE for a specific transformer.

5.10.5 Expected Interfaces from NvM

The specification of the RTE requires the usage of the following NvM API functions.

NvM API function	Context
`NvM_SetBlockProtection`	to set/reset the write protection for a NV block
`NvM_EraseBlock`	to erase a NV block.
`NvM_GetDataIndex`	to get the currently set DataIndex of a dataset NVRAM block.
`NvM_GetErrorStatus`	to read the block dependent error/status information.
`NvM_InvalidateNvBlock`	to invalidate a NV block.

NvM API function	Context
NvM_ReadBlock	to copy the data of the NV block to its corresponding RAM block.
NvM_ReadPRAMBlock	to copy the data of the NV block to its corresponding permanent RAM block.
NvM_RestoreBlockDefaults	to restore the default data to its corresponding RAM block.
NvM_RestorePRAMBlock Defaults	to restore the default data to its corresponding permanent RAM block.
NvM_SetDataIndex	to set the DataIndex of a dataset NVRAM block.
NvM_SetRamBlockStatus	to set the RAM block status of an NVRAM block.
NvM_WriteBlock	to copy the data of the RAM block to its corresponding NV block.
NvM_WritePRAMBlock	to copy the data of the RAM block to its corresponding permanent RAM block.

Table 5.40: NvM API functions used by the RTE

5.11 VFB Tracing Reference

The RTE's "VFB Tracing" functionality permits the monitoring of AUTOSAR signals as they are sent and received across the VFB.

The RTE operates in at least two builds (some implementations may provide more than two builds). The first, production, does not enable VFB tracing whereas the second, debug, can be configured to trace some or all "interesting events".

[SWS_Rte_01327] ⌈ The RTE generator shall support a build where no VFB events are traced. ⌋*(SRS_Rte_00005)*

[SWS_Rte_01328] ⌈ The RTE generator shall support a build that traces (configured) VFB events. ⌋*(SRS_Rte_00005)*

The RTE generator's 'trace' build is enabled or disabled through definitions in the RTE Configuration Header File [SWS_Rte_01322] and [SWS_Rte_01323]. Note that this 'trace' build is intended to enable debugging of software components and not the RTE itself.

5.11.1 Principle of Operation

The "VFB Tracing" mechanism is designed to offer a lightweight means to monitor the interactions of AUTOSAR software-components with the VFB.

The VFB tracing in 'debug' build is implemented by a series of "hook" functions that are invoked automatically by the generated RTE when "interesting events" occur. Each hook function corresponds to a single event.

The supported trace events are defined in Section 5.11.5. A mechanism is described in Section 5.11.6 for configuring which of the many potential trace events are of interest.

5.11.2 Support for multiple clients

The “VFB Tracing” mechanism is designed to support multiple clients for each trace event.

[SWS_Rte_05093] ⌈ For each RteVfbTraceClientPrefix configured in the RTE Configuration input each Trace Event shall be generated using that *client prefix* in the optional <client> position of the API function name. ⌋*(SRS_Rte_00005, SRS_Rte_00008, SRS_Rte_00192)*

[SWS_Rte_05091] ⌈ The RTE Generator shall provide each Trace Event without a *client prefix*. ⌋*(SRS_Rte_00005, SRS_Rte_00008, SRS_Rte_00192)*

The generation of Trace Events without a *client prefix* ensures compatibility of the trace events with previous RTE releases.

[SWS_Rte_05092] ⌈ In case of multiple clients for one Trace Event the individual trace functions shall be called in the following order:

1. The trace function without *client prefix*.
2. The trace functions with *client prefix* in alphabetically ascending order of the RteVfbTraceClientPrefix (ASCII / ISO 8859-1).

⌋*(SRS_Rte_00005, SRS_Rte_00008, SRS_Rte_00192)*

The calling order specification ensures a deterministic execution of the multiple clients.

5.11.3 Support for Multiple Instantiation

[SWS_Rte_06031] ⌈ The Component Data Structure type for a multiply instantiatable SWC type shall be introduced as a forward reference when used within the VFB Tracing Header File. ⌋*(SRS_Rte_00005, SRS_Rte_00011)*

The use of a forward reference enables a pointer to the object to be taken (since the size of the data structure does not need to be known).

5.11.4 Contribution to the Basic Software Module Description

The RTE Generator in Generation Phase shall also update its Basic Software Module Description ([SWS_Rte_05086]) in order to document the possibly traceable functions and their signatures.

[SWS_Rte_05106] ⌈ For each generated hook function - including multiple trace clients ([SWS_Rte_05093]) - an entry in the Basic Software Module Description shall be entered describing the hook function and its signature. The outgoingCallback element of BswModuleDescription shall be used to capture the information. ⌋*(SRS_Rte_00005, SRS_Rte_00192)*

5.11.5 Trace Events

5.11.5.1 RTE API Trace Events

RTE API trace events occur when an AUTOSAR software-component interacts with the generated RTE API. For implicit S/R communication, however, tracing is not supported.

5.11.5.1.1 RTE API Start

Description: RTE API Start is invoked by the RTE when an API call is made by a component.

Signature: **[SWS_Rte_01238]** ⌈

```
void Rte_[<client>_]<api>Hook_<cts>_<ap>_Start
      ([const Rte_CDS_<cts>*, ]<param>)
```

Where `<api>` is the RTE API Name (Write, Call, etc.),

`<cts>` is the `component type symbol` of the `AtomicSwComponentType` and

`<ap>` the access point name (e.g. port and data element or operation name, exclusive area name, etc.).

The parameters of the API shall be the same as the corresponding RTE API. As with the API itself, the instance handle is included if and only if the software component's `supportsMultipleInstantiation` attribute is set to true and the RTE API function is per-instance. Thus the instance handle is always omitted for SWCs supporting single instantiation and also for per-SWC functions, such as `Rte_CData` for shared `ParameterDataPrototype`s, for SWCs supporting multiple instantiation. Note that `Rte_Instance` cannot be used directly, as there will be pointers to multiple components' structure types within the single VFB Tracing header file, and `Rte_Instance` would therefore be ambiguous. ⌋*(SRS_Rte_00045, SRS_Rte_00003, SRS_Rte_00004)*

5.11.5.1.2 RTE API Return

Description: RTE API Return is a trace event that is invoked by the RTE just before an API call returns control to a component.

Signature: **[SWS_Rte_01239]** ⌈

```
void Rte_[<client>_]<api>Hook_<cts>_<ap>_Return
      ([const Rte_CDS_<cts>*, ]<param>)
```

Where `<api>` is the RTE API Name (Write, Call, etc.),

<cts> is the component type symbol of the AtomicSwComponentType and

<ap> the access point name (e.g. port and data element or operation name, exclusive area name, etc.).

The parameters of the API are the same as the corresponding RTE API and contain the values of OUT and INOUT parameters on exit from the function.

As with the API itself, the instance handle is included if and only if the software component's supportsMultipleInstantiation attribute is set to true and the RTE API function is per-instance. Thus the instance handle is always omitted for SWCs supporting single instantiation and also for per-SWC functions, such as Rte_CData for shared ParameterDataPrototypes, for SWCs supporting multiple instantiation. Note that Rte_Instance cannot be used directly, as there will be pointers to multiple components' structure types within the single VFB Tracing header file, and Rte_Instance would therefore be ambiguous. ⌋*(SRS_Rte_00045)*

5.11.5.2 BSW Scheduler API Trace Events

BSW Scheduler API trace events occur when an AUTOSAR Basic Software Module interacts with the generated BSW Scheduler API.

5.11.5.2.1 BSW Scheduler API Start

Description: BSW Scheduler API Start is invoked by the BSW Scheduler when an API call is made by a Basic Software Module.

Signature: **[SWS_Rte_04531]** ⌈

```
void SchM_[<client>_]<api>Hook_<bnsp>_[<vi>_<ai>]_
                                <name>_Start(<param>)
```

Where <api> is the BSW Scheduler API Name (Send, Call, etc.),

<bsnp> is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the BSW module,

<ai> is the vendorApiInfix of the BSW module and

<name> is the name provided by the API (e.g. shortName of the VariableDataPrototype of a sender-receiver connection).

The parameters of the API shall be the same as the corresponding BSW Scheduler API.

The sub part in square brackets `[_<vi>_<ai>]` is omitted if no vendorApiInfix is defined for the Basic Software Module. See ([SWS_Rte_07528]).

⌋*(SRS_Rte_00003, SRS_Rte_00004, SRS_Rte_00045)*

5.11.5.2.2 BSW Scheduler API Return

Description: BSW Scheduler API Return is invoked by the BSW Scheduler just before an API call returns control to a Basic Software Module.

Signature: **[SWS_Rte_04532]** ⌈

```
void SchM_[<client>_]<api>Hook_<bnsp>_[<vi>_<ai>]_
                                  <name>_Return(<param>)
```

Where `<api>` is the BSW Scheduler API Name (Send, Call, etc.),

`<bsnp>` is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

`<vi>` is the `vendorId` of the BSW module,

`<ai>` is the `vendorApiInfix` of the BSW module and

`<name>` is the name provided by the API (e.g. `shortName` of the `VariableDataPrototype` of a sender-receiver connection).

The parameters of the API shall be the same as the corresponding BSW Scheduler API.

The sub part in square brackets `[_<vi>_<ai>]` is omitted if no vendorApiInfix is defined for the Basic Software Module. See ([SWS_Rte_07528]).

⌋*(SRS_Rte_00003, SRS_Rte_00004, SRS_Rte_00045)*

5.11.5.3 COM Trace Events

COM trace events occur when the generated RTE interacts with the AUTOSAR communication service.

5.11.5.3.1 Signal Transmission

Description: A trace event indicating a transmission request of an Inter-ECU signal (or signal in a signal group) by the RTE. Invoked by the RTE just before Com_SendSignal, Com_SendDynSignal, or Com_SendSignalGroupArray is invoked.

Signature: **[SWS_Rte_01240]** ⌈

```
void Rte_[<client>_]ComHook_<signalName>_SigTx
    (<data>)
```

Where <signalName> is the COM signal name and <data> is a pointer to the signal data to be transmitted. ⌋*(SRS_Rte_00045, SRS_Rte_00003, SRS_Rte_00004)*

5.11.5.3.2 Signal Reception

Description: A trace event indicating a successful attempt to read an Inter-ECU signal (or signal in a signal group) by the RTE. Invoked by the RTE after return from Com_ReceiveSignal, Com_ReceiveDynSignal, or Com_ReceiveSignalGroupArray.

Signature: **[SWS_Rte_01241]** ⌈

```
void Rte_[<client>_]ComHook_<signalName>_SigRx
    (<data>)
```

Where <signalName> is the COM signal name and <data> is a pointer to the signal data received. ⌋*(SRS_Rte_00045, SRS_Rte_00003, SRS_Rte_00004)*

5.11.5.3.3 Signal Invalidation

Description: A trace event indicating a signal invalidation request of an Inter-ECU signal (or of a signal in a signal group) by the RTE. Invoked by the RTE just before Com_InvalidateSignal is invoked.

Signature: **[SWS_Rte_03814]** ⌈

```
void Rte_[<client>_]ComHook_<signalName>_SigIv
    (void)
```

Where <signalName> is the COM signal or a signal group name. ⌋*(SRS_Rte_00045, SRS_Rte_00003, SRS_Rte_00004)*

5.11.5.3.4 Signal Group Invalidation

Description: A trace event indicating a signal group invalidation request of an Inter-ECU signal group by the RTE. Invoked by the RTE just before Com_InvalidateSignalGroup is invoked.

Signature: **[SWS_Rte_07639]** ⌈

```
void Rte_[<client>_]ComHook_<signalGroupName>_SigGroupIv
    (void)
```

Where `<signalGroupName>` is the name of the signal group. ⌋ *(SRS_Rte_00045, SRS_Rte_00003, SRS_Rte_00004)*

5.11.5.3.5 COM Callback

Description: A trace event indicating the start of a COM call-back. Invoked by generated RTE code on entry to the COM call-back.

Signature: **[SWS_Rte_01242]** ⌈

```
void Rte_[<client>_]ComHook<Event>_<signalName>
    (void)
```

Where `<signalName>` is the name of the COM signal or signal group and `<Event>` indicates the callback type and can take the values

- "Rx" for a reception indication callback
- "Inv" for an invalidation callback
- "RxTOut" for a reception timeout callback
- "TxTOut" for a transmission timeout callback
- "TAck" for a transmission acknowledgement callback
- "TErr" for a transmission error callback

⌋ *(SRS_Rte_00045, SRS_Rte_00003, SRS_Rte_00004)*

5.11.5.4 OS Trace Events

OS trace events occur when the generated RTE interacts with the AUTOSAR operating system.

5.11.5.4.1 Task Activate

Description: A trace event that is invoked by the RTE immediately prior to the activation of a task containing runnable entities.

Signature: **[SWS_Rte_01243]** ⌈

```
void Rte_[<client>_]Task_Activate(TaskType task)
```

Where `task` is the OS's handle for the task. ⌋ *(SRS_Rte_00045)*

5.11.5.4.2 Task Dispatch

Description: A trace event that is invoked immediately an RTE generated task (containing runnable entities) has commenced execution.

Signature: **[SWS_Rte_01244]** ⌈

```
void Rte_[<client>_]Task_Dispatch(TaskType task)
```

Where `task` is the OS's handle for the task. ⌋*(SRS_Rte_00045)*

5.11.5.4.3 Task Termination

Description: A trace event invoked immediately prior to an RTE generated task (containing runnable entities) terminating execution. The same task termination VFB event is used whether the RTE generated task terminates by either a `TerminateTask` or a `ChainTask` OS Service call.

Signature: **[SWS_Rte_06032]** ⌈

```
void Rte_[<client>_]Task_Terminate(TaskType task)
```

Where `task` is the OS's handle for the task. ⌋*(SRS_Rte_00045)*

5.11.5.4.4 Set OS Event

Description: A trace event invoked immediately before generated RTE code attempts to set an OS Event.

Signature: **[SWS_Rte_01245]** ⌈

```
void Rte_[<client>_]Task_SetEvent(TaskType task,
                                  EventMaskType ev)
```

Where `task` is the OS's handle for the task for which the event is being set and `ev` the OS event mask. ⌋*(SRS_Rte_00045)*

5.11.5.4.5 Wait OS Event

Description: Invoked immediately before generated RTE code attempts to wait on an OS Event. This trace event does *not* indicate that the caller has suspended execution since the OS call may immediately return if the event was already set.

Signature: **[SWS_Rte_01246]** ⌈

```
void Rte_[<client>_]Task_WaitEvent(TaskType task,
                                   EventMaskType ev)
```

Where `task` is the OS's handle for the task (that is waiting for the event) and `ev` the OS event mask. ⌋*(SRS_Rte_00045)*

5.11.5.4.6 Received OS Event

Description: Invoked immediately after generated RTE code returns from waiting on an event.

Signature: **[SWS_Rte_01247]** ⌈

```
void Rte_[<client>_]Task_WaitEventRet(TaskType task,
                                      EventMaskType ev)
```

Where `task` is the OS's handle for the task (that was waiting for an event) and `ev` the event mask indicating the received event. ⌋*(SRS_Rte_00045)*

Note that not all of the trace events listed above may be available for a given input configuration. For example if a task is activated by a schedule table, it is activated by the OS rather than by the RTE, hence no trace hook function for task activation can be invoked by the RTE.

5.11.5.5 Runnable Entity Trace Events

Runnable entity trace events occur when a runnable entity is started.

5.11.5.5.1 Runnable Entity Invocation

Description: Event invoked by the RTE just before execution of runnable entry starts via its entry point. This trace event occurs after any copies of data elements are made to support the `Rte_IRead` API Call.

Signature: **[SWS_Rte_01248]** ⌈

```
void Rte_[<client>_]Runnable_<cts>_<reName>_Start
     ([const Rte_CDS_<cts>*])
```

Where `<cts>` is the `component type symbol` of the `AtomicSwComponentType`

and `reName` the runnable entity name.

The instance handle is included if and only if the software component's `supportsMultipleInstantiation` attribute is set to true. Note that `Rte_Instance` cannot be used directly, as there will be pointers to multiple components' structure types within the single VFB Tracing header file, and `Rte_Instance` would therefore be ambiguous. ⌋*(SRS_Rte_00045)*

5.11.5.5.2 Runnable Entity Termination

purpose: Event invoked by the RTE immediately execution returns to RTE code from a runnable entity. This trace event occurs before any write-back of data elements are made to support the Rte_IWrite API Call.

Signature: **[SWS_Rte_01249]** ⌈

```
void Rte_[<client>_]Runnable_<cts>_<reName>_Return
      ([const Rte_CDS_<cts>*])
```

Where <cts> is the component type symbol of the AtomicSwComponentType

and reName the runnable entity name.

The instance handle is included if and only if the software component's supportsMultipleInstantiation attribute is set to true. Note that Rte_Instance cannot be used directly, as there will be pointers to multiple components' structure types within the single VFB Tracing header file, and Rte_Instance would therefore be ambiguous. ⌋*(SRS_Rte_00045)*

5.11.5.6 BSW Schedulable Entities Trace Events

BSW Schedulable entity trace events occur when a BSW Schedulable entity is started.

5.11.5.6.1 BSW Schedulable Entity Invocation

Description: Event invoked by the BSW Scheduler just before execution of BSW Schedulable entry starts via its entry point.

Signature: **[SWS_Rte_04533]** ⌈

```
void SchM_[<client>_]Schedulable_<bnsp>[_<vi>_<ai>]
            _<entityName>_Start
      (void)
```

Where

<bnsp> is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the BSW module,

<ai> is the vendorApiInfix of the BSW module and

<entityName> is the name of the BSW Schedulable Entity or BSW Callable Entity.

The sub part in square brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the Basic Software Module. See ([SWS_Rte_07528]).

⌋*(SRS_Rte_00045)*

5.11.5.6.2 BSW Schedulable Entity Termination

Description: Event invoked by the BSW Scheduler immediately after execution returns to BSW Scheduler code from a BSW Schedulable Entity.

Signature: **[SWS_Rte_04534]** ⌈

```
void SchM_[<client>_]Schedulable_<bnsp>[_<vi>_<ai>]
          _<entityName>_Return(void)
```

Where

<bnsp> is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the BSW module,

<ai> is the vendorApiInfix of the BSW module and

<entityName> is the name of the BSW Schedulable Entity or BSW Callable Entity.

The sub part in square brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the Basic Software Module. See ([SWS_Rte_07528]).

⌋*(SRS_Rte_00045)*

5.11.5.7 RPT Trace Events

RPT trace events occur when a RP global buffer is sent or received.

5.11.5.7.1 Transmission

Description: Event invoked by the RTE immediately before transmission of an RP global buffer.

The event takes as parameter a **reference** to the RP global buffer allowing the VFB trace hook to both monitor and influence the value.

Signature: **[SWS_Rte_06113]** ⌈

```
void Rte_[<client>_]RptHook_<cts>_<var>_Transmit
     ([const Rte_CDS_<cts>*], <type>* <buffer> )
```

Where `<cts>` is the `component type symbol` of the `AtomicSwComponentType`, `<var>` the identifying name of the `RP global buffer`, e.g. port and data element names. `<buffer>` is a reference to the `RP global buffer`.

The instance handle is included if and only if the software component's `supportsMultipleInstantiation` attribute is set to true. Note that `Rte_Instance` cannot be used directly, as there will be pointers to multiple components' structure types within the single VFB Tracing header file, and `Rte_Instance` would therefore be ambiguous. ⌋*(SRS_Rte_00045, SRS_Rte_00244)*

5.11.5.7.2 Reception

Description: Event invoked by the RTE immediately before the received value is copied from the `RP global buffer` to the RTE API's `OUT` parameter or return value. Placing the VFB trace hook at this position ensures that any conditional writes to the `RP global buffer` governed by `RP enabler flag` will have taken effect.

The event takes as parameter a **reference** to the `RP global buffer` allowing the VFB trace hook to both monitor and influence the value.

Signature: **[SWS_Rte_06114]** ⌈

```
void Rte_[<client>_]RptHook_<cts>_<var>_Reception
     ([const Rte_CDS_<cts>*], <type>* <buffer> )
```

Where `<cts>` is the `component type symbol` of the `AtomicSwComponentType`, `<var>` the identifying name of the `RP global buffer`, e.g. port and data element names. `<buffer>` is a reference to the `RP global buffer`.

The instance handle is included if and only if the software component's `supportsMultipleInstantiation` attribute is set to true. Note that `Rte_Instance` cannot be used directly, as there will be pointers to multiple components' structure types within the single VFB Tracing header file, and `Rte_Instance` would therefore be ambiguous. ⌋*(SRS_Rte_00045, SRS_Rte_00244)*

5.11.6 Configuration

The VFB tracing mechanism works by the RTE invoking the tracepoint *hook* function whenever the tracing event occurs.

The support trace events and their hook function name and signature are defined in Section 5.11.5. There are many potential trace events and it is likely that only a few will be of interest at any one time. Therefore The RTE generator supports a mechanism to configure which trace events are of interest.

In order to minimize RTE Overheads, trace events that are not enabled should have no run-time effect on the generated system. This is achieved through generated code within the VFB Tracing Header File (see Section 5.3.7) and the user supplied definitions from the RTE Configuration Header file (see Section 5.3.8).

The definition of trace event hook functions is contained within user code. If a definition is encapsulated within a `#if` block, as follows, the definition will automatically be omitted when the trace event is disabled.

```
#if !defined(<trace event>)
void <trace event>(<params>)
{
  /* Function definition */
}
#endif
```

The configuration of which individual trace events are enabled is entirely under the control of the user via the definitions included in the RTE Configuration header file.

[SWS_Rte_08000] ⌈ When RteVfbTrace is set to "true", a user shall be able to enable any hook function in the RTE Configuration header file, regardless of whether it was not enabled in the RTE configuration with a `RteVfbTraceFunction` parameter. ⌋ *(SRS_Rte_00005, SRS_Rte_00008)*

5.11.7 Interaction with Object-code Software-Components

VFB tracing is only available during the “RTE Generation” or “Basic Software Scheduler Generation” phase [SWS_Rte_01319] and therefore hook functions never appear in an application header or in a Module Interlink Header file created during “RTE Contract” resp. “Basic Software Scheduler Contract” phase. However, object-code software-components and / or Basic Software Modules are compiled against the “RTE Contract” resp. “Basic Software Scheduler Contract” phase headers and can therefore only trace events that are inserted into the generated RTE. In particular they cannot trace events that require invocation of hook functions to be inserted into the API mapping such as the `Rte_Pim` API. However, many trace events are applicable to object-code software-components including trace events related to the explicit communication API, to task activity and for runnable entity start and stop.

This approach means that the external interactions of the object-code software-component can be monitored without requiring modification of the delivered object-code and without revealing the internal activity of the software-component. The approach is therefore considered to be consistent with the desire for IP protection that prompts delivery of a software-component as object-code. Finally, tracing can easily be disabled for a production build without invalidating tests of the object-code software-component.

6 Basic Software Scheduler Reference

6.1 Scope

This chapter presents the *Basic Software Scheduler* API from the perspective of *AUTOSAR Basic Software Module* – these API is not applicable for *AUTOSAR software-components*.

Section 6.2 presents basic principles of the API including naming conventions and supported programming languages. Section 6.3 describes the header files used by the *Basic Software Scheduler* and the files created by an RTE generator. The data types used by the API are described in Section 6.4 and Sections 6.5 and 6.6 provide a reference to the *Basic Software Scheduler* API itself including the definition of *Basic Software Module Entities*.

6.2 API Principles

6.2.1 Basic Software Scheduler Namespace

The *Basic Software Scheduler* is interleaved with the scheduling part of the *RTE*. Further on it is generated by the *RTE Generator* together with the *RTE* so *Basic Software Scheduler* and *RTE* can not be separated if both are generated. Therefore the *Basic Software Scheduler* uses the namespace of the *RTE* for internal symbols, variables and functions, see [SWS_Rte_01171].

The only exceptions are defines, data types and functions belonging to the interface of the *Basic Software Scheduler*. These are explicitly mentioned in the specification.

[SWS_Rte_07284] ⌈ All Basic Software Scheduler symbols (e.g. function names, data types, etc.) belonging to the *Basic Software Scheduler*s interfaces are required to use the `SchM_` prefix. ⌋*(SRS_BSW_00307, SRS_BSW_00300, SRS_Rte_00055)*

In case of *Basic Software Module*s supporting multiple instances of the same *Basic Software Module* the name space of the `BswSchedulableEntity`s and the *Basic Software Scheduler* API related to one instance of a *Basic Software Module* is extended by the `vendorId` and the `vendorApiInfix`. See document [12] [SRS_BSW_00347]. In the following chapters this optional part is denoted by usage of squared brackets `[_<vi>_<ai>]`.

[SWS_Rte_07528] ⌈ If the attribute `vendorApiInfix` exists for a *Basic Software Module*, the RTE generator shall insert the `vendorId` (`<vi>`) and the `vendorApiInfix` (`<ai>`) with leading underscores where it is denoted by `[_<vi>_<ai>]`. ⌋*(SRS_BSW_00347)*

6.2.2 BSW Scheduler Name Prefix and Section Name Prefix

Since the Basic Software Module Description supports the description of BSW Module Clusters one *Basic Software Module Description* can contain the content of several BSW Modules. In order to fulfill the Standardized Interfaces with the cluster interface different ICC3 *Module abbreviation*s [9] inside one cluster can occur. For the Basic Software Scheduler the *Module abbreviation* is used as *BSW Scheduler Name Prefix* in the SchM API. Nevertheless the `shortName` of the `BswModuleDescription` can as well describe the `BSW Scheduler Name Prefix` and `Section Name Prefix` in order to provide one common prefix in case of ICC3 modules.

In the Meta Model *Module abbreviation*s relevant for the Schedule Manager API are explicitly expressed with the meta class `BswSchedulerNamePrefix`. Further information can be found in document [9].

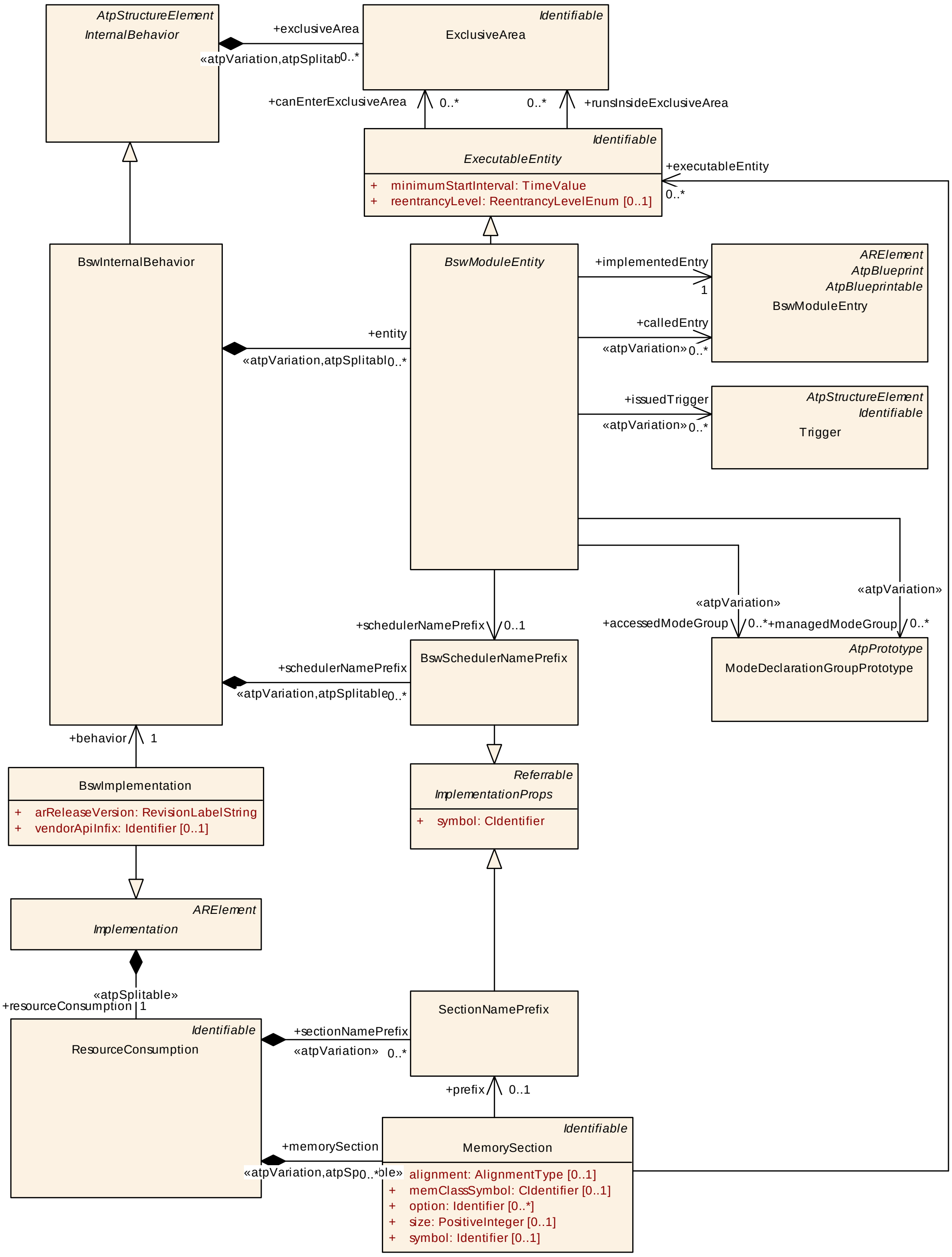

Figure 6.1: BswSchedulerNamePrefix and SectionNamePrefix

In several requirements of this specification the *Module Prefix* is required and determined as follows:

[SWS_Rte_07593] ⌈ The BSW Scheduler Name Prefix <bsnp> of the calling BSW module shall be derived from the BswModuleDescription shortName if no BswSchedulerNamePrefix is defined for the BswModuleEntity using the related Basic Software Scheduler API. ⌋ *(SRS_Rte_00148, SRS_Rte_00149)*

[SWS_Rte_07594] ⌈ The `BSW Scheduler Name Prefix` <bsnp> shall be the value of the `symbol` attribute of the `BswSchedulerNamePrefix` of the `BswModuleEntity` if a `BswSchedulerNamePrefix` is defined for the `BswModuleEntity` using the related Basic Software Scheduler API. ⌋ *(SRS_Rte_00148, SRS_Rte_00149)*

Further on the *Memory Mapping* inside one cluster can either keep or abolish the ICC3 borders. For some cases (e.g. *Entry Point Prototype*) the RTE has to know the used prefixes for the *Memory Allocation Keywords* as well.

In the Meta Model these prefixes are expressed with the meta class `SectionNamePrefix`. Further information can be found in document [9].

[SWS_Rte_07595] ⌈ The `Section Name Prefix` <snp> shall be the module abbreviation (in uppercase letters) of the BSW module derived from the `BswModuleDescription`'s `shortName` if no `SectionNamePrefix` is defined for the `BswModuleEntity` implementing the related `BswModuleEntry`. ⌋ *(SRS_Rte_00148, SRS_Rte_00149)*

[SWS_Rte_07596] ⌈ The `Section Name Prefix` <snp> shall be the symbol of the `SectionNamePrefix` of the `MemorySection` associated to the `BswModuleEntity` implementing the related `BswModuleEntry` if a `SectionNamePrefix` is defined for the `BswModuleEntity` implementing the related `BswModuleEntry`. ⌋ *(SRS_Rte_00148, SRS_Rte_00149)*

For instance the following input configuration

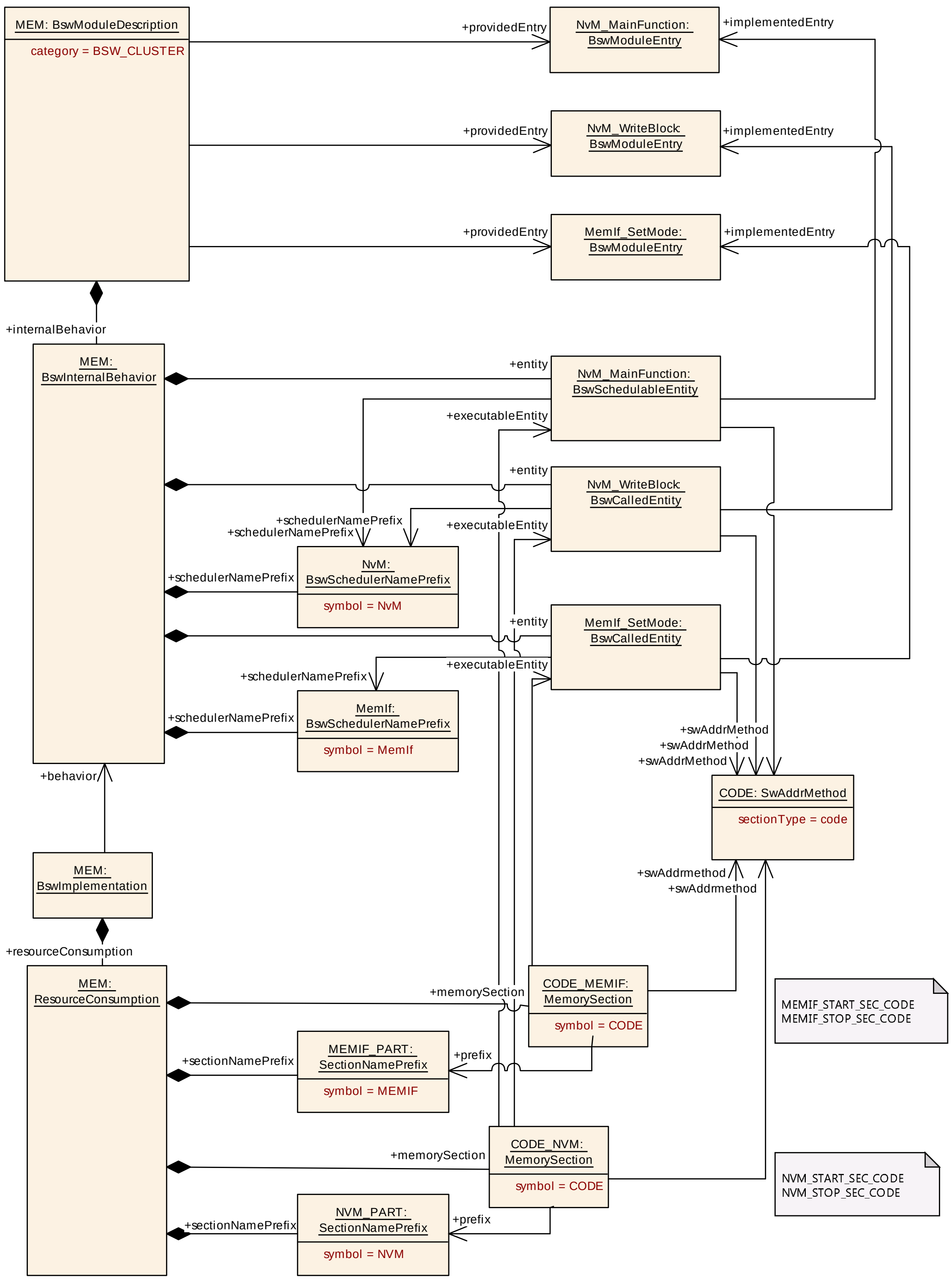

Figure 6.2: Example of ICC2 cluster

would result in the generation of the *Entry Point Prototype* according [SWS_Rte_07195] as:

```
#define NVM_START_SEC_CODE
#include "MEM_MemMap.h"

```

```
FUNC(void, NVM_CODE) NvM_MainFunction (void);

#define NVM_STOP_SEC_CODE
#include "MEM_MemMap.h"
```

6.2.3 BSW Scheduler API options

[SWS_Rte_06811] ⌈ If the attribute enableTakeAddress is set to TRUE for a providedData, requiredData, perInstanceParameter, providedModeGroup, requiredModeGroup, releasedTrigger, requiredClientServerEntry, BswInternalTriggeringPoint or arTypedPerInstanceMemory the RTE generator shall provide an API implementation of the related SchM APIs for which it is valid to take the address of an API function at compile time. ⌋*()*

In C it is valid to take the address of a function but not of a function-like macro. If the enableTakeAddress attribute is not set or set to FALSE for a particular SchM API, the RTE generator may provide 'C' functions or function like macro depending from the implementation.

6.3 Basic Software Scheduler modules

[SWS_Rte_07288] ⌈ Every file of the *Basic Software Scheduler* shall be named with the prefix SchM_. ⌋*(SRS_BSW_00300)*

6.3.1 Module Interlink Types Header

The *Module Interlink Types Header* defines specific types related to this basic software module derived either from the input configuration or from the RTE / Basic Software Scheduler implementation.

[SWS_Rte_07503] ⌈ The RTE generator shall create a *Module Interlink Types Header File* for each BswSchedulerNamePrefix in the BswInternalBehavior of each BswImplementation referencing such BswInternalBehavior defined in the input. ⌋*(SRS_BSW_00415)*

For instance an input configuration with two BswImplementations (typical with different API infix) referencing a BswInternalBehavior with three BswSchedulerNamePrefixes would result in the generation of six Module Interlink Types Header Files.

6.3.1.1 File Name

[SWS_Rte_07295] ⌈ The name of the *Module Interlink Types Header File* shall be formed in the following way:

`SchM_<bsnp>_[<vi>_<ai>]Type.h`

Where here

`<bsnp>` is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

`<vi>` is the `vendorId` of the BSW module and

`<ai>` is the `vendorApiInfix` of the BSW module.

The sub part in squared brackets `[<vi>_<ai>]` is omitted if no `vendorApiInfix` is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋*(SRS_BSW_00415, SRS_BSW_00300, SRS_BSW_00347)*

Example 6.1

The following declaration in the input XML:

```xml
<AR-PACKAGE>
  <SHORT-NAME>CanDriver</SHORT-NAME>
  <ELEMENTS>
    <BSW-MODULE-DESCRIPTION>
      <SHORT-NAME>Can</SHORT-NAME>
      <INTERNAL-BEHAVIORS>
        <BSW-INTERNAL-BEHAVIOR>
          <SHORT-NAME>YesWeCan</SHORT-NAME>
        </BSW-INTERNAL-BEHAVIOR>
      </INTERNAL-BEHAVIORS>
    </BSW-MODULE-DESCRIPTION>
    <BSW-IMPLEMENTATION>
      <SHORT-NAME>MyCanDrv</SHORT-NAME>
      <VENDOR-ID>25</VENDOR-ID>
      <BEHAVIOR-REF DEST="BSW-INTERNAL-BEHAVIOR">/CanDriver/Can/
         YesWeCan</BEHAVIOR-REF>
      <VENDOR-API-INFIX>Dev0815</VENDOR-API-INFIX>
    </BSW-IMPLEMENTATION>
  </ELEMENTS>
</AR-PACKAGE>
```

should result in the *Module Interlink Types Header* `SchM_Can_25_Dev0815Type.h` being generated.

The concatenation of the basic software module prefix (which has to be equally with the short name of the basic software module description) and the vendor API infix is required to support the separation of several basic software module instances. In difference to the multiple instantiation concept of software components, where the same component code is used for all component instances, basic software modules are multiple instantiated by creation of own code per instance in a different name space.

6.3.1.2 Scope

[SWS_Rte_07297] ⌈ The *Module Interlink Types Header* shall be valid for both C and C++ source. ⌋*(SRS_Rte_00126, SRS_Rte_00138)*

Requirement [SWS_Rte_07297] is met by ensuring that all definitions within the *Application Types Header File* are defined using C linkage if a C++ compiler is used.

[SWS_Rte_07298] ⌈ All definitions within in the *Module Interlink Types Header File* shall be preceded by the following fragment:

```
#ifdef __cplusplus
extern "C" {
#endif /* __cplusplus */
```

⌋*(SRS_Rte_00126, SRS_Rte_00138)*

[SWS_Rte_07299] ⌈ All definitions within the *Module Interlink Types Header* shall be suffixed by the following fragment:

```
#ifdef __cplusplus
} /* extern "C" */
#endif /* __cplusplus */
```

⌋*(SRS_Rte_00126, SRS_Rte_00138)*

6.3.1.3 File Contents

[SWS_Rte_07500] ⌈ The *Module Interlink Types Header* shall include the *RTE Types Header File*. ⌋*(SRS_BSW_00415)*

The name of the *RTE Types Header File* is defined in Section 5.3.4.

6.3.1.4 Basic Software Scheduler Modes

The *Module Interlink Types Header File* shall contain identifiers for the `ModeDeclaration`s and type definitions for `ModeDeclarationGroup`s as defined in Chapter 6.4.2

6.3.2 Module Interlink Header

The *Module Interlink Header* defines the *Basic Software Scheduler* API and any associated data structures that are required by the *Basic Software Scheduler* implementation. But the *Module Interlink Header* file is not allowed to create objects in memory.

[SWS_Rte_07501] ⌈The RTE generator shall create a *Module Interlink Header File* for each `BswSchedulerNamePrefix` in the `BswInternalBehavior` of each `BswImplementation` referencing such `BswInternalBehavior` defined in the input.⌋ *(SRS_BSW_00415)*

[SWS_Rte_CONSTR_09059] Usage of *Basic Software Scheduler* API prerequisites the include of the *Module Interlink Header File* ⌈Each BSW module implementation shall include its *Module Interlink Header File* if it uses *Basic Software Scheduler* API or if it implements `BswSchedulableEntity`s. ⌋*()*

[SWS_Rte_07502] ⌈The *Module Interlink Header File* shall not contain code that creates objects in memory. ⌋*(SRS_BSW_00308)*

6.3.2.1 File Name

[SWS_Rte_07504] ⌈

The name of the *Module Interlink Header File* shall be formed in the following way:

```
SchM_<bsnp>[_<vi>_<ai>].h
```

Where here

`<bsnp>` is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

`<vi>` is the `vendorId` of the BSW module and

`<ai>` is the `vendorApiInfix` of the BSW module.

The sub part in squared brackets `[_<vi>_<ai>]` is omitted if no `vendorApiInfix` is defined for the *Basic Software Module*. ⌋*(SRS_BSW_00415, SRS_BSW_00300, SRS_BSW_00347)*

Example 6.2

The following declaration in the input XML:

```xml
<AR-PACKAGE>
  <SHORT-NAME>CanDriver</SHORT-NAME>
  <ELEMENTS>
    <BSW-MODULE-DESCRIPTION>
      <SHORT-NAME>Can</SHORT-NAME>
      <INTERNAL-BEHAVIORS>
        <BSW-INTERNAL-BEHAVIOR>
          <SHORT-NAME>YesWeCan</SHORT-NAME>
        </BSW-INTERNAL-BEHAVIOR>
      </INTERNAL-BEHAVIORS>
    </BSW-MODULE-DESCRIPTION>
    <BSW-IMPLEMENTATION>
      <SHORT-NAME>MyCanDrv</SHORT-NAME>
      <VENDOR-ID>25</VENDOR-ID>
```

```
        <BEHAVIOR-REF DEST="BSW-INTERNAL-BEHAVIOR">/CanDriver/Can/
            YesWeCan</BEHAVIOR-REF>
        <VENDOR-API-INFIX>Dev0815</VENDOR-API-INFIX>
      </BSW-IMPLEMENTATION>
    </ELEMENTS>
  </AR-PACKAGE>
```

should result in the *Module Interlink Header* `SchM_Can_25_Dev0815.h` being generated.

The concatenation of the basic software module prefix (which has to be equally with the short name of the basic software module description) and the `vendorApiInfix` is required to support the separation of several basic software module instances. In difference to the multiple instantiation concept of software components, where the same component code is used for all component instances, basic software modules are multiple instantiated by creation of own code per instance in a different name space.

6.3.2.2 Scope

[SWS_Rte_07505] ⌈ The *Module Interlink Header* for a component shall contain declarations relevant for that instance of a basic software module. ⌋*(SRS_BSW_00415)*

Requirement [SWS_Rte_07505] means that compile time checks ensure that a *Module Interlink Header File* that uses the *Module Interlink Header File* only accesses the generated data types to which it has been configured. The use of data types which are not used by the basic software module, will fail with a compiler error [SRS_Rte_00017].

6.3.2.3 File Contents

[SWS_Rte_07506] ⌈ The *Module Interlink Header File* shall include the *Module Interlink Types Header File*. ⌋*(SRS_BSW_00415)*

The name of the *Module Interlink Types Header File* is defined in Section 6.3.1.

[SWS_Rte_07507] ⌈ The *Module Interlink Header* shall be valid for both C and C++ source. ⌋*(SRS_Rte_00126, SRS_Rte_00138)*

Requirement [SWS_Rte_07507] is met by ensuring that all definitions within the *Application Types Header File* are defined using C linkage if a C++ compiler is used.

[SWS_Rte_07508] ⌈ All definitions within in the *Module Interlink Header File* shall be preceded by the following fragment:

```
#ifdef __cplusplus
extern "C" {
#endif /* __cplusplus */
```

⌋*(SRS_Rte_00126, SRS_Rte_00138)*

[SWS_Rte_07509] ⌈ All definitions within the *Module Interlink Header File* shall be suffixed by the following fragment:

```
#ifdef __cplusplus
} /* extern "C" */
#endif /* __cplusplus */
```

⌋*(SRS_Rte_00126, SRS_Rte_00138)*

6.3.2.3.1 Entry Point Prototype

The *Module Interlink Header File* also includes a prototype for each `BswSchedulableEntity`s entry point ([SWS_Rte_04542]).

6.3.2.3.2 Basic Software Scheduler - Basic Software Module Interface

The *Module Interlink Header File* defines the "interface" between a *Basic Software Module* and the *Basic Software Scheduler*. The interface consists of the *Basic Software Scheduler* API for the *Basic Software Module* and the prototypes for `BswSchedulableEntity`s entry point. The definition of the *Basic Software Scheduler* API requires in case of macro implementation that both relevant data structures and API calls are defined. In case of interfaces implemented as functions, the prototypes for the *Basic Software Scheduler* API of the particular *Basic Software Module* instance is sufficient. The data structures are dependent from the implementation and configuration of the *Basic Software Scheduler* and are not standardized. If data structures are required these shall be accessible via the *Module Interlink Header File* as well.

The RTE generator is required [SWS_Rte_07505] to limit the contents of the *Module Interlink Header* file to only that information that is relevant to that instance of a basic software module. This requirement includes the definition of the API.

[SWS_Rte_07510] ⌈ Only *Basic Software Scheduler* API calls that are valid for the particular instance of a basic software module shall be defined within the modules *Module Interlink Header File*. ⌋*(SRS_BSW_00415, SRS_Rte_00017)*

Requirement [SWS_Rte_07510] ensures that attempts to invoke invalid API calls will be rejected as a compile-time error [SRS_Rte_00017].

[SWS_Rte_06534] ⌈ The RTE Generator shall wrap each *Basic Software Scheduler* API definition of a variant existent API according table 4.28 if the variability shall be implemented.

```
#if (<condition> [||<condition>])

<Basic Software Scheduler API Definition>

#endif
```

where condition are the condition value macro(s) of the VariationPoints relevant for the conditional existence of the RTE API (see table 4.28), Basic Software Scheduler API Definition is the code according an invariant *Basic Software Scheduler* API definition (see also [SWS_Rte_07510], [SWS_Rte_07250], [SWS_Rte_07253], [SWS_Rte_07255], [SWS_Rte_07260], [SWS_Rte_07556], [SWS_Rte_07263], [SWS_Rte_07266]) ⌋*(SRS_Rte_00229)*

The Basic Software Scheduler API for basic software modules is defined in 6.5

[SWS_Rte_07511] ⌈ The *Basic Software Scheduler* API of the particular *Basic Software Module* instance shall be implemented as functions if the basic software module is delivered as object code. ⌋*(SRS_BSW_00342)*

In case of basic software modules delivered as source code the definitions of the *Basic Software Scheduler* API contained in the *Module Interlink Header File* can be optimized during the “RTE Generation” phase when the mapping of the BswSchedulableEntitys to OS Tasks is known.

6.3.2.3.3 Provide activating Bsw event

The provide activating event feature is enabled if the executable entity has at least one activationReason defined.

[SWS_Rte_08056] ⌈ If the provide activating event feature is enabled, the RTE generator in contract phase shall generate the executable entity signature according to [SWS_Rte_07282] and [SWS_Rte_08071]. ⌋*(SRS_Rte_00238)*

[SWS_Rte_08057] ⌈ If the provide activating event feature is enabled, the RTE generator in contract phase shall generate the type SchM_ActivatingEvent_<name> (activation vector), where <name> is the symbol describing the executable entity’s entry point, to store the activation bits. Based on the highest value of ExecutableEntityActivationReason.bitPosition for this executable entity the type shall be either uint8, uint16, or uint32 so that the highest value of bitPosition fits into the data type. ⌋*(SRS_Rte_00238)*

Note that it is considered an invalid configuration if ExecutableEntityActivationReason.bitPosition has a value higher than 31 (see [constr_1226] in software component template [2]).

[SWS_Rte_08058] ⌈ If the provide activating event feature is enabled, the RTE generator in contract phase shall generate for each ExecutableEntityActivationReason of one executable entity a definition to provide the specific bit position in the Rte_ActivatingEvent_<name> data type:

```
#define SchM_ActivatingEvent_<name>_<activation> xxU
```

The value of xx is defined by the bitPosition xx = 2^bitPosition. ⌋*(SRS_Rte_00238)*

For further details see section 4.2.3.3 Provide activating RTE event.

6.3.2.3.4 RunnableEntity mapped to BswModuleEntity

In the case that a RunnableEntity is mapped to a BswSchedulableEntity the RTE Generator only emits the *Entry Point Prototype* (6.3.2.3.1) for the BswSchedulableEntity (see [SWS_Rte_01132]). Since RunnableEntity and BswModuleEntry define a overlapping set of attributes its technically possible to have redundancy in the AUTOSAR models between the BSW Module Description and the Software Component Description. In order to support a non redundant M1 model the RTE Generator has to determined common attributes from the BswModuleEntity and apply them to the mapped RunnableEntity.

[SWS_Rte_06731] ⌈ The RTE Generator shall determine the attribute values of

- RunnableEntity.symbol
- RunnableEntity.minimumStartInterval
- RunnableEntity.canBeInvokedConcurrently
- RunnableEntity.swAddrMethod

from the mapped BswModuleEntity and its referred BswModuleEntry if an applicable SwcBswRunnableMapping exists for the RunnableEntity. ⌋*()*

Nevertheless if the attribute values are defined at both places for RunnableEntity and the mapped BswModuleEntity the values have to be consistent.

[SWS_Rte_06732] ⌈ The RTE generator shall reject configurations violating the [constr_4071]. ⌋*(SRS_Rte_00018)*

Within the scope of a SwcBswRunnableMapping both RTEEvents and BswEvents are applicable. Therefore the ExecutableEntityActivationReasons of the RunnableEntity and the mapped BswModuleEntity have to be overlayed.

[SWS_Rte_08071] ⌈ The signature of a RunnableEntity and a BswModuleEntity with a SwcBswRunnableMapping shall contain all ExecutableEntityActivationReasons that are defined for each entity. ⌋*(SRS_Rte_00238)*

Note: Multiple definition of identical activationReasons with respect to shortName and bitPosition yields to a valid configuration since both RunnableEntitys and BswModuleEntitys may provide separate activationReasons.

6.3.2.3.5 Condition Value Macros

[SWS_Rte_08790] ⌈ For each VariationPointProxy which bindingTime = PreCompileTime the *Module Interlink Header File* shall contain a definition

```
#define SchM_SysCon_<name>
            SchM_SysCon_<bsnp>[_<vi>_<ai>]_<ki>_<name>
```

Where

`<bsnp>` is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

`<vi>` is the `vendorId` of the BSW module,

`<ai>` is the `vendorApiInfix` of the BSW module,

`<ki>` is the *kind infix* according table 4.28,

`<name>` is the short name of the element which is subject to variability in table 4.28 defining the *Basic Software Scheduler* API name infix.

The sub part in squared brackets `[_<vi>_<ai>]` is omitted if no `vendorApiInfix` is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋*(SRS_Rte_00229, SRS_BSW_00347)*

6.4 API Data Types

Besides the API functions for accessing *Basic Software Scheduler* services, the API also contains *Basic Software Scheduler* specific data types.

6.4.1 Predefined Error Codes for Std_ReturnType

The specification in [31] specifies a standard API return type `Std_ReturnType`. The `Std_ReturnType` defines the "'status"' and "'error values"' returned by API functions. It is defined as a `uint8` type. The value “0” is reserved for “No error occurred”.

Symbolic name	Value	Comments
SCHM_E_OK	0	[SWS_Rte_07289]
SCHM_E_LIMIT	130	[SWS_Rte_07290]
SCHM_E_NO_DATA	131	[SWS_Rte_07562]
SCHM_E_TRANSMIT_ACK	132	[SWS_Rte_07563]
SCHM_E_IN_EXCLUSIVE_AREA	135	[SWS_Rte_02747]
SCHM_E_TIMEOUT	129	[SWS_Rte_07054]
SCHM_E_LOST_DATA	64	[SWS_Rte_02312]

Table 6.1: Basic Software Scheduler Error and Status values

The underlying type for `Std_ReturnType` is defined as a `uint8` for reasons of compatibility. Consequently, `#define` is used to declare the error values:

```
typedef uint8 Std_ReturnType; /* defined in Std_Types.h */

#define SCHM_E_OK 0U
```

[SWS_Rte_07291] ⌈ The errors as defined in table 6.1 shall be defined in the *RTE Header File*. ⌋*(SRS_Rte_00051)*

An `Std_ReturnType` value can be directly compared (for equality) with the above pre-defined error identifiers.

6.4.1.1 SCHM_E_OK

[SWS_Rte_07289] ⌈
Symbolic name: `SCHM_E_OK`
Value: 0
Comments: No error occurred. ⌋*(SRS_BSW_00327)*

6.4.1.2 SCHM_E_LIMIT

[SWS_Rte_07290] ⌈
Symbolic name: `SCHM_E_LIMIT`
Value: 130
Comments: An internal *Basic Software Scheduler* limit has been exceeded. Request could not be handled. OUT buffers are not modified.

Note: The value has to be identical with [SWS_Rte_01317] ⌋*(SRS_BSW_00327)*

6.4.1.3 SCHM_E_NO_DATA

[SWS_Rte_07562] ⌈
Symbolic name: `SCHM_E_NO_DATA`
Value: 131
Comments: An explicit read API call returned no data. (This is no error.)

Note: The value has to be identical with [SWS_Rte_01061] ⌋*(SRS_BSW_00327)*

6.4.1.4 SCHM_E_TRANSMIT_ACK

[SWS_Rte_07563] ⌈
Symbolic name: `SCHM_E_TRANSMIT_ACK`
Value: 132
Comments: Transmission acknowledgement received.

Note: The value has to be identically with [SWS_Rte_01065] ⌋*(SRS_BSW_00327)*

6.4.1.5 SCHM_E_IN_EXCLUSIVE_AREA

[SWS_Rte_02747] ⌈
Symbolic name: `SCHM_E_IN_EXCLUSIVE_AREA`

Value: 135
Comments: The error is returned by a blocking API and indicates that the schedulable entity could not enter a wait state, because one `ExecutableEntity` of the current task's call stack has entered an `ExclusiveArea`.

Note: There are no blocking SchM APIs and therefore this value cannot be returned. It is defined here for future use and for consistency with [SWS_Rte_02739]. Both error values have to be identical. ⌋*(SRS_BSW_00327)*

6.4.1.6 SCHM_E_TIMEOUT

[SWS_Rte_07054] ⌈
Symbolic name: `SCHM_E_TIMEOUT`
Value: 129
Comments: The configured timeout exceeds before the intended result was ready.

Note: The value has to be identical with [SWS_Rte_01064] ⌋*(SRS_BSW_00327)*

6.4.1.7 SCHM_E_LOST_DATA

[SWS_Rte_02312] ⌈
Symbolic name: `SCHM_E_LOST_DATA`
Value: 64
Comments: An API call for reading received data with event semantics indicates that some incoming data has been lost due to an overflow of the receive queue or due to an error of the underlying communication stack.

Note: The value has to be identical with [SWS_Rte_02571] ⌋*(SRS_BSW_00327, SRS_Rte_00107, SRS_Rte_00110, SRS_Rte_00094)*

6.4.2 Basic Software Modes

[SWS_Rte_07293] ⌈ For each `ModeDeclarationGroup` of category "`ALPHABETIC_ORDER`", the *Module Interlink Types Header File* shall contain a definition

```
#ifndef RTE_TRANSITION_<prefix><ModeDeclarationGroup>
#define RTE_TRANSITION_<prefix><ModeDeclarationGroup> \
  <n>U
#endif
```

where `<ModeDeclarationGroup>` is the short name of the `ModeDeclarationGroup`[1],

[1] No additional capitalization is applied to the names.

<prefix> is the optional prefix attribute defined by the IncludedModeDeclarationGroupSet referring the ModeDeclarationGroup and

<n> is the number of modes declared within the group. ⌋*(SRS_Rte_00213)*

[SWS_Rte_08600] ⌈ For each ModeDeclarationGroup of category "EXPLICIT_ORDER", the *Module Interlink Types Header File* shall contain a definition

```
#ifndef RTE_TRANSITION_<prefix><ModeDeclarationGroup>
#define RTE_TRANSITION_<prefix><ModeDeclarationGroup> \
      <onTransitionValue>U
#endif
```

where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup[2],

<prefix> is the optional prefix attribute defined by the IncludedModeDeclarationGroupSet referring the ModeDeclarationGroup and

<onTransitionValue> is the onTransitionValue of the *ModeDeclarationGroup*. ⌋*(SRS_Rte_00213)*

[SWS_Rte_07294] ⌈ For each mode of a ModeDeclarationGroup of category "ALPHABETIC_ORDER", the *Module Interlink Types Header File* shall contain a definition

```
#ifndef RTE_MODE_<prefix><ModeDeclarationGroup>_<ModeDeclaration>
#define RTE_MODE_<prefix><ModeDeclarationGroup>_<ModeDeclaration> \
      <index>U
#endif
```

where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup,

<prefix> is the optional prefix attribute defined by the IncludedModeDeclarationGroupSet referring the ModeDeclarationGroup

<ModeDeclaration> is the short name of a ModeDeclaration[3],

and <index> is the index of the ModeDeclarations in alphabetic ordering (ASCII / ISO 8859-1 code in ascending order) of the short names within the ModeDeclarationGroup.

The lowest index shall be '0' and therefore the range of assigned values is 0..<n> where <n> is the number of modes declared within the group ⌋*(SRS_Rte_00213)*

[SWS_Rte_08601] ⌈ For each mode of a ModeDeclarationGroup of category "EXPLICIT_ORDER", the *Module Interlink Types Header File* shall contain a definition

```
#ifndef RTE_MODE_<prefix><ModeDeclarationGroup>_<ModeDeclaration>
#define RTE_MODE_<prefix><ModeDeclarationGroup>_<ModeDeclaration> \
```

[2]No additional capitalization is applied to the names.
[3]No additional capitalization is applied to the names.

```
        <value>U
#endif
```

where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup,

<prefix> is the optional prefix attribute defined by the IncludedModeDeclarationGroupSet referring the ModeDeclarationGroup

<ModeDeclaration> is the short name of a ModeDeclaration[4],

and <value> is the *value* specified at the ModeDeclaration. ⌋*(SRS_Rte_00213)*

6.4.3 Enumeration Data Types

Enumeration is not a plain primitive ImplementationDataType. Rather a range of integers can be used as a structural description. The mapping of integers on "labels" in the enumeration is actually modeled in the SwC-T with the semantics class CompuMethod of a SwDataDefProps [2]. Enumeration data types are modeled as ImplementationDataTypes having a SwDataDefProps referencing a CompuMethod that contains only CompuScales with point ranges (i. e. lower and upper limit of a CompuScale are identical).

[SWS_Rte_03983] ⌈ The *The Module Interlink Types Header File* shall include the definitions of all constants of ImplementationDataTypes and ApplicationDataTypes for each ImplementationDataType/ApplicationDataTypes used (See [SWS_Rte_08803] for the meaning of the term "used") by this Basic Software module.

This includes constants for CompuMethods referenced by ImplementationDataTypeElements of ImplementationDataTypes directly referenced by the Basic Software module and constants for CompuMethods of ImplementationDataTypes which are referenced indirectly via ImplementationDataTypes / ImplementationDataTypeElements of category TYPE_REFERENCE. ⌋*(SRS_Rte_00252)*

[SWS_Rte_03983] is applicable regardless if the AutosarDataType is referenced in DataPrototypes defined in the InternalBehavior of the Basic Software module or AutosarDataTypes which are only referenced by the IncludedDataTypeSet.

This requirement ensures the availability of AutosarDataType constants for the internal use in Basic Software modules, for example enumeration constants.

The name of those constants bases on the CompuScale symbolic name as defined in [TPS_SWCT_01569].

[4]No additional capitalization is applied to the names.

[SWS_Rte_03984] ⌈ For each CompuScale which has a point range and is located in the *compuInternalToPhys* container of a CompuMethod referenced by an *ImplementationDataType* or ApplicationPrimitiveDataType according [SWS_Rte_03983] with *category* "TEXTTABLE", "SCALE_LINEAR_AND_TEXTTABLE", "SCALE_RATIONAL_AND_TEXTTABLE", or BITFIELD_TEXTTABLE, the *Module Interlink Types Header File* shall contain a definition

```
#ifndef <prefix><EnumLiteral>
#define <prefix><EnumLiteral> <value><suffix>
#endif /* <prefix><EnumLiteral> */
```

where the name of the enumeration literal <EnumLiteral> is derived according to the following rule:

if (attribute symbol of CompuScale is available and not empty) {
<EnumLiteral> **:=** C identifier specified in symbol attribute of CompuScale
} **else** {
if (string specified in the VT element of the CompuConst of the CompuScale
is a valid C identifier) {
<EnumLiteral> **:=**
string specified in the VT element of the CompuConst of the CompuScale
} **else** {
if (attribute shortLabel of CompuScale is available and not empty) {
<EnumLiteral> **:=**
string specified in shortLabel attribute of CompuScale
}
}
}

<prefix> is the optional literalPrefix attribute defined by the IncludedDataTypeSet referring the AutosarDataType using the CompuMethod.
<value> is the value representing the CompuScale's point range.
<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋ *(SRS_Rte_00252)*

Please note that the prefix can either be defined that the IncludedDataTypeSet with a literalPrefix attribute references the ApplicationDataType or it references the ImplementationDataType.

[SWS_Rte_03984] implies that the RTE does add prefix to the names of the enumeration constants on explicit demand only. This is necessary in order to handle enumeration constants supplied by Basic Software modules which all use their own prefix convention. Such Enumeration constant names have to be unique in the whole AUTOSAR system.

[SWS_Rte_03985] ⌈ In the case that the same ImplementationDataType or ApplicationPrimitiveDataType is referenced via different IncludedDataTypeSets with different literalPrefix attributes, the definition according to [SWS_Rte_03984] has to be provided once for each different literalPrefix. ⌋ *(SRS_Rte_00252)*

[SWS_Rte_03986] ⌈ If the input of the RTE generator contains a CompuMethod with category "TEXTTABLE", "SCALE_LINEAR_AND_TEXTTABLE", "SCALE_RATIONAL_AND_TEXTTABLE", or BITFIELD_TEXTTABLE that contains a CompuScale with a point range, and

- neither the attribute symbol of the CompuScale is available and not empty,
- nor the string specified in the VT element of the CompuConst of the CompuScale is a valid C identifier,
- nor the attribute shortLabel of CompuScale is available and not empty,

the RTE generator shall reject this input as an invalid configuration. ⌋*(SRS_Rte_00018)*

[SWS_Rte_03987] ⌈ The RTE shall reject configurations where the same Basic Software module uses ImplementationDataTypes and ApplicationPrimitiveDataTypes referencing two or more CompuMethods with category "TEXTTABLE", "SCALE_LINEAR_AND_TEXTTABLE", "SCALE_RATIONAL_AND_TEXTTABLE", or BITFIELD_TEXTTABLE that both contain a CompuScale with a different point range and an identical CompuScale symbolic names as an invalid configuration. The only exception is that the usage of the ImplementationDataTypes and ApplicationPrimitiveDataTypes are defined with non identical <literalPrefix>es. ⌋ *(SRS_Rte_00018)*

[SWS_Rte_03988] ⌈ The RTE generator shall reject configurations violating the [constr_1133]. ⌋*(SRS_Rte_00018)*

This rejects configurations where an ImplementationDataType or an ApplicationPrimitiveDataType references a CompuMethod which is of category "TEXTTABLE", "SCALE_LINEAR_AND_TEXTTABLE", "SCALE_RATIONAL_AND_TEXTTABLE", or BITFIELD_TEXTTABLE and has CompuScales with identical CompuScale symbolic names but different CompuScale.lowerLimit or CompuScale.upperLimit.

Note that there might exist additional CompuScales with non-point ranges inside a CompuMethod of category "TEXTTABLE", "SCALE_LINEAR_AND_TEXTTABLE", "SCALE_RATIONAL_AND_TEXTTABLE", or BITFIELD_TEXTTABLE , but for those no enumeration literals are generated by the RTE generator.

The RTE generator does not support the use of C enums for DataPrototypes used in Basic Software.

[SWS_Rte_03989] ⌈ The RTE generator shall reject configurations violating the [constr_1244], so where a DataPrototype that is used in an Basic Software module has set the swDataDefProps.additionalNativeTypeQualifier attribute set to enum. ⌋*(SRS_Rte_00018)*

[SWS_Rte_08803] The meaning of the term "used" with respect to AutosarDataTypes ⌈ An AutosarDataType is used if it meets any one of the following conditions:

- it is referenced by a DataPrototype in the BswInternalBehavior, or

- it is referenced by a VariationPointProxy in the BswInternalBehavior, or
- it is referenced by a DataPrototype referenced by a providedData or requiredData, or
- it is referenced by an IncludedDataTypeSet in the BswInternalBehavior, or
- it is the ImplementationDataType mapped to an ApplicationDataType (i.e. via the DataTypeMappingSet) that is used in one of the above ways, or
- it is an ImplementationDataTypeElement of a complex ImplementationDataType that is used in one of the above ways, or
- it is referenced as the target type of an ImplementationDataType or ImplementationDataTypeElement of category TYPE_REFERENCE that is used in one of the above ways, or
- it is an ApplicationDataType referenced as the type of a sub-element of a complex ApplicationDataType that is used in one of the above ways.

⌋*()*

Please note that in contrast to the TYPE_REFERENCE case, when an ImplementationDataType of category DATA_REFERENCE is "used" the target ImplementationDataType it references is not considered used, unless it is independently used in its own right.

6.4.4 Range Data Types

For the ApplicationPrimitiveDataType a Range might be specified by referencing a data constraint (dataConstr) giving the lowerLimit and the upperLimit. To allow a Basic Software Module the access to these values two definitions for these values shall be generated.

[SWS_Rte_03990] ⌈ The *The Module Interlink Types Header File* shall include the definitions of all lowerLimit and upperLimit constants of each ApplicationPrimitiveDataType used by this Basic Software Module once per ApplicationPrimitiveDataType if the ApplicationPrimitiveDataType is not referenced via different IncludedDataTypeSets. ⌋*(SRS_Rte_00252)*

[SWS_Rte_03991] ⌈ The *Module Interlink Types Header File* shall include the definitions of all lowerLimit and upperLimit constants of each ApplicationPrimitiveDataType used by this Basic Software Module for each combination of different literalPrefix and ApplicationPrimitiveDataType when the same ImplementationDataType or ApplicationPrimitiveDataType is referenced via different IncludedDataTypeSets. ⌋*(SRS_Rte_00252)*

[SWS_Rte_03992] ⌈ The lowerLimit and upperLimit constants for *ApplicationPrimitiveDataType* referencing a DataConstr shall be generated by RTE generator in the *Module Interlink Types Header File* as:

```
#define <prefix><DataType>_LowerLimit <lowerValue><suffix>
#define <prefix><DataType>_UpperLimit <upperValue><suffix>
```

where <DataType> is the name of the ApplicationPrimitiveDataType used by the Basic Software Module.

<prefix> is the optional literalPrefix attribute defined by the IncludedDataTypeSet referring the AutosarDataType to which the DataConstr belongs.

<lowerValue> and <upperValue> are the values lowerLimit and upperLimit of the dataConstr referenced by the *ApplicationPrimitiveDataType* onto which the corresponding CompuMethod has been applied (see [SWS_Rte_07038]). The values in the macro definitions shall always reflect the closed interval, regardless of the interval type specified by the dataConstr.

<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋ *(SRS_Rte_00252)*

Please note that [SWS_Rte_07196] is not applicable for [SWS_Rte_03992]. Further on it's possible that a DataPrototype using an *ApplicationPrimitiveDataType* might reference additional dataConstr (see [SWS_Rte_07196]). In this case the upperLimit and lowerLimit definitions according [SWS_Rte_03992] do not reflect the real applicable range of the DataPrototype. No macros are generated for DataPrototype specific data constraints.

Please note that the prefix can either be defined that the IncludedDataTypeSet with a literalPrefix attribute references the ApplicationDataType or it references the ImplementationDataType.

Rationale: ApplicationPrimitiveDataType is taken as the basis for the generation of limits (as opposed to take the corresponding ImplementationDataType) because the limits defined on the ImplementationDataType) may be wider than the limits of the ApplicationPrimitiveDataType ((see subsection "Data Types for Single Values" in the AUTOSAR SW-C Template [2]).

[SWS_Rte_03993] ⌈ For AUTOSAR data types which have an invalidValue specified, the Module Interlink Types Header File shall contain the definition

```
#define InvalidValue_<prefix><DataType> <invalidValue><suffix>
```

where

<prefix> is the optional literalPrefix attribute defined by the Included-DataTypeSet referring the AutosarDataType

<DataType> is the short name of the data type.

<invalidValue> is the value defined as invalidValue for the data type.

<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋()

[SWS_Rte_03994] ⌈ The *Module Interlink Types Header File* shall include the definitions of all invalidValue constants used by this Basic Software Module for each combination of different literalPrefix and ApplicationPrimitiveDataType when the same ImplementationDataType or ApplicationPrimitiveDataType is referenced via different IncludedDataTypeSets. ⌋ *(SRS_Rte_00252)*

6.4.5 Data Types with bitfield conversions

AutosarDataTypes associated with a CompuMethod of category BITFIELD_TEXTTABLE support the concatenation of a value set inside a single scalar variable. Thereby single bits may get an individual (boolean) meaning or a set of bits is used to carry an enumeration. Please note that those data types are not mapped to C bit fields rather than to scalars (e.g. uint8). Thereby the RTE Generator provides a set of definitions for the "Bit Mask", "Bit Start Position" and the "Number of Bits" in order to support the usage of the AUTOSAR Bit Handling Routines [32] for those kind of data types. For some operations on a set of bits (the set may contain only 1 bit) the AUTOSAR bitfield library requires a single contiguous bit field which means that all bits set to 1 in the in the CompuScale.mask attribute value are adjoining, e.g. 0b00010000 or 0b00111100.

[SWS_Rte_03995] ⌈ For each unique CompuScale.shortLabel / CompuScale.mask value pair for a CompuScale which is located in the compuInternalToPhys container of a CompuMethod referenced by an ImplementationDataType or ApplicationPrimitiveDataType according [SWS_Rte_03984] with category BITFIELD_TEXTTABLE the *Module Interlink Types Header File* shall contain a definition for the bit field mask

```
#ifndef <prefix><BflMaskLabel>_BflMask
#define <prefix><BflMaskLabel>_BflMask <mask><suffix>
#endif /* <prefix><BflMaskLabel>_BflMask */
```

where
<BflMaskLabel> is the value of the attribute CompuScale.shortLabel
<mask> is the value of the attribute mask
<prefix> is the optional literalPrefix attribute defined by the IncludedDataTypeSet referring the AutosarDataType using the CompuMethod.
<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋ *(SRS_Rte_00252)*

[SWS_Rte_03996] ⌈ For each unique CompuScale.shortLabel / CompuScale.mask value pair for a CompuScale with a single contiguous bit field which is located in the compuInternalToPhys container of a CompuMethod referenced by an ImplementationDataType or ApplicationPrimitiveDataType according [SWS_Rte_03984] with category BITFIELD_TEXTTABLE the *Module Interlink Types Header File* shall contain a definition for the bit start position

```
#ifndef <prefix><BflStartPnLabel>_BflPn
#define <prefix><BflStartPnLabel>_BfltPn <BflStartPnNumber><suffix>
#endif /* <prefix><BflStartPnLabel>_BfltPn */
```

where
<BitStartPnLabel> is the value of the attribute CompuScale.shortLabel
<BflStartPnNumber> is the number of the first bit in the attribute value CompuScale.mask which is set to 1. Thereby the bit counting starts from 0 (LSB) to n (MSB).
<prefix> is the optional literalPrefix attribute defined by the IncludedDataTypeSet referring the AutosarDataType using the CompuMethod.
<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋ *(SRS_Rte_00252)*

[SWS_Rte_03997] ⌈ For each unique CompuScale.shortLabel / CompuScale.mask value pair for a CompuScale with a single contiguous bit field which is located in the compuInternalToPhys container of a CompuMethod referenced by an ImplementationDataType or ApplicationPrimitiveDataType according [SWS_Rte_03984] with category BITFIELD_TEXTTABLE the *Module Interlink Types Header File* shall contain a definition for the bit field length

```
#ifndef <prefix><BflLengthLabel>_BflLn
#define <prefix><BflLengthLabel>_BflLn <BflLength><suffix>
#endif /* <prefix><BflLengthLabel>_BflLn */
```

where
<BflLengthLabel> is the value of the attribute shortLabel.
<BflLength> is the number of contiguous bits set to 1 in the attribute value CompuScale.mask.
<prefix> is the optional literalPrefix attribute defined by the IncludedDataTypeSet referring the AutosarDataType using the CompuMethod.
<suffix> shall be "U" for unsigned data types and empty for signed data types. ⌋ *(SRS_Rte_00252)*

Please note the example in section F.3.

[SWS_Rte_07415] ⌈ The requirements [SWS_Rte_03995], [SWS_Rte_03996], and [SWS_Rte_03997] are only applied to CompuScales where the attribute shortLabel is defined. ⌋ *(SRS_Rte_00252)*

6.5 API Reference

This chapter defines the “interface” between a particular instance of a *Basic Software Module* and the *Basic Software Scheduler*. The wild-card <bsnp> is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594].

6.5.1 SchM_Enter

Purpose: SchM_Enter function enters an exclusive area of an *Basic Software Module*.

Signature: **[SWS_Rte_07250]** ⌈
`void SchM_Enter_<bsnp>[_<vi>_<ai>]_[<me>_]<name>()`

Where here

<bsnp> is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the calling BSW module,

<ai> vendorApiInfix of the calling BSW module,

<me> is the shortName of the BswModuleEntity and

<name> is the exclusive area name. The sub part in squared brackets [<me>_] is emitted if the attribute BswExclusiveAreaPolicy.apiPrinciple is set to "perExecutable". The sub part in squared brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋ *(SRS_Rte_00222, SRS_BSW_00347, SRS_Rte_00046)*

Existence: **[SWS_Rte_07251]** ⌈ A SchM_Enter API shall be created for each ExclusiveArea that is declared in the BswInternalBehavior and which has an canEnterExclusiveArea association. ⌋ *(SRS_Rte_00222, SRS_Rte_00046)*

Description: The SchM_Enter API call is invoked by an AUTOSAR BSW module to define the start of an exclusive area.

Return Value: None.

Notes: The *Basic Software Scheduler* is not required to support nested invocations of SchM_Enter for the same exclusive area.

[SWS_Rte_07252] ⌈ The *Basic Software Scheduler* shall permit calls to SchM_Enter and SchM_Exit to be nested as long as different exclusive areas are exited in the reverse order they were entered. ⌋ *(SRS_Rte_00222, SRS_Rte_00046)*

[SWS_Rte_CONSTR_09046] SchM_Enter and SchM_Exit API may only be used by BswModuleEntitys describing its usage ⌈ The SchM_Enter and SchM_Exit API may only be used by BswModuleEntitys that contain a corresponding canEnterExclusiveArea association ⌋ *()*

[SWS_Rte_CONSTR_09047] Nested call of SchM_Enter and SchM_Exit API is restricted ⌈ The SchM_Enter and SchM_Exit

API may only be called nested if different exclusive areas are invoked; in this case exclusive areas shall exited in the reverse order they were entered. ⌋*()*

[SWS_Rte_07578] ⌈ The *Basic Software Scheduler* shall support calls of `SchM_Enter` and `SchM_Exit` after initialization of the OS but before the *Basic Software Scheduler* is initialized. ⌋*(SRS_Rte_00222, SRS_Rte_00046)*

[SWS_Rte_07579] ⌈ The *Basic Software Scheduler* shall support calls of `SchM_Enter` and `SchM_Exit` in the context of os tasks, category 1 and category 2 interrupts. ⌋*(SRS_Rte_00222, SRS_Rte_00046)*

Note: the possible implementation mechanism for such an exclusive area is limited in this case to mechanism available for the related kind of context. For instance `SuspendAllInterrupts` and `ResumeAllInterrupts` service of the OS are available for all kind of context but `GetResource` and `ReleaseResource` is only available for tasks and category 2 interrupts.

Within the *AUTOSAR OS* an attempt to lock a resource cannot fail because the lock is already held. The lock attempt can only fail due to configuration errors (e.g. caller not declared as accessing the resource) or invalid handle. Therefore the return type from this function is `void`.

Mutual exclusion of tasks requesting the same exclusive area shall be ensured across partition and core boundaries.

6.5.2 SchM_Exit

Purpose: `SchM_Exit` function leaves an exclusive area of an *Basic Software Module*.

Signature: **[SWS_Rte_07253]** ⌈

```
void
SchM_Exit_<bsnp>[_<vi>_<ai>]_[<me>_]<name>()
```

Where

`<bsnp>` is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

`<vi>` is the `vendorId` of the calling BSW module,

`<ai>` `vendorApiInfix` of the calling BSW module,

`<me>` is the shortName of the `BswModuleEntity` and

<name> is the exclusive area name. The sub part in squared brackets [<me>_] is emitted if the attribute BswExclusiveAreaPolicy.apiPrinciple is set to "perExecutable". The sub part in squared brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋ *(SRS_Rte_00222, SRS_BSW_00347, SRS_Rte_00046)*

Existence: **[SWS_Rte_07254]** ⌈ A SchM_Exit API shall be created for each ExclusiveArea that is declared in the BswInternalBehavior and which has an canEnterExclusiveArea association.. ⌋ *(SRS_Rte_00222, SRS_Rte_00046)*

Description: The SchM_Exit API call is invoked by an AUTOSAR BSW module to define the end of an exclusive area.

Return Value: None.

Notes: The *Basic Software Scheduler* is not required to support nested invocations of SchM_Exit for the same exclusive area.

Requirement [SWS_Rte_07252] permits calls to SchM_Exit and SchM_Exit to be nested as long as different exclusive areas are exited in the reverse order they were entered.

[SWS_Rte_CONSTR_09048] SchM_Exit API may only be used by BswModuleEntitys that describe its usage ⌈ The SchM_Exit API may only be used by BswModuleEntitys that contain a corresponding canEnterExclusiveArea association ⌋*()*

6.5.3 SchM_Call

Purpose: Invokes a Client-Server operation between BSW modules, possibly crossing partition boundaries.

Signature: **[SWS_Rte_08733]** ⌈

```
Std_ReturnType SchM_Call_<bsnp>[_<vi>_<ai>]_<name>(
                      [OUT <typeOfReturnValue> returnValue]
                      [IN|IN/OUT|OUT]<data_1>...
                      [IN|IN/OUT|OUT] <data_n>)
```

where there is a BSW module providing an entry which is the base for a generated function <typeOfReturnValue> <bsnp>[_<vi>_<ai>]_<name>(<data_1>...<data_n>)

with <typeOfReturnValue> is the returnType of the referenced BswModuleEntry. If the returnType of the referenced BswModuleEntry is of type void or execution is asynchronous, this part should be omitted.

<bsnp> is the BSW Scheduler Name Prefix of the BSW module providing the entry according to [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the calling BSW module,

<ai> is the vendorApiInfix of the calling BSW module,

<name> is the shortName of the BswModuleClientServerEntry defined with the role of requiredClientServerEntry.

The sub part in square brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the Basic Software Module. See [SWS_Rte_07528]. ⌋*(SRS_Rte_00243)*

Existence: **[SWS_Rte_08734]** ⌈ A synchronous SchM_Call API shall be generated if a callPoint association to a BswSynchronousServerCallPoint exists and the BswSynchronousServerCallPoint references a BswModuleClientServerEntry as calledEntry and this BswModuleClientServerEntry is referenced by the BswModuleDescription as a requiredClientServerEntry. ⌋*(SRS_Rte_00243)*

[SWS_Rte_08735] ⌈ An asynchronous SchM_Call API shall be generated if a callPoint association to a BswAsynchronousServerCallPoint exists and the BswAsynchronousServerCallPoint references a BswModuleClientServerEntry as calledEntry and this BswModuleClientServerEntry is referenced by the BswModuleDescription as a requiredClientServerEntry. ⌋*(SRS_Rte_00243)*

A configuration that includes both synchronous and asynchronous Call Points is invalid.

[SWS_Rte_CONSTR_09079] SchM_Call API may only be used by the BswModuleEntity that describe its usage ⌈ The SchM_Call API may only be used within the BswModuleEntity that references the corresponding BswSynchronousServerCallPoint respectively BswAsynchronousServerCallPoint using a callPoint association. ⌋*()*

Description: Function to initiate Client-Server communication between BSW modules. The SchM_Call API is used for both synchronous and asynchronous calls.

When the BswModuleClientServerEntry is called the SchM shall invoke the referenced BswModuleEntry providing the C-function with the signature <bpns>[_<vi>_<ai>]_name(<data_1>...(<data_n>) on the partition of the task assigned to the respective BswOperationInvokedEvent, or on the local partition if the BswOperationInvokedEvent is not mapped to a task.

[SWS_Rte_08736] ⌈ The OUT parameter returnValue shall only exist if the returnType of BswModuleEntry is not void and the SchM_Call is synchronous. ⌋*(SRS_Rte_00243)*

[SWS_Rte_08737] ⌈ The datatype of the OUT parameter returnValue shall be equal to returnType of the called BswModuleEntry. ⌋*(SRS_Rte_00243)*

[SWS_Rte_08738] ⌈ The return value of the called BswModuleEntry shall be returned inside the OUT parameter returnValue. ⌋*(SRS_Rte_00243)*

[SWS_Rte_08739] ⌈ The SchM shall ensure that the BswModuleEntity implementing a server operation has completed the processing of a request before it begins processing the next request, if call serialization is required by the server operation, i.e the isReentrant attribute of the corresponding BswModuleClientServerEntry which is referenced as providedClientServerEntry is set to false and more than one BswModuleClientServerEntry in the role requiredClientServerEntry references this server. If the SchM_Call crosses partition borders, the call is mapped to IOCSend_<id>(). ⌋*(SRS_Rte_00243)*

The pointers to all parameters passed by reference must remain valid until the API call returns.

Return Value: **[SWS_Rte_08740]** ⌈ The return value shall be used to indicate infrastructure errors detected by the RTE during execution of the SchM_Call call. ⌋*()*

- **[SWS_Rte_08741]** ⌈ SCHM_E_OK - The API call completed successfully. ⌋*()*
- **[SWS_Rte_08742]** ⌈ SCHM_E_LIMIT - There are multiple outstanding asynchronous calls of the same BswModuleEntry. The invocation shall be discarded, the buffers of the return parameters shall not be modified. ⌋*()*
- **[SWS_Rte_04555]** ⌈ SCHM_E_TIMEOUT – if the call is ignored according to [SWS_Rte_04552] ⌋*()*

6.5.4 SchM_Result

Purpose: Get the result of an asynchronous call of a BswModuleEntry.

Signature: **[SWS_Rte_08743]** ⌈

```
Std_ReturnType
SchM_Result_<bsnp>[_<vi>_<ai>]_<name>(
                    [OUT <typeOfReturnValue> returnValue]
                    [IN/OUT|OUT]<data_1> ...
                    [IN/OUT|OUT] <data_n>)
```

where there is a BSW module providing an entry which is the base for a generated function <bsnp>[_<vi>_<ai>]_name(<data_1>...<data_n>)

with <bsnp> is the BSW Scheduler Name Prefix of the BSW module sending the callback according to [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the calling BSW module,

<ai> is the vendorApiInfix of the calling BSW module,

<name> is the shortName of the BswModuleClientServerEntry defined with the role of requiredClientServerEntry.

The sub part in squared brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋*(SRS_Rte_00243)*

[SWS_Rte_08420] ⌈ The OUT parameter returnValue shall exist if the returnType of BswModuleEntry is different fromvoid. ⌋*(SRS_Rte_00243)*

[SWS_Rte_08421] ⌈ The datatype of the OUT parameter returnValue shall be equal to returnType of the called BswModuleEntry. ⌋*(SRS_Rte_00243)*

[SWS_Rte_08422] ⌈ The return value of the called BswModuleEntry shall be returned inside the OUT parameter returnValue. ⌋*(SRS_Rte_00243)*

Existence: **[SWS_Rte_08744]** ⌈ A non-blocking SchM_Result API shall be generated if a callPoint association to a BswAsynchronousServerCallResultPoint exists. ⌋*(SRS_Rte_00243)*

[SWS_Rte_CONSTR_09076] SchM_Result API may only be used by the BswModuleEntity that describe its usage ⌈ The SchM_Result API may only be used within the BswModuleEntity that references the corresponding BswAsynchronousServerCallResultPoint using a callPoint association. ⌋*()*

Description: The SchM_Result is used to collect the result of an asynchronous call of a BswModuleEntry invoked by SchM_Call_<bsnp>[_<vi>_<ai>]_name(<data_1>...<data_n>).

Using SchM_Result it is possible get back the result of call.

The SchM_Result API includes zero or more IN/OUT and OUT parameters to pass back results.

The pointers to all parameters passed by reference must remain valid until the API call returns.

If the SchM_Result crosses partition borders, the callback is mapped to IOCSend_<id>().

Return Value: The return value is used to indicate errors from either the SchM_Result call itself or communication errors detected before the API call was made.

- **[SWS_Rte_08745]** ⌈ SCHM_E_OK - The API call completed successfully. ⌋*()*
- **[SWS_Rte_08746]** ⌈ SCHM_E_NO_DATA - The BswModuleEntry's result is not available but no other error occurred within the API call or the BswModuleEntry was not called using SchM_Call. The buffers for the IN/OUT and OUT parameters shall not be modified. ⌋*()*
- **[SWS_Rte_04556]** ⌈ SCHM_E_TIMEOUT – if the call is ignored according to [SWS_Rte_04552] ⌋*()*

The SCHM_E_NO_DATA return value is not considered to be an error but rather indicate correct operation of the API call. When SCHM_E_NO_DATA occurs, a BSW module is free to invoke SchM_Result again and thus repeat the attempt to read the result.

6.5.5 SchM_Send

Purpose: Initiate an "explicit" sender-receiver transmission of data elements with "event" semantic (queued) between BSW modules.

Signature: **[SWS_Rte_08747]** ⌈

```
Std_ReturnType
SchM_Send_<bsnp>[_<vi>_<ai>]_<name>(IN <data>)
```

with <bsnp> is the BSW Scheduler Name Prefix of the BSW module providing the data according to [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the BSW module providing the data,

<ai> is the vendorApiInfix of the BSW module providing the data,

<name> is the shortName of the VariableDataPrototype of this sender-receiver connection.

The sub part in square brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋*(SRS_Rte_00243)*

Existence: **[SWS_Rte_08748]** ⌈ The existence of a dataSendPoint association to a providedData VariableDataPrototype shall result in the generation of a SchM_Send API for the provided VariableDataPrototype. ⌋*(SRS_Rte_00243)*

[SWS_Rte_CONSTR_09077] SchM_Send API may only be used by the BswModuleEntity that describes its usage ⌈ The SchM_Send API may only be used within the BswModuleEntity that references the VariableDataPrototype using a dataSendPoint. ⌋*()*

Description: When a BSW module writes data to a sender-receiver connection on a system with the BSW running on multiple partitions, it shall invoke SchM_Send_<bsnp>[_<vi>_<ai>]_<name>(<data>). The SchM_Send API call initiates a sender-receiver communication where the transmission occurs at the point the API call is made (cf. explicit transmission). The SchM_Send API call includes the IN parameter <data> to pass the data element to write. The IN parameter <data> is passed by value or reference according to the ImplementationDataType as described in the section 5.2.6.5. If the IN parameter <data> is passed by reference, the pointer must remain valid until the API call returns.

Return Value: The return value is used to indicate errors detected by the SchM during execution of the SchM_Send.

- **[SWS_Rte_08749]** ⌈ SCHM_E_OK - data passed to communication service successfully. ⌋*()*
- **[SWS_Rte_08750]** ⌈ SCHM_E_LIMIT - an 'event' has been discarded due to a full queue by one of the partition local receivers. ⌋*()*

Notes: The SchM_Send API is used to transmit data with "events" semantics which means that they are getting queued.

[SWS_Rte_08751] ⌈ In case of inter partition communication, the SchM_Send API call shall cause an immediate transmission request. ⌋*(SRS_Rte_00243)*

For inter-partition communication the IOC can be used for transmitting the data to the other partition.

[SWS_Rte_08752] ⌈ If the VariableDataPrototype in the providedData role is connected to multiple VariableDataPrototypes in the role requiredData, then the SchM shall ensure that writes to all receivers are independent. ⌋*(SRS_Rte_00243)*

This ensures that an error detected by the SchM when writing to one receiver does not prevent the transmission of this message to other BSW modules.

[SWS_Rte_08753] ⌈ In case of intra partition communication, the SchM_Send API call shall return after copying the data to RTE local memory or using IOC buffers. ⌋*(SRS_Rte_00243)*

6.5.6 SchM_Receive

Purpose: Perfoms an "explicit" sender-receiver reception of data elements with "event" semantic (queued) between BSW modules.

Signature: **[SWS_Rte_08754]** ⌈

```
Std_ReturnType
SchM_Receive_<bsnp>[_<vi>_<ai>]_<name>(OUT <data>)
```

with `<bsnp>` is the BSW Scheduler Name Prefix of the BSW module reading the data according to [SWS_Rte_07593] and [SWS_Rte_07594],

`<vi>` is the vendorId of the BSW module reading the data,

`<ai>` is the vendorApiInfix of the BSW module reading the data,

`<name>` is the shortName of the VariableDataPrototype of this sender-receiver connection.

The sub part in square brackets `[_<vi>_<ai>]` is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋*(SRS_Rte_00243)*

Existence: **[SWS_Rte_08755]** ⌈ The existence of a dataReceivePoint association to a requiredData VariableDataPrototype shall result in the generation of a SchM_Receive API for the required VariableDataPrototype. ⌋*(SRS_Rte_00243)*

[SWS_Rte_CONSTR_09078] SchM_Receive API may only be used by the BswModuleEntity that describes its usage ⌈ The SchM_Receive API may only be used within the BswModuleEntity that references the VariableDataPrototype using a dataReceivePoint. ⌋*()*

Description: When a BSW module handles a BswDataReceivedEvent on a system with the BSW running on multiple partitions, it shall invoke SchM_Receive_<bsnp>[_<vi>_<ai>]_<name>(<data>). For a sender-receiver connection crossing partition boundaries, the SchM shall then read the data from a shared buffer, where it has been put by SchM_Send.

The SchM_Receive API call includes the OUT parameter <data> to pass back the received data element.

The pointers to the OUT parameters must remain valid until the API call returns.

Return Value: The return value is used to indicate errors detected by the SchM during execution of the SchM_Receive or errors detected by the communication system.

- **[SWS_Rte_08757]** ⌈ SCHM_E_OK - data read successfully. ⌋*()*
- **[SWS_Rte_08758]** ⌈ SCHM_E_NO_DATA - no "events" (means queued data) were received and no other error occurred when the read was attempted. ⌋*()*

  [SWS_Rte_02313] ⌈ SCHM_E_LOST_DATA - Indicates that some incoming data has been lost due to an overflow of the receive queue or due to an error of the underlying communication layers. This is not an error of the data returned in the parameters. This Overlayed Error can be combined with any other error. ⌋*(SRS_Rte_00107, SRS_Rte_00110, SRS_Rte_00094)*

[SWS_Rte_08756] ⌈ In case return value is SCHM_E_NO_DATA the OUT parameters shall remain unchanged. ⌋*(SRS_Rte_00243)*

The SCHM_E_NO_DATA return value is not considered to be an error but rather indicates correct operation of the API call.

6.5.7 SchM_Switch

Purpose: Initiate a mode switch. The SchM_Switch API call is used for sending of a mode switch notification by a *Basic Software Module*.

Signature: **[SWS_Rte_07255]** ⌈

```
Std_ReturnType
SchM_Switch_<bsnp>[_<vi>_<ai>]_<name>(
                        IN <mode>)
```

Where here

<bsnp> is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the calling BSW module,

<ai> vendorApiInfix of the calling BSW module and

<name> is the provided (providedModeGroup) ModeDeclarationGroupPrototype name.

The sub part in squared brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋*(SRS_Rte_00215, SRS_BSW_00347)*

Existence: **[SWS_Rte_07256]** ⌈ The existence of a managedModeGroup association to a providedModeGroup ModeDeclarationGroupPrototype shall result in the generation of a SchM_Switch API. ⌋ *(SRS_Rte_00215)*

[SWS_Rte_CONSTR_09049] SchM_Switch API may only be used by BswModuleEntitys that describe its usage ⌈ The SchM_Switch API may only be used by BswModuleEntitys that contain a corresponding managedModeGroup association ⌋*()*

Description: The SchM_Switch triggers a mode switch for all connected required (requiredModeGroup) ModeDeclarationGroupPrototypes.

The SchM_Switch API call includes exactly one IN parameter for the next mode <mode>. The IN parameter <mode> is passed by value according to the ImplementationDataType on which the ModeDeclarationGroup is mapped. The type name shall be equal to the ImplementationDataType symbol.

Return Value: The return value is used to indicate errors detected by the *Basic Software Scheduler* during execution of the SchM_Switch call.

- **[SWS_Rte_07258]** ⌈ SCHM_E_OK – data passed to service successfully. ⌋*(SRS_Rte_00213, SRS_Rte_00214, SRS_Rte_00094)*
- **[SWS_Rte_07259]** ⌈ SCHM_E_LIMIT – a mode switch has been discarded due to a full queue. ⌋*(SRS_Rte_00213, SRS_Rte_00214, SRS_Rte_00143)*

Notes: SchM_Switch is restricted to ECU local communication.

If a mode instance is currently involved in a transition then the SchM_Switch API will attempt to queue the request and return [SWS_Rte_02667]. However if no transition is in progress for the mode instance, the mode disablings and the activations of *on-entry*, *on-transition*, and *on-exit* runnables for this mode instance are executed before the SchM_Switch API returns [SWS_Rte_02665].

Note that the mode switch might be discarded when the queue is full and a mode transition is in progress, see [SWS_Rte_02675].

[SWS_Rte_07286] ⌈ If the mode switched acknowledgment is enabled, the RTE shall notify the mode manager when the mode switch is completed. ⌋*(SRS_Rte_00213, SRS_Rte_00214, SRS_Rte_00122)*

6.5.8 SchM_Mode

There exist two versions of the `SchM_Mode` APIs. Depending on the attribute `enhancedModeApi` in the *basic software module description* there shall be provided different versions of this API (see also 6.5.9).

Purpose: Provides the currently active mode of a (`requiredModeGroup` or `providedModeGroup`) `ModeDeclarationGroupPrototype`.

Signature: **[SWS_Rte_07260]** ⌈

```
<return>
SchM_Mode_<bsnp>[_<vi>_<ai>]_<name>()
```

Where here

`<bsnp>` is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

`<vi>` is the `vendorId` of the calling BSW module,

`<ai>` `vendorApiInfix` of the calling BSW module and

`<name>` is the (`requiredModeGroup` or `providedModeGroup`) `ModeDeclarationGroupPrototype` name.

The sub part in squared brackets `[_<vi>_<ai>]` is omitted if no `vendorApiInfix` is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋*(SRS_Rte_00213, SRS_BSW_00347)*

Existence: **[SWS_Rte_07261]** ⌈ If a `accessedModeGroup` association to a `providedModeGroup` or `requiredModeGroup` `ModeDeclarationGroupPrototype` exists and if the attribute `enhancedModeApi` of the `BswModeSenderPolicy` resp. `BswModeReceiverPolicy` is set to *false* a `SchM_Mode` API according to [SWS_Rte_07260] shall be generated. ⌋*(SRS_Rte_00215)*

Note: This ensures the availability of the `SchM_Mode` API for the `mode manager` and `mode user`

[SWS_Rte_CONSTR_09050] `SchM_Mode` API may only be used by `BswModuleEntity`s that describe its usage ⌈ The `SchM_Mode`

API may only be used by BswModuleEntitys that contain a corresponding managedModeGroup association or accessedModeGroup association ⌋()

Description: The SchM_Mode API tells the *Basic Software Module* which mode of a required or provided ModeDeclarationGroupPrototype is currently active. This is the information that the *RTE* uses for the ModeDisablingDependencys. A new mode will not be indicated immediately after the reception of a mode switch notification from a mode manager, see section 4.4.4.During mode transitions, i.e. during the execution of runnables that are triggered on exiting one mode or on entering the next mode, overlapping mode disablings of two modes are active. In this case, the SchM_Mode API will return RTE_TRANSITION_<ModeDeclarationGroup>.

The SchM_Mode will return the same mode for all required or provided ModeDeclarationGroupPrototypes that are connected. (see [SWS_Rte_02630]).

Return Value: The return type of SchM_Mode is dependent on the ImplementationDataType of the ModeDeclarationGroup. It shall return the value of the ModeDeclarationGroupPrototype. The type name shall be equal to the ImplementationDataType symbol.

[SWS_Rte_07262] ⌈ The SchM_Mode API shall return the following values:

- during mode transitions:
  RTE_TRANSITION_<ModeDeclarationGroup>,

  where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup.

- else:
  RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration>,

  where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup and <ModeDeclaration> is the short name of the currently active ModeDeclaration

⌋*(SRS_Rte_00144)*

Notes: None.

6.5.9 Enhanced SchM_Mode

Purpose: Provides the currently active mode of a (requiredModeGroup or providedModeGroup) ModeDeclarationGroupPrototype. If the corresponding mode machine instance is in transition additionally the values of the previous and the next mode are provided.

Signature: **[SWS_Rte_07694]** ⌈

```
<return>
SchM_Mode_<bsnp>[_<vi>_<ai>]_<name>(
                    OUT <previousmode>,
                    OUT <nextmode>)
)
```

Where here

<bsnp> is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the calling BSW module,

<ai> vendorApiInfix of the calling BSW module and

<name> is the (requiredModeGroup or providedModeGroup) ModeDeclarationGroupPrototype name.

The sub part in squared brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋*(SRS_Rte_00213, SRS_BSW_00347)*

Existence: **[SWS_Rte_08507]** ⌈ The existence of a accessedModeGroup association to a providedModeGroup or requiredModeGroup ModeDeclarationGroupPrototype given that the attribute enhancedModeApi of the BswModeSenderPolicy resp. BswModeReceiverPolicy is set to *true* a SchM_Mode API according to [SWS_Rte_07694] shall be generated. ⌋*(SRS_Rte_00215)*

Note: This ensures the availability of the SchM_Mode API for the mode manager and mode user

[SWS_Rte_CONSTR_09051] SchM_Mode API may only be used by BswModuleEntitys that describe its usage ⌈ The SchM_Mode API may only be used by BswModuleEntitys that contain a corresponding managedModeGroup association or accessedModeGroup association ⌋*()*

Description: The SchM_Mode API tells the *Basic Software Module* which mode of a required or provided ModeDeclarationGroupPrototype is currently active. This is the information that the *RTE* uses for the ModeDisablingDependencys. A new mode will not be indicated immediately after the reception of a mode switch notification from a mode manager, see section 4.4.4.During mode transitions, i.e. during the execution of runnables that are triggered on exiting one mode or on entering the next mode, overlapping mode disablings of two modes are active. In this case, the SchM_Mode API will return RTE_TRANSITION_<ModeDeclarationGroup>. The parameter <previousmode> then contains the mode currently being left. The parameter <nextmode> contains the mode being entered.

The SchM_Mode will return the same mode for all required or provided ModeDeclarationGroupPrototypes that are connected. (see [SWS_Rte_02630]).

Return Value: The return type of SchM_Mode is dependent on the ImplementationDataType of the ModeDeclarationGroup. It shall return the value of the ModeDeclarationGroupPrototype. The type name shall be equal to the ImplementationDataType symbol.

[SWS_Rte_08509] ⌈ During transitions SchM_Mode API shall return the following values:

- the return value shall be RTE_TRANSITION_<ModeDeclarationGroup>
- <previousmode> shall contain the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration> of the mode being left,
- <nextmode> shall contain the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration> of the mode being entered,

where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup.

⌋*(SRS_Rte_00144)*

[SWS_Rte_08510] ⌈ If the mode machine instance is in a defined mode SchM_Mode shall return the follwing values:

- the return value shall contain the value of the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration>,
- <previousmode> shall contain the value of the RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration>,
- <nextmode> shall contain the the value of RTE_MODE_<ModeDeclarationGroup>_<ModeDeclaration>,

where <ModeDeclarationGroup> is the short name of the ModeDeclarationGroup and <ModeDeclaration> is the short name of the currently active ModeDeclaration.

⌋*(SRS_Rte_00144)*

Notes: None.

6.5.10 SchM_SwitchAck

Purpose: Provide access to acknowledgment notifications for mode communication.

Signature: **[SWS_Rte_07556]** ⌈

```
Std_ReturnType
SchM_SwitchAck_<bsnp>[_<vi>_<ai>]_<name>()
```

Where here

`<bsnp>` is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

`<vi>` is the `vendorId` of the calling BSW module,

`<ai>` `vendorApiInfix` of the calling BSW module and

`<name>` is the provided (`provideModeGroup`) `ModeDeclarationGroupPrototype` name.

The sub part in squared brackets `[_<vi>_<ai>]` is omitted if no `vendorApiInfix` is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋*(SRS_BSW_00310, SRS_Rte_00213)*

Existence: **[SWS_Rte_07557]** ⌈ Acknowledgement is enabled for a provided (`providedModeGroup`) `ModeDeclarationGroupPrototype` by the presence of an `ackRequest` attribute of the `BswModeSenderPolicy`. ⌋*(SRS_Rte_00213, SRS_Rte_00122)*

[SWS_Rte_07558] ⌈ A non-blocking `SchM_SwitchAck` API shall be generated for a provided (`providedModeGroup`) `ModeDeclarationGroupPrototype` if acknowledgement is enabled and a `managedModeGroup` association references the `providedModeGroup` `ModeDeclarationGroupPrototype`. ⌋*(SRS_Rte_00213, SRS_Rte_00122)*

[SWS_Rte_CONSTR_09052] `SchM_SwitchAck` API may only be used by `BswModuleEntity`s that describe its usage ⌈ The `SchM_SwitchAck` API may only be used by `BswModuleEntity`s that contain a corresponding `managedModeGroup` association ⌋*()*

Description: The `SchM_SwitchAck` API takes no parameters – the return value is used to indicate the acknowledgement status to the caller.

Return Value: The return value is used to indicate the “status” status and errors detected by the *Basic Software Scheduler* during execution of the `Rte_SwitchAck` call.

- **[SWS_Rte_07560]** ⌈ `SCHM_E_NO_DATA` – (non-blocking read) no error is occurred when the `SchM_SwitchAck` read was attempted. ⌋*(SRS_Rte_00213, SRS_Rte_00122)*

- **[SWS_Rte_07561]** ⌈ SCHM_E_TRANSMIT_ACK – For communication of mode switches, this indicates, that the BswSchedulableEntitys on the transition have been executed and the mode disablings have been switched to the new mode (see [SWS_Rte_02587]). ⌋*(SRS_Rte_00213, SRS_Rte_00122)*
- **[SWS_Rte_07055]** ⌈ SCHM_E_TIMEOUT The configured timeout exceeds before the mode transition was completed.
  OR:
  Any mode users partition is stopped or restarting or has been restarted while the mode switch was requested. ⌋*(SRS_Rte_00213, SRS_Rte_00122)*

The SCHM_E_TRANSMIT_ACK return value is not considered to be an error but rather indicates correct operation of the API call.

When SCHM_E_NO_DATA occurs, a *Basic Software Module* is free to reinvoke SchM_SwitchAck and thus repeat the attempt to read the mode switch acknowledgment status.

The SCHM_E_TIMEOUT return value can denote a stopped or restarting partition even for the SchM_SwitchAck API in case of a common mode machine instance.

Notes: If multiple transmissions on the same provided (providedModeGroup) ModeDeclarationGroupPrototype are outstanding it is not possible to determine which is acknowledged first. If this is important, transmissions should be serialized with the next occurring only when the previous transmission has been acknowledged or has timed out.

6.5.11 SchM_Trigger

Purpose: Triggers the activation of connected BswSchedulableEntitys of the same or other *Basic Software Modules*.

Signature: **[SWS_Rte_07263]** ⌈
signature without queuing support:

```
void
SchM_Trigger_<bsnp>[_<vi>_<ai>]_<name>()
```

signature with queuing support:

```
Std_ReturnType
SchM_Trigger_<bsnp>[_<vi>_<ai>]_<name>()
```

Where here

<bsnp> is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the calling BSW module,

<ai> vendorApiInfix of the calling BSW module and

<name> is the released (releasedTrigger) Trigger name.

The sub part in squared brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528].

The signature for queuing support shall be generated by the RTE generator if the swImplPolicy of the Trigger is set to queued. ⌋ *(SRS_Rte_00218, SRS_BSW_00347)*

Existence: **[SWS_Rte_07264]** ⌈ The existence of a issuedTrigger association to the released (releasedTrigger) Trigger shall result in the generation of a SchM_Trigger API. ⌋ *(SRS_Rte_00218)*

[SWS_Rte_CONSTR_09053] SchM_Trigger API may only be used by the BswModuleEntitys that describe its usage ⌈ The SchM_Trigger API may only be used by the BswModuleEntity that contains the corresponding issuedTrigger association. ⌋ *()*

Description: The SchM_Trigger triggers an execution for all BswSchedulableEntitys whose BswExternalTriggerOccurredEvent is associated to connected required Trigger.

Return Value: None in case of signature without queuing support.

[SWS_Rte_06722] ⌈ The SchM_Trigger API shall return the following values:

- SCHM_E_OK if the trigger was successfully queued or if no queue is configured
- SCHM_E_LIMIT if the trigger was not queued because the maximum queue size is already reached.

in the case of signature with queuing support. ⌋ *(SRS_Rte_00235)*

Notes: SchM_Trigger is restricted to ECU local communication.

6.5.12 SchM_ActMainFunction

Purpose: Triggers the activation of the BswSchedulableEntity which is associated with an activationPoint of the same or *Basic Software Module*.

Signature: **[SWS_Rte_07266]** ⌈

signature without queuing support:

```
void
SchM_ActMainFunction_<bsnp>[_<vi>_<ai>]_<name>()
```

signature with queuing support:

```
Std_ReturnType
SchM_ActMainFunction_<bsnp>[_<vi>_<ai>]_<name>()
```

Where here

`<bsnp>` is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

`<vi>` is the `vendorId` of the calling BSW module,

`<ai>` `vendorApiInfix` of the calling BSW module and

`<name>` is the associated `BswInternalTriggeringPoint` short name.

The sub part in squared brackets `[_<vi>_<ai>]` is omitted if no `vendorApiInfix` is defined for the *Basic Software Module*. See [SWS_Rte_07528].

The signature for queuing support shall be generated by the RTE generator if the `swImplPolicy` of the `BswInternalTriggeringPoint` is set to `queued`. ⌋*(SRS_Rte_00218, SRS_BSW_00347)*

Existence: **[SWS_Rte_07267]** ⌈ The existence of an `activationPoint` shall result in the generation of a `SchM_ActMainFunction` API. ⌋ *(SRS_Rte_00218)*

[SWS_Rte_CONSTR_09054] `SchM_ActMainFunction` API may only be used by the `BswModuleEntity`s that describe its usage ⌈ The `SchM_ActMainFunction` API may only be used by the `BswModuleEntity` that contains the corresponding `activationPoint` association. ⌋*()*

Description: The `SchM_ActMainFunction` triggers an execution for all `BswSchedulableEntity`s whose `BswInternalTriggerOccurredEvent` is associated by `activationPoint`.

Return Value: None in case of signature without queuing support.

[SWS_Rte_06723] ⌈ The `SchM_ActMainFunction` API shall return the following values:

- `SCHM_E_OK` if the trigger was successfully queued or if no queue is configured
- `SCHM_E_LIMIT` if the trigger was not queued because the maximum queue size is already reached.

in the case of signature with queuing support. ⌋*(SRS_Rte_00235)*

Notes: SchM_ActMainFunction is restricted to ECU local communication.

6.5.13 SchM_CData

Purpose: Provide access to the calibration parameter of a *Basic Software Module* defined internally. The ParameterDataPrototype in the role perInstanceParameter is used to define *Basic Software Module* internal calibration parameters. Internal because the ParameterDataPrototype cannot be reused outside the *Basic Software Module*. Access is read-only. Each instance has an own data value associated with it.

Signature: **[SWS_Rte_07093]** ⌈

```
<return> SchM_CData_<bsnp>[_<vi>_<ai>]_<name>()
```

Where here

<bsnp> is the *BSW Scheduler Name Prefix* according [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the calling BSW module,

<ai> vendorApiInfix of the calling BSW module and

<name> is the shortName of the ParameterDataPrototype.

The sub part in squared brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋*(SRS_BSW_00347, SRS_Rte_00155)*

Existence: **[SWS_Rte_07094]** ⌈ An SchM_CData API shall be created for each defined ParameterDataPrototype in the role perInstanceParameter ⌋*(SRS_Rte_00155)*

Description: The SchM_CData API provides access to the defined calibration parameter within a *Basic Software Module*. The actual data values for a *Basic Software Module* instance may be set after component compilation.

Return Value: The SchM_CData return value provide access to the data value of the ParameterDataPrototype in the role perInstanceParameter.

The return type of SchM_CData is dependent on the ImplementationDataType of the ParameterDataPrototype and can either be a value or a pointer to the location where the value can be accessed. Thus the component does not need to use type casting to convert access to the ParameterDataPrototype data.

For details of the <return> value definition see section 5.2.6.6.

[SWS_Rte_07095] ⌈ The return value of the corresponding SchM_CData API shall provide access to the calibration parameter value specific to the instance of the *Basic Software Module*. ⌋ *(SRS_Rte_00155)*

Notes: None.

6.5.14 SchM_Pim

Purpose: Provide access to the defined per-instance memory (section) of a Basic Software Module.

Signature: **[SWS_Rte_06203]** ⌈

```
<return> SchM_Pim_<bsnp>[_<vi>_<ai>]_<name>()
```

with `<bsnp>` is the BSW Scheduler Name Prefix of the BSW module reading the data according to [SWS_Rte_07593] and [SWS_Rte_07594],

`<vi>` is the vendorId of the BSW module reading the data,

`<ai>` is the vendorApiInfix of the BSW module reading the data,

`<name>` is the shortName of the VariableDataPrototype defined in the role arTypedPerInstanceMemory.

The sub part in square brackets `[_<vi>_<ai>]` is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528]. ⌋ *(SRS_BSW_00347, SRS_Rte_00075)*

Existence: **[SWS_Rte_06204]** ⌈ A SchM_Pim API shall be created for each defined VariableDataPrototype in the role arTypedPerInstanceMemory within the Basic Software Module description. ⌋ *(SRS_Rte_00075)*

Description: The SchM_Pim API provides access to the arTypedPerInstanceMemory defined in the context of a BswInternalBehavior of a Basic Software Module description.

Return Value: **[SWS_Rte_06205]** ⌈ The API returns a typed reference (in C a typed pointer) to the arTypedPerInstanceMemory. ⌋ *(SRS_Rte_00051, SRS_Rte_00075)*

Notes: For an arTypedPerInstanceMemory the `<return reference>` is defined by the associated AutosarDataType (see [SWS_Rte_07161]). For details of the `<return reference>` definition see section 5.2.6.7.

6.6 Bsw Module Entity Reference

An *AUTOSAR Basic Software Module* defines one or more *"BSW module entities"*. A BSW Module Entity is a piece of code with a single entry point and an associate set of attributes. In contrast to runnable entities which are exclusively scheduled by the RTE only a subset of the BSW module entities, the `BswSchedulableEntity`s and `BswCalledEntity`s are called by the *Basic Software Scheduler*. Others might implement 'C' function interfaces which are directly called by other BSW modules or interrupts which are called by OS / interrupt controller.

A *Basic Software Module Description* provides definitions for each `BswModuleEntity` within the BSW Module. The *Basic Software Scheduler* triggers the execution of `BswSchedulableEntity`s and `BswCalledEntity`s in response to different `BswEvent`s.

The `BswCalledEntity`s are triggered by `BswOperationInvokedEvent`s, the `BswSchedulableEntity`s by `BswScheduleEvent`s.

For BSW modules implemented using C or C++ the entry point of a `BswSchedulableEntity` is implemented by a function with global scope defined within a BSW Modules source code. The following sections consider the function signature and prototype.

6.6.1 Signature

The definition of all `BswSchedulableEntity`s, whatever the `BswScheduleEvent` that triggers their execution, follows the same basic form.

Purpose: Trigger a `BswSchedulableEntity` if the related `BswScheduleEvent` defined within the `BswModuleDescription` is raised.

Signature: **[SWS_Rte_07282]** ⌈

```
FUNC(void, <memclass>) <bsnp>[_<vi>_<ai>]_<name>(
[IN SchM_ActivatingEvent_<name> <activation>])
```

⌋*(SRS_BSW_00347, SRS_Rte_00211, SRS_Rte_00213, SRS_Rte_00216, SRS_Rte_00238)*

The usage of `SchM_ActivatingEvent` is optional and defined in [SWS_Rte_08056].

For `BswCalledEntity`s the signature contains the parameters and return type. It can be seen in [SWS_Rte_08765].

Purpose: Trigger a `BswCalledEntity` if the related `BswOperationInvokedEvent` defined within the `BswModuleDescription` is raised.

Signature: **[SWS_Rte_08765]** ⌈

```
FUNC(<returnType>, <memclass>) <bsnp>[_<vi>_<ai>]_<name>(
[IN|IN/OUT|OUT] <parameter_1>...
[IN|IN/OUT|OUT] <parameter_n>)
```

⌋*(SRS_BSW_00347, SRS_Rte_00241, SRS_Rte_00243)*

There is currently no possibility to obtain the activating BswOperationInvokedEvent of a BswCalledEntity.

Where here for both of them

<bsnp> is the BSW Scheduler Name Prefix according [SWS_Rte_07593] and [SWS_Rte_07594],

<vi> is the vendorId of the BSW module,

<ai> is the vendorApiInfix of the BSW module

<name> is the substring after "<bsnp>_" of the BswModuleEntry shortName referred as implementedEntry. However if "<bsnp>_" is not the prefix of the related BswModuleEntry shortName then <name> shall be the BswModuleEntry shortName.

<memclass> is the Compiler Abstraction Memory Class according [SWS_Rte_06739] and [SWS_Rte_06740].

<returnType> is the return type defined in the SwServiceArg in the role returnType of the BswModuleEntry which is referenced by the BswModuleClientServerEntry in the role encapsulatedEntry. If no type is defined, the <returnType> is of type void.

<parameter_x> are the arguments defined in the SwServiceArgs in the role argument of the BswModuleEntry which is referenced by the BswModuleClientServerEntry in the role encapsulatedEntry. For each argument the type has to be give according to [SWS_Rte_08766].

The sub part in square brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528].

[SWS_Rte_08766] ⌈ The datatype of the argument is depending on SwServiceArgs.

For category of SwServiceArg of type TYPE_REFERENCE:
If the ImplementationDataType in the role implementationDataType of the SwDataDefProps of the SwServiceArg resolves to a primitive and the direction of the SwServiceArg is IN, the datatype of the argument is defined by the ImplementationDataType (possibly referred over a chain of ImplementationDataTypes of category TYPE_REFERENCE) in the role implementationDataType of the SwDataDefProps of the SwServiceArg which represents the argument.

If the ImplementationDataType in the role implementationDataType of the SwDataDefProps of the SwServiceArg resolves to a pointer type where the final pointer target is a primitive or composite and the direction of the SwServiceArg is IN, INOUT or OUT, the datatype of the argument is defined by the SwPointerTargetProps element referred by the ImplementationDataType of category DATA_REFERENCE (possibly referred over a chain of ImplementationDataTypes of category TYPE_REFERENCE).

For category of SwServiceArg of type DATA_REFERENCE:
If the SwPointerTargetProps in the role swPointerTargetProps of the SwDataDefProps of the SwServiceArg resolves to a primitive or composite and the direction of the SwServiceArg is IN, INOUT or OUT, the datatype of the argument is defined by the SwPointerTargetProps in the SwDataDefProps of the SwServiceArg which represents the argument (which may include resolving a chain of ImplementationDataTypes if the target category of the SwPointerTargetProps is TYPE_REFERENCE).

For category of SwServiceArg of type FUNCTION_REFERENCE:
This case is not supported.

⌋*(SRS_Rte_00243)*

[SWS_Rte_CONSTR_09058] BswSchedulableEntity is not allowed to have service arguments or return value ⌈ The Basic Software Scheduler requires that the BswModuleEntry has no service arguments (unless SchM_ActivatingEvent is enabled) and no return value. ⌋*()*

[SWS_Rte_06739] ⌈ <memclass> shall be defined as <snp>[_<vi>_<ai>]_<memClassSymbol> if a MemorySection.memClassSymbol and an associated MemorySection is defined and where

<snp> is the Section Name Prefix according [SWS_Rte_07595] and [SWS_Rte_07596],

<vi> is the vendorId of the BSW module,

<ai> is the vendorApiInfix of the BSW module, and

<memClassSymbol> is the value of the attribute memClassSymbol the of the MemorySection associated via executableEntity reference to the BswModuleEntity implementing the related BswModuleEntry. ⌋*()*

[SWS_Rte_06740] ⌈ <memclass> shall be defined as <snp>[_<vi>_<ai>]_<sadm> if no MemorySection.memclassSymbol is applicable (see [SWS_Rte_06739]) and where

<snp> is the Section Name Prefix according [SWS_Rte_07595] and [SWS_Rte_07596],

<vi> is the vendorId of the BSW module,

<ai> is the vendorApiInfix of the BSW module, and

<sadm> is the shortName of the referred swAddrMethod. ⌋*()*

6.6.2 Entry Point Prototype

The entry point defined in the Basic Software Modules source *must* be compatible with the called function when the BswSchedulableEntity or BswCalledEntity is triggered by the *Basic Software Scheduler* and therefore the RTE generator is required to emit a prototype for the function.

[SWS_Rte_04542] ⌈ The RTE generator shall emit an *Entry Point Prototype* for each BswSchedulableEntitys implementedEntry in the *Module Interlink Header* file. See chapter 6.3.2 according [SWS_Rte_07282]. ⌋*(SRS_Rte_00211, SRS_Rte_00213, SRS_Rte_00216)*

[SWS_Rte_04543] ⌈ The RTE generator shall emit an *Entry Point Prototype* for each BswCalledEntitys implementedEntry in the *Module Interlink Header* file, if the value of the attribute functionPrototypeEmitter is set to "RTE" . See chapter 6.3.2 according [SWS_Rte_08765]. ⌋*(SRS_Rte_00211, SRS_Rte_00213, SRS_Rte_00216)*

[SWS_Rte_07195] ⌈ The RTE Generator shall wrap each BswSchedulableEntity's *Entry Point Prototype* in the *Module Interlink Header* with the *Memory Mapping* and *Compiler Abstraction* macros.

```
#define <snp>[_<vi>_<ai>]_START_SEC_<sadm>
#include "<MemMap_filename.h>"

FUNC(void, <memclass>) <bsnp>[_<vi>_<ai>]_<name>
    ([IN SchM_ActivatingEvent_<name> <activation>]);

#define <snp>[_<vi>_<ai>]_STOP_SEC_<sadm>
#include "<MemMap_filename.h>"
```

The RTE Generator shall wrap each BswCalledEntity's *Entry Point Prototype* in the *Module Interlink Header* with the *Memory Mapping* and *Compiler Abstraction* macros.

```
#define <snp>[_<vi>_<ai>]_START_SEC_<sadm>
#include "<MemMap_filename.h>"

FUNC(<returnType>, <memclass>) <bsnp>[_<vi>_<ai>]_<name>(
    [IN|IN/OUT|OUT] <parameter_1> ... [IN|IN/OUT|OUT] <parameter_n>);

#define <snp>[_<vi>_<ai>]_STOP_SEC_<sadm>
#include "<MemMap_filename.h>"
```

Where here for both of them

<bsnp> is the BSW Scheduler Name Prefix according [SWS_Rte_07593] and [SWS_Rte_07594],

<snp> is the Section Name Prefix according [SWS_Rte_07595] and [SWS_Rte_07596],

<vi> is the vendorId of the BSW module,

<ai> is the vendorApiInfix of the BSW module,

<name> is the substring after "<bsnp>_" of the BswModuleEntry shortName referred as implementedEntry. However if "<bsnp>_" is not the prefix of the related BswModuleEntry shortName then <name> shall be the BswModuleEntry shortName, and

<returnType> is the return type defined in the SwServiceArg in the role returnType of the BswModuleEntry which is referenced by the BswModuleClientServerEntry in the role encapsulatedEntry. If no type is defined, the <returnType> is of type void.

<parameter_x> are the arguments defined in the SwServiceArgs in the role argument of the BswModuleEntry which is referenced by the BswModuleClientServerEntry in the role encapsulatedEntry. For each argument the type has to be give according to [SWS_Rte_08766].

<sadm> is the shortName of the referred swAddrMethod.

<memclass> is the Compiler Abstraction Memory Class according [SWS_Rte_06739] and [SWS_Rte_06740]

<MemMap_filename.h> is the *Applicable Memory Mapping Header File Name* according [SWS_Rte_07830], [SWS_Rte_07831] and [SWS_Rte_07832].

The sub part in square brackets [_<vi>_<ai>] is omitted if no vendorApiInfix is defined for the *Basic Software Module*. See [SWS_Rte_07528].

The usage of SchM_ActivatingEvent is optional for BswSchedulableEntity and defined in [SWS_Rte_08056]. It does currently not exist for BswCalledEntitys.

The Memory Mapping macros could wrap several *Entry Point Prototype* if these referring the same swAddrMethod. If the BswSchedulableEntity or the BswCalledEntity does not refer a swAddrMethod the <sadm> is set to CODE. ⌋ *(SRS_Rte_00148, SRS_Rte_00149, SRS_Rte_00238)*

[SWS_Rte_07830] ⌈ The RTE Generator shall emit the *Applicable Memory Mapping Header File Name* <MemMap_filename.h> as <Msn>[_<vi>_<ai>]_MemMap.h if the BswImplementation does not contain a DependencyOnArtifact in the role requiredArtifact where the DependencyOnArtifact.category is set to MEMMAP. <Msn> is the shortName (case sensitive) of the BswModuleDescription. ⌋ *(SRS_Rte_00148)*

[SWS_Rte_07831] ⌈ The RTE generator shall emit the *Applicable Memory Mapping Header File Name* <MemMap_filename.h> identical to the attribute value requiredArtifact.artifactDescriptor.shortLabel if the BswImplementation does contain exactly one DependencyOnArtifact in the role requiredArtifact where the DependencyOnArtifact.category is set to MEMMAP. ⌋ *(SRS_Rte_00148)*

[SWS_Rte_07832] ⌈ The RTE Generator shall emit the *Applicable Memory Mapping Header File Name* <MemMap_filename.h> identical to the attribute value requiredArtifact.artifactDescriptor.shortLabel of the DependencyOnArtifact in the role requiredArtifact where the DependencyOnArtifact.category is set to MEMMAP and which is associated with the SectionNamePrefix implementedIn of the MemorySection associated to the BswModuleEntity. ⌋ *(SRS_Rte_00148)*

Please note the example 6.2 of *Entry Point Prototype*.

[SWS_Rte_06533] ⌈ The RTE Generator shall wrap each *Entry Point Prototype* in the *Module Interlink Header* file of a variant existent BswSchedulableEntity or BswCalledEntity if the variability shall be implemented.

```
#if (<condition>)

<Entry Point Prototype>

#endif
```

where condition is the *Condition Value Macro* of the VariationPoint relevant for the variant existence of the BswSchedulableEntity or BswCalledEntity (see table 4.30), Entry Point Prototype is the code according an invariant *Entry Point Prototype* (see also [SWS_Rte_07282], [SWS_Rte_04542]). ⌋ *(SRS_Rte_00229)*

6.6.3 Reentrancy

The BswSchedulableEntitys and BswCalledEntitys are declared within a BSW Module. The *Basic Software Module Scheduler* ensures that concurrent activation of the same BswSchedulableEntity or BswCalledEntity is only allowed if the implemented entry points attribute "isReentrant" is set to "true" (see Section 4.2.6).

Consistency rule:

[SWS_Rte_07588] ⌈ The RTE Generator shall reject configurations where a BswSchedulableEntity whose referenced BswModuleEntry in the role implementedEntry has its isReentrant attribute set to false, and this BswSchedulableEntity is mapped to different tasks which can pre-empt each other. ⌋ *(SRS_Rte_00018)*

6.6.4 Provide activating Bsw event

[SWS_Rte_08059] ⌈ If the provide activating Bsw event feature is enabled, the RTE shall collect the activating Bsw events, which have the activationReasonRepresentation reference defined, in the context of the OS task the executable entity is mapped to in an activation vector at the corresponding bit position as defined in [SWS_Rte_08058]. ⌋ *(SRS_Rte_00238)*

[SWS_Rte_08060] ⌈ If the provide activating Bsw event feature is enabled, the RTE shall provide the collected activating Bsw events (activation vector) to the executable entity API when the executable entity is "started". The activation vector shall be reset immediately after it has been provided. ⌋*(SRS_Rte_00238)*

Provision of the activating Bsw event is curerntly not availbale for `BswCalledEntity`s.

Since it is possible that there is a time gap between the activation and the execution (start) of an executable entity the subsequent activations are summed up and provided with the start of the executable entity.

Activations during the execution of an executable entity are collected for the next start of that runnable entity.

6.7 Basic Software Scheduler Lifecycle API Reference

6.7.1 SchM_Init

Service name:	SchM_Init	

Syntax:	`void SchM_Init(`
	`const SchM_ConfigType* ConfigPtr`
	`)`	

Service ID[hex]:	0x00	
Sync/Async:	Synchronous	
Reentrancy:	Non Reentrant	
Parameters (in):	ConfigPtr	Pointer to configuration set in Variant Post-Build.
Parameters (inout):	None	
Parameters (out):	None	
Return value:	None	
Description:	SchM_Init is intended to allocate and initialize system resources used by the Basic Software Scheduler part of the RTE for the core on which it is called.	
Available via:	SchM.h	

Table 6.2: SchM_Init

`SchM_Init` is intended to allocate and initialize system resources used by the *Basic Software Scheduler* part of the RTE for the core on which it is called.

[SWS_Rte_07270] ⌈

```
void SchM_Init(const SchM_ConfigType * ConfigPtr)
```

⌋*(SRS_BSW_00101, SRS_Rte_00116)*

[SWS_Rte_07271] ⌈ The `SchM_Init` API is always created. ⌋*(SRS_BSW_00101)*

[SWS_Rte_07273] ⌈ `SchM_Init` shall return within finite execution time – it must not enter an infinite loop. ⌋*(SRS_BSW_00101)*

`SchM_Init` may be implemented as a function or a macro.

SchM_Init is declared in the lifecycle header file Rte_Main.h.

6.7.2 SchM_Start

Service name:	SchM_Start

Syntax:	`void SchM_Start(`
	`void`
	`)`

Service ID[hex]:	0x70
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Basic Software Scheduler initialized. Shall be called before BswM_Init().
Available via:	SchM.h

Table 6.3: SchM_Start

SchM_Start is intended to initialize the *Basic Software Scheduler*. It shall be called before BswM_Init().

[SWS_Rte_04546] ⌈

```
void SchM_Start(void)
```

⌋*(SRS_BSW_00101)*

[SWS_Rte_04547] ⌈ The SchM_Start API is always created. ⌋*(SRS_BSW_00101)*

[SWS_Rte_04548] ⌈ SchM_Start shall return within finite execution time – it must not enter an infinite loop. ⌋*(SRS_BSW_00101)*

SchM_Start may be implemented as a function or a macro.

SchM_Start is declared in the lifecycle header file Rte_Main.h.

6.7.3 SchM_StartTiming

Service name:	SchM_StartTiming

Syntax:	`void SchM_StartTiming(`
	`void`
	`)`

Service ID[hex]:	0x76
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None

Description:	Start periodical events for BSW/SWCs. SchM_Init() has to be called before.
Available via:	SchM.h

Table 6.4: SchM_StartTiming

SchM_StartTiming starts the *Basic Software Scheduler* part of the RTE.

SchM_Start starts periodical events for BSW/SWCs. SchM_Init() has to be called before.

[SWS_Rte_04549] ⌈

```
void SchM_StartTiming(void)
```

⌋*(SRS_BSW_00101)*

[SWS_Rte_04550] ⌈ The SchM_StartTiming API is always created. ⌋*(SRS_BSW_00101)*

[SWS_Rte_04551] ⌈ SchM_StartTiming shall return within finite execution time – it must not enter an infinite loop. ⌋*(SRS_BSW_00101)*

SchM_StartTiming may be implemented as a function or a macro.

SchM_StartTiming is declared in the lifecycle header file Rte_Main.h.

[SWS_Rte_CONSTR_09055] SchM_Init, SchM_Start, SchM_StartTiming shall be called only once ⌈ SchM_Init, SchM_Start, SchM_StartTiming shall be called only once by the *EcuStateManager* on each core after the basic software modules required by the *Basic Software Scheduler* part of the RTE are initialized. ⌋*()*

These modules include:

- OS

6.7.4 SchM_Deinit

Service name:	SchM_Deinit

Syntax:	`void SchM_Deinit(`
	`void`
	`)`

Service ID[hex]:	0x01
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	SchM_Deinit is used to finalize Basic Software Scheduler part of the RTE of the core on which it is called. This service releases all system resources allocated by the Basic Software Scheduler part on that core.

Available via:	SchM.h

Table 6.5: SchM_Deinit

`SchM_Deinit` finalizes the *Basic Software Scheduler* part of the RTE on the core it is called.

[SWS_Rte_07274] ⌈
```
void SchM_Deinit(void)
```
⌋*(SRS_BSW_00336)*

[SWS_Rte_07275] ⌈The `SchM_Deinit` API is always created. ⌋*(SRS_BSW_00336)*

[SWS_Rte_CONSTR_09057] `SchM_Deinit` shall be called before shut down of BSW ⌈`SchM_Deinit` shall be called by the *EcuStateManager* before the basic software modules required by *Basic Software Scheduler* part are shut down. ⌋*()*

These modules include:

- OS

[SWS_Rte_CONSTR_09056] `SchM_Deinit` API may only be used after the was RTE finalized ⌈The `SchM_Deinit` API may only be used after the RTE finalized (after termination of the `Rte_Stop`) ⌋*()*

[SWS_Rte_07277] ⌈`SchM_Deinit` shall return within finite execution time. ⌋*(SRS_BSW_00336)*

`SchM_Deinit` may be implemented as a function or a macro.

`SchM_Deinit` is declared in the lifecycle header file `Rte_Main.h`.

6.7.5 SchM_GetVersionInfo

Service name:	SchM_GetVersionInfo	

Syntax:	`void SchM_GetVersionInfo(`
	`Std_VersionInfoType* versioninfo`
	`)`	

Service ID[hex]:	0x02	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	None	
Parameters (inout):	None	
Parameters (out):	versioninfo	Pointer to the memory location holding the version information of the module
Return value:	None	
Description:	Returns the version information of the Basic Software Scheduler.	
Available via:	SchM.h	

Table 6.6: SchM_GetVersionInfo

[SWS_Rte_07278] ⌈
```
void SchM_GetVersionInfo(Std_VersionInfoType * versioninfo)
```
⌋*(SRS_BSW_00407)*

[SWS_Rte_07279] ⌈ The SchM_GetVersionInfo API is only created if RteSchMVersionInfoApi is set to true. ⌋*(SRS_BSW_00407)*

[SWS_Rte_07280] ⌈ SchM_GetVersionInfo shall return the version information of the RTE module which includes the *Basic Software Scheduler*. The version information includes:

- Module Id
- Vendor Id
- Vendor specific version numbers

⌋*(SRS_BSW_00407)*

[SWS_Rte_07281] ⌈ The parameter versioninfo of the SchM_GetVersionInfo shall point to the memory location holding the version information of the *Basic Software Scheduler*. ⌋*(SRS_BSW_00407)*

SchM_GetVersionInfo may be implemented as a function or a macro.

SchM_GetVersionInfo is declared in the lifecycle header file Rte_Main.h.

The existence of the API SchM_GetVersionInfo depends on the parameter RteSchMVersionInfoApi.

Vendor specific version numbers shall represent build version which depends from the RTE generator version and the input configuration. It is not in the scope if this specification to standardize the way how the version numbers are created in detail because these are the vendor specific version numbers.

7 RTE Implementation Plug-Ins Reference

Please note, that the requirements concerning RTE Implementation Plug-Ins in this chapter are set to draft to support a simple revise of requirements in case of defects. Nevertheless, all addressed concept elements were fully elaborated and incorporated in the AUTOSAR specifications.

It's expected, that all draft requirements in this section will be set to valid in the next minor release.

7.1 Introduction

For a standard RTE Generator, the possibilities to determine the system dynamics are very limited (task priorities, internal OsResources ...). A real ECU SW will have more constraints, e.g. tasks that only run in different system states, tasks that follow the execution of other tasks (i.e. chains of tasks). Without this knowledge an RTE will on one side use more protection of internal variables and on the other side perform more data buffering than necessary. This will lead to higher CPU resource consumption than necessary. AUTOSAR provides some ideas and requirements regarding buffering of implicitly accessed data, but mostly leaves the optimization up to the RTE vendor. For the RTE vendor, the buffer optimization is one of the most challenging jobs when implementing an RTE Generator. And it does again not have all the knowledge about the system dynamics nor about the optimization goals (AUTOSAR only provides optimization switches MEMORY and RUNTIME). The idea of RTE Implementation Plug-In is to move the jobs of protection and buffering optimizations from the RTE vendor to some domain specific tool which has a more detailed knowledge about optimization goals and system dynamics. The interface between the RTE and the domain specific tooling will mostly be a C code interface. Further on in this document this domain specific tooling with the RTE extending C-code will be called RTE Implementation Plug-In.

7.1.1 RTE Implementation Plug-Ins in the AUTOSAR Architecture

From the AUTOSAR software layered architecture point of view the RTE Implementation Plug-Ins are a part of the RTE. This means the "Core" RTE provided by the RTE Generator plus the RTE Implementation Plug-Ins implement the overall RTE. Nevertheless the interface between the "Core" RTE and the RTE Implementation Plug-Ins is standardized in order to support, that the RTE Generator and the RTE Implementation Plug-Ins can be provided by different vendors.

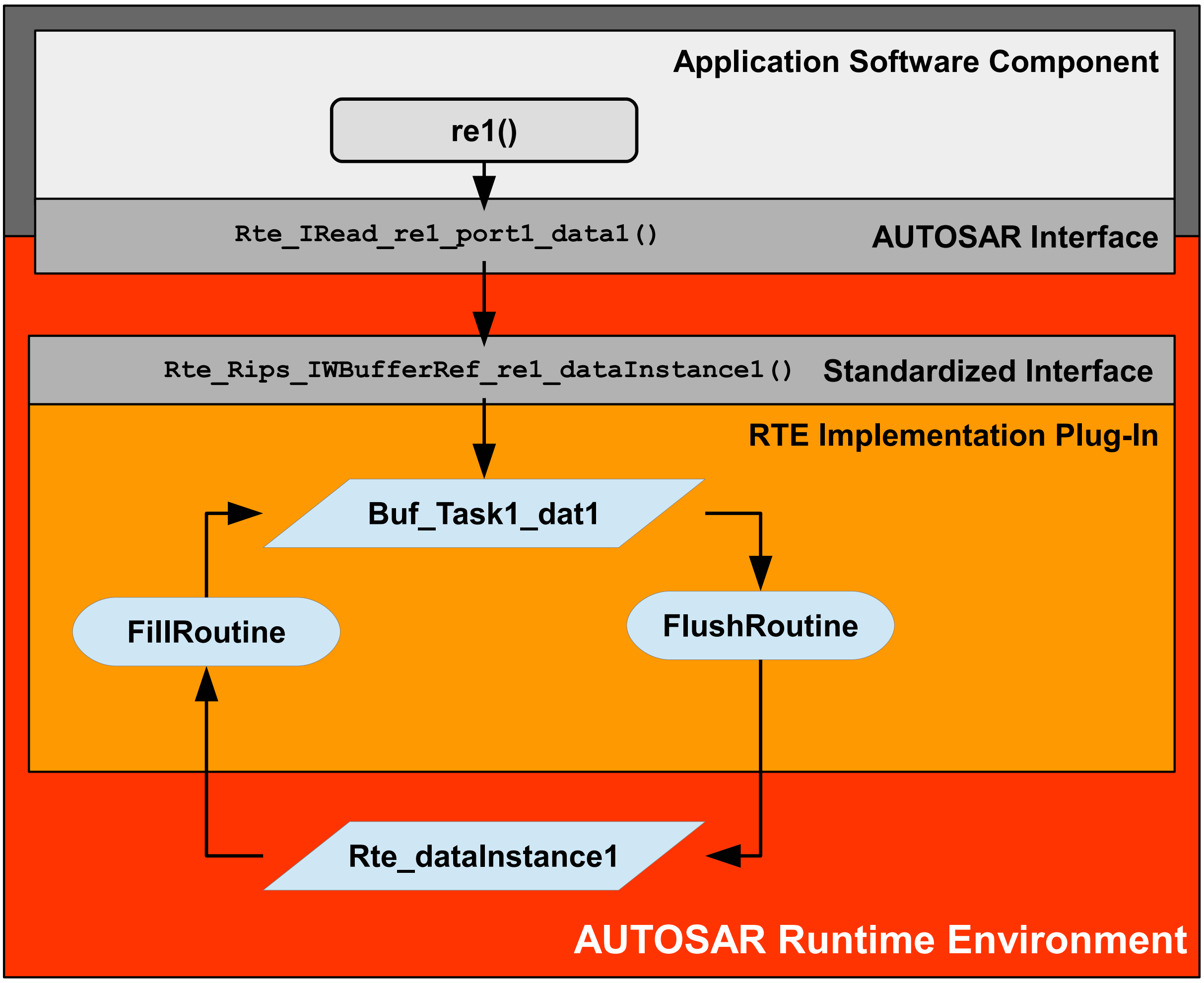

Figure 7.1: Example of implicit communication via RTE Implementation Plug-In

The Figure 7.1 shows the principle of implicit communication implementation via an RTE Implementation Plug-In. Based on the Software Component Description the RTE provides the Rte_IRead API. This Rte_IRead API uses the Rte_Rips_IWBufferRef API from the RTE Implementation Plug-In to get the address of the implicit communication buffer Buf_Task1_dat1. The RTE Implementation Plug-In provides the fill- and flush routines and the implicit communication buffer instance. Via interface conventions it knows as well the global copy Rte_dataInstance1 which is related to the Data Communication Graph. This supports the creation of the according copy code for the fill- and flush routines.

7.2 Interface between RTE Implementation Plug-Ins and RTE

7.2.1 File Structure

The following subsection describes the content of the RTE Implementation Plug-In specific files and the additional requirements on the standardized Header Files of the RTE.

The shown file structure is the one relevant for Generation Phase. RTE Implementation Plug-Ins do not have any influence on the RTE Contract Phase or Basic Software Scheduler Contract Phase.

The general coding rules mandate to have exactly one declaration for each C symbol definition and that this declaration is visible to the definition as well as the users of the C symbol. Furthermore the file structure represents only the idea and some kind of best practice. The RTE as well as the RTE Implementation Plug-Ins are free to adapt this structure to their needs. However, the essence of the interface between the two has to be maintained. That is,

- which file of one domain (RTE or RTE Implementation Plug-In) exports which declaration or definition into the other domain and
- which files (or better their contents) have to be expected to be visible in other files at the same time (risk of double declarations, double inclusion protection taking effect etc.).

The term 'export' in that sense means that the exported definition or declaration shall be visible in the file including the exporting header. It does not matter if that header performs the declarations or definitions itself or if they are performed by another header included into this one.

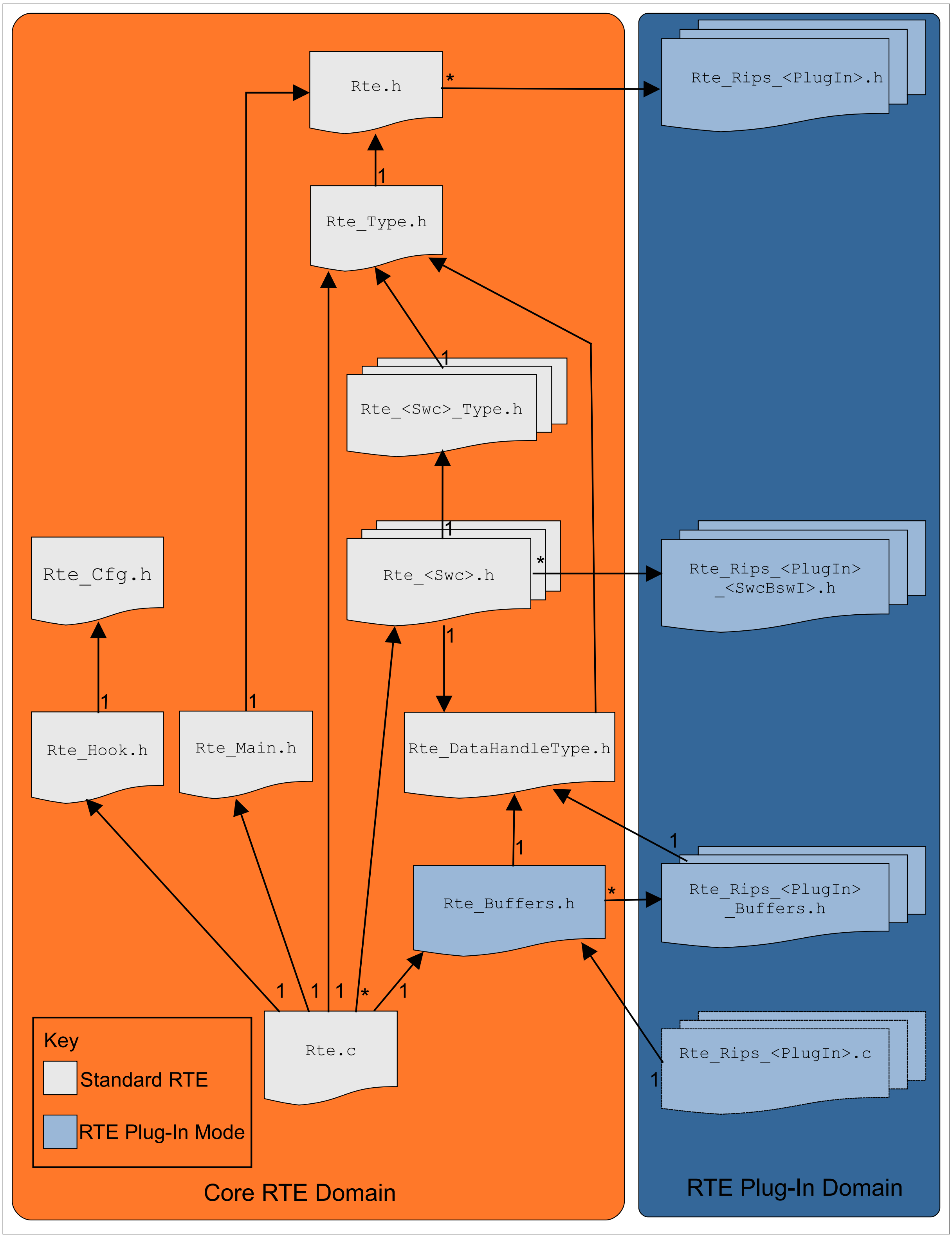

Figure 7.2: Include Structure of RTE Implementation Plug-Ins for RTE

7.2.1.1 RTE Global Buffer Declaration File

The RTE Global Buffer Declaration File makes all global copies of data instantiated by the RTE visible to the RTE Implementation Plug-In Services and the RTE Implementation Plug-In C-code. As the RTE Implementation Plug-In only knows their name by the related RIPS FlatInstanceDescriptor, it might be necessary to have an according mapping in case the resulting global copy name differs from this one. The RTE therefore has to map the name derived from the RIPS FlatInstanceDescriptor domain to the real C name implemented by the RTE. An example of a RTE Global Buffer Declaration File containing a plain declaration and a declaration with mapping can be seen below in Example 7.1.

Example 7.1

```
#ifndef RTE_BUFFERS_H
#define RTE_BUFFERS_H

#include "Rte_DataHandleType.h"
#include "Rte_Rips_myPlugin1_Buffers.h"
#include "Rte_Rips_myPlugin2_Buffers.h"

extern uint32 Rte_someInternalNameForData;

#define Rte_Rips_GlobalCopy_myMappedData Rte_someInternalNameForData

#endif /* RTE_BUFFERS_H */
```

[SWS_Rte_80000] DRAFT ⌈ The RTE Global Buffer Declaration File shall have the name Rte_Buffers.h. ⌋ *(SRS_Rte_00306)*

[SWS_Rte_80001] DRAFT ⌈ The RTE Generator shall create the RTE Global Buffer Declaration File when the RTE Implementation Plug-In mode is enabled. ⌋ *(SRS_Rte_00306)*

[SWS_Rte_80002] DRAFT ⌈ The RTE Global Buffer Declaration File shall include the RTE Data Handle Types Header File. ⌋ *(SRS_Rte_00306)*

[SWS_Rte_80003] DRAFT ⌈ The RTE Global Buffer Declaration File shall include all RIPS Buffer Declaration Files of all participating RTE Implementation Plug-Ins. ⌋ *(SRS_Rte_00306)*

[SWS_Rte_80005] DRAFT ⌈ The RTE Global Buffer Declaration File shall export the declarations of all global copies for implicit communication instantiated by the RTE, where the Data Communication Graph is associated with a RTE Implementation Plug-In. ⌋ *(SRS_Rte_00306)*

Please note: The data structures for queues inside an RTE are considered as specific for each RTE implementation. Since there is never the use case to buffer queued communication there is no need to make them accessible for the RTE Implementation Plug-In code.

[SWS_Rte_80006] DRAFT ⌈ For each global copy of a Data Communication Graph associated to an RTE Implementation Plug-In and implemented by the RTE where the C symbol is different to the shortName of the respective RIPS FlatInstanceDescriptor prefixed by Rte_Rips_GlobalCopy_, the RTE Global Buffer Declaration File shall export a mapping from the shortName of the RIPS FlatInstanceDescriptor prefixed by Rte_Rips_GlobalCopy_ to the according C symbol of the global copy. ⌋*(SRS_Rte_00306)*

Example 7.2

```
#ifndef RTE_BUFFERS_H
#define RTE_BUFFERS_H

extern uint32 Rte_someInternalNameForData;

#define Rte_Rips_GlobalCopy_myMappedData Rte_someInternalNameForData

#endif /* RTE_BUFFERS_H */
```

[SWS_Rte_80007] DRAFT ⌈ The RTE shall be implemented in a way that the mappings resulting from [SWS_Rte_80006] shall not have any effect on the AUTOSAR RTE code, specifically Rte.c, as they might cause unintended replacements there. In particular this means that they shall not change the C symbol of the global copies. ⌋*(SRS_Rte_00306)*

Note: [SWS_Rte_80007] can be simply implemented by the fact that the RTE code does not use any symbols starting with Rte_Rips_GlobalCopy_.

7.2.1.2 RIPS Buffer Declaration Files

The RIPS Buffer Declaration File makes all global copies of data instantiated by the RTE Implementation Plug-In visible to the RTE.

[SWS_Rte_70000] DRAFT ⌈ The RIPS Buffer Declaration File shall have the name Rte_Rips_<PlugIn>_Buffers.h, where <PlugIn> is the name of the related RTE Implementation Plug-In defined by the container RteRipsPluginProps. ⌋*(SRS_Rte_00306)*

[SWS_Rte_70001] DRAFT ⌈ The RTE Implementation Plug-In shall create the RIPS Buffer Declaration File. ⌋*(SRS_Rte_00306)*

Note: Each participating RTE Implementation Plug-In creates a separate RIPS Buffer Declaration File.

[SWS_Rte_70002] DRAFT ⌈ The RIPS Buffer Declaration File shall include the RTE Data Handle Types Header File (Rte_DataHandleType.h). ⌋*(SRS_Rte_00306)*

[SWS_Rte_70003] DRAFT ⌈ The RIPS Buffer Declaration File shall export the declarations of the implicit communication buffers for the RIPS relevant data handled by this RTE Implementation Plug-In. ⌋*(SRS_Rte_00306, SRS_Rte_00301)*

[SWS_Rte_70004] DRAFT ⌈ The RIPS Buffer Declaration File shall export the type definitions of the implicit communication buffers for RIPS relevant data handled by this RTE Implementation Plug-In. ⌋*(SRS_Rte_00306, SRS_Rte_00301)*

7.2.1.3 RTE Implementation Plug-In Header File

[SWS_Rte_70005] DRAFT ⌈ The RTE Implementation Plug-In Header File shall have the name Rte_Rips_<PlugIn>.h, where <PlugIn> is the name of the related RTE Implementation Plug-In defined by the container RteRipsPluginProps. ⌋*(SRS_Rte_00306)*

[SWS_Rte_70006] DRAFT ⌈ The RTE Implementation Plug-In shall create the RTE Implementation Plug-In Header File. ⌋*(SRS_Rte_00306)*

Note: Each participating RTE Implementation Plug-In creates a separate RTE Implementation Plug-In Header File.

[SWS_Rte_70007] DRAFT ⌈ The RTE Implementation Plug-In Header File shall export the Rte_Rips_Enter and Rte_Rips_Exit Services related to ExclusiveAreas used as runsInsideExclusiveArea. ⌋*(SRS_Rte_00306, SRS_Rte_00302)*

[SWS_Rte_70098] DRAFT ⌈ The RTE Implementation Plug-In Header File shall export the Rte_Rips_EnterModeQueue and Rte_Rips_ExitModeQueue Services related to mode machine instances and distributed shared mode queues. ⌋*(SRS_Rte_00306, SRS_Rte_00310, SRS_Rte_00315)*

[SWS_Rte_70029] DRAFT ⌈ The RTE Implementation Plug-In Header File shall export the declarations of the lifecycle APIs of the RTE Implementation Plug-In. ⌋*(SRS_Rte_00306)*

Please note: The lifecycle APIs of RTE Implementation Plug-Ins are defined in section 7.2.4.11.

[SWS_Rte_70046] DRAFT ⌈ The RTE Implementation Plug-In Header File shall export the declarations of the Rte_Rips_FillFlushRoutines of the RTE Implementation Plug-In. ⌋*(SRS_Rte_00306, SRS_Rte_00301)*

[SWS_Rte_80026] DRAFT ⌈ The RTE shall include the RTE Implementation Plug-In Header File where it needs the contained definitions and declarations. ⌋*(SRS_Rte_00306)*

Note: Due to the relationship to the lifecycle API a reasonable include might be the Rte.h file as shown in 7.2.

7.2.1.4 RIPS SWC-BSW-Instance Header File

[SWS_Rte_70031] DRAFT ⌈ The RIPS SWC-BSW-Instance Header File shall be named Rte_Rips_<PlugIn>_<SwcBswI>.h, where <PlugIn> is the name of the related RTE Implementation Plug-In defined by the container RteRipsPluginProps and <SwcBswI> is the SWC-BSW-Instance name according to [SWS_Rte_70035] ⌋ *(SRS_Rte_00306)*

[SWS_Rte_70032] DRAFT ⌈ The RIPS SWC-BSW-Instance Header File shall be generated by the RTE Implementation Plug-In for each Software Component or BSW Module which either has

- an ExclusiveArea with enabled RTE Implementation Plug-In support mapped to this RTE Implementation Plug-In (see [SWS_Rte_80024]) OR
- an access to a Communication Graph with enabled RTE Implementation Plug-In support mapped to this RTE Implementation Plug-In OR
- an access to a mode machine instance with enabled RTE Implementation Plug-In support mapped to this RTE Implementation Plug-In OR
- an access to a mode machine instance belonging to a distributed shared mode queue with enabled RTE Implementation Plug-In support mapped to this RTE Implementation Plug-In.

⌋ *(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00301, SRS_Rte_00302, SRS_Rte_00310, SRS_Rte_00312, SRS_Rte_00315)*

[SWS_Rte_70033] DRAFT ⌈ The RIPS SWC-BSW-Instance Header File shall include the RTE Global Buffer Declaration File. ⌋ *(SRS_Rte_00306)*

[SWS_Rte_70039] DRAFT ⌈ The RIPS SWC-BSW-Instance Header File shall export the definitions of the

- Rte_Rips_Enter/Rte_Rips_Exit Services for ExclusiveAreas with a canEnterExclusiveArea association
- Rte_Rips_StartRead, Rte_Rips_StopRead, Rte_Rips_StartWrite, and Rte_Rips_StopWrite Services for explicit access protection
- Rte_Rips_Read and Rte_Rips_Write Services for explicit data accesses
- Rte_Rips_IRead, Rte_Rips_IWrite, Rte_Rips_IRBufferRef, and Rte_Rips_IWBufferRef Services for implicit accesses
- Rte_Rips_Invoke and Rte_Rips_ReturnResult for clients and trigger sources

handled by this RTE Implementation Plug-In for this component instance / *Basic Software Module instance*. ⌋*(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00301, SRS_Rte_00302, SRS_Rte_00310, SRS_Rte_00312, SRS_Rte_00315)*

7.2.1.5 RTE Implementation Plug-In Implementation File

[SWS_Rte_70008] DRAFT ⌈ The RTE Implementation Plug-In shall name the RTE Implementation Plug-In Implementation Files in a way that name collisions with file names of AUTOSAR Basic Software Modules and Software Components are avoided. ⌋*(SRS_Rte_00306)*

Please note that the file structure of the RTE Implementation Plug-In is not strictly standardized. Nevertheless [SWS_Rte_70009] defines a recommendation for the case the RTE Implementation Plug-In needs only one source file. For sure the given name pattern can also be extended to support more than one file, e.g. one source file per ASIL level.

[SWS_Rte_70009] DRAFT ⌈ If the RTE Implementation Plug-In uses a single source file, the RTE Implementation Plug-In Implementation File should have the name `Rte_Rips_<PlugIn>.c`, where `<PlugIn>` is the name of the related RTE Implementation Plug-In defined by the container RteRipsPluginProps. ⌋*(SRS_Rte_00306)*

[SWS_Rte_70010] DRAFT ⌈ The RTE Implementation Plug-In shall create the RTE Implementation Plug-In Implementation Files. ⌋*(SRS_Rte_00306)*

Note: Each participating RTE Implementation Plug-In creates a separate set of RTE Implementation Plug-In Implementation Files.

[SWS_Rte_70011] DRAFT ⌈ The RTE Implementation Plug-In Implementation Files shall include the RTE Global Buffer Declaration File. ⌋*(SRS_Rte_00306)*

[SWS_Rte_70012] DRAFT ⌈ The RTE Implementation Plug-In Implementation Files shall include the RTE Implementation Plug-In Header File. ⌋*(SRS_Rte_00306)*

[SWS_Rte_70013] DRAFT ⌈ The RTE Implementation Plug-In Implementation Files shall contain the definition of the implicit communication buffers for RIPS relevant data handled by this RIPS plug-in. ⌋*(SRS_Rte_00306, SRS_Rte_00301)*

The RIPS Implementation File shall contain the definition of the implicit communication buffers for RIPS relevant data handled by this RIPS plug-in, the implementation of the fill- and flush-Runnables and all further memory consuming C objects that might be necessary by the RIPS implementation of this plug-in.

7.2.1.6 RTE Header File

This subsection describes the additional requirements on the `RTE Header File` of the RTE when the `RTE Implementation Plug-In` mode is enabled.

[SWS_Rte_80008] DRAFT ⌈ The `RTE Header File` (`Rte.h`) shall include the `RTE Implementation Plug-In Header Files` of all participating `RTE Implementation Plug-Ins`. ⌋*(SRS_Rte_00306)*

7.2.1.7 Application Header File

This subsection describes the additional requirements on the `Application Header File` of the RTE when the `RTE Implementation Plug-In` mode is enabled.

[SWS_Rte_80027] DRAFT ⌈ The `Application Header File` of a Software Component shall include the `RIPS SWC-BSW-Instance Header File` of all `RTE Implementation Plug-Ins` applicable for this component instance, if they exist (refer to [SWS_Rte_70032]). ⌋*(SRS_Rte_00306)*

7.2.1.8 Module Interlink Header

This subsection describes the additional requirements on the `Module Interlink Header` of the Basic Software Scheduler when the `RTE Implementation Plug-In` mode is enabled.

[SWS_Rte_80028] DRAFT ⌈ The `Module Interlink Header` of a BSW Module shall include the `RIPS SWC-BSW-Instance Header File` of all `RTE Implementation Plug-Ins` applicable for this *Basic Software Module instance*, if they exist (refer to [SWS_Rte_70032]). ⌋*(SRS_Rte_00306)*

7.2.1.9 RTE Data Handle Types Header File

This subsection describes the additional requirements on the `RTE Data Handle Types Header File` of the RTE when the `RTE Implementation Plug-In` mode is enabled.

[SWS_Rte_80079] DRAFT ⌈ In case the RTE implements a `global copy` of some RIPS relevant `Data Communication Graphs` data the `RTE Data Handle Types Header File` shall contain a wrapper type definition for each `global copy`

```
typedef <type of global copy> Rte_Rips_GlobalCopy_<CGI>_Type;
```

where `<CGI>` is the name of the `Communication Graph` Instance defined by the `shortName` of the `RIPS FlatInstanceDescriptor` referencing the `Communication Graph`. ⌋*(SRS_Rte_00306, SRS_Rte_00301, SRS_Rte_00302)*

This wrapper type is intended for RTE Implementation Plug-Ins with type independent buffering strategy. In this case the buffering decisions are driven by the timing behavior and interference of readers and writers. For instance LET based buffering. In this case the RTE Implementation Plug-Ins can omit the gathering of types from the AUTOSAR model.

[SWS_Rte_80009] DRAFT ⌈ The RTE Data Handle Types Header File (Rte_DataHandleType.h) shall include the RTE Types Header File independent whether this is directly needed or not. ⌋*(SRS_Rte_00306)*

7.2.2 API principles

7.2.2.1 API name pattern

The RTE Implementation Plug-In Services are defined according to the following principles.

The RTE APIs towards the Software Components or Basic Software Modules are defined amongst the AUTOSAR Meta Model (e.g. providing an explicit write access to a specific data element in a specific port of a SwComponentType). In contrast the interface towards the RTE Implementation Plug-Ins is on one hand strictly use case oriented resp. instance based. Use case oriented means that for the same use case (e.g. starting the protection of an ExclusiveArea) which may exist in Software Components or Basic Software Modules the same kind of RTE Implementation Plug-In Service is defined and provided for use by the RTE code.

Instance based means that the name of a RTE Implementation Plug-In Service reflects the specific activity on a specific entity in the ECU SW implemented by a specific RTE Implementation Plug-In, e.g. determining the location in memory where data values from a communication graph can be read from for a specific RunnableEntity of a specific Software Component Instance.

Except for the lifecycle APIs any RTE Implementation Plug-In Service is defined according the following name scheme:

Rte_Rips_<PlugIn>_<useCase>_<SwcBswI>[_<ExE>]_<elementInstance>

[SWS_Rte_70034] DRAFT ⌈ <PlugIn> is the name of the related RTE Implementation Plug-In defined by the container RteRipsPluginProps. ⌋ *(SRS_Rte_00306)*

[SWS_Rte_70099] DRAFT ⌈ <useCase> is the name part which denotes the purpose of the RTE Implementation Plug-In Service and is one of the following:

- IRead
- IWrite
- IRBufferRef

- IWBufferRef
- StartRead
- StopRead
- StartWrite
- StopWrite
- Read
- Write
- Enter
- Exit
- EnterModeQueue
- ExitModeQueue
- Invoke
- ReturnResult

⌋*(SRS_Rte_00306)*

Further details are described in section 7.2.4.

[SWS_Rte_70035] DRAFT ⌈ <SwcBswI> SWC-BSW-Instance name is either the shortName of the SwComponentPrototype (in the RootSwComposition of the ECU Extract) or the BSW Module Instance Name according to [SWS_Rte_70036]. ⌋*(SRS_Rte_00306)*

[SWS_Rte_70036] DRAFT ⌈ The BSW Module Instance Name <bsnp>[_<vi>_<ai>] is composed out of <bsnp> is the BSW Scheduler Name Prefix according [SWS_Rte_07593] and [SWS_Rte_07594], <vi> is the vendorId of the accessing BSW module, <ai> is the vendorApiInfix of the accessing BSW module. ⌋*(SRS_Rte_00306)*

[SWS_Rte_70037] DRAFT ⌈ <ExE> is the shortName of the ExecutableEntity accessing an element instance. The name part <ExE> only exists in case the RTE offers the ability to distinguish the accesses of different ExecutableEntitys. ⌋*(SRS_Rte_00306)*

[SWS_Rte_70038] DRAFT ⌈ <elementInstance> identifies the element to which the access is provided. Since a specific use case is typically linked to a specific element, following specific element instance name parts will be used:

- <CGI> is the name of the Communication Graph Instance defined by the shortName of the RIPS FlatInstanceDescriptor referencing the Communication Graph.
- <ExclusiveArea> is the shortName of the ExclusiveArea.

- <MMI> is the shortName of the RteModeMachineInstanceConfig or RteBswModeMachineInstanceConfig container.
- <DSMQ> is the shortName of the RteDistributedSharedModeQueue or RteBswModeMachineInstanceConfig container.

⌋(*SRS_Rte_00306*)

7.2.2.2 Basic requirements on RTE Implementation Plug-In Service

The RTE Implementation Plug-In Services are intended to be used in the RTE's C-implementation. Hereby an important aspect is the fact that RTE APIs can be implemented as C-functions and function like macros, see section 5.2.6.3. In case of function like macros the RTE implementation uses very likely comma expressions to return either the error code or a read return value. This requires that an RTE Implementation Plug-In Service can be used in such a comma expression.

[SWS_Rte_70030] DRAFT ⌈ The RTE Implementation Plug-In shall implement every RTE Implementation Plug-In Service that it can be used in a comma expression. ⌋(*SRS_Rte_00306*)

7.2.2.3 Basic requirements on RTE Implementation

7.2.2.3.1 Macro API implementations

API implementations as function like macros can have strange side effects. A special case is the nested call of APIs, e.g. an Rte_DRead as a parameter of an Rte_Write. The user would naturally expect that the code of Rte_DRead is executed before entering into the Rte_Write API. But since macros are just text replacements, this is technically not the case. Instead, the Rte_DRead will be executed where the parameter is used inside the Rte_Write. This can lead to various effects, such as undesired nesting of (RTE or RTE Implementation Plug-Ins) protection code or multiple executions of Rte_DRead with differing results. This has to be avoided.

[SWS_Rte_80025] DRAFT ⌈ The RTE shall implement its code in a way to be robust against the undesired nesting of passed as macro parameter into the critical sections protected by the call of RTE Implementation Plug-In Services, e.g. Rte_Rips_StartRead, Rte_Rips_StopRead, Rte_Rips_StartWrite, and Rte_Rips_StopWrite. ⌋(*SRS_Rte_00306, SRS_Rte_00314*)

Note: This can be achieved by either using real functions, inline functions, or by assigning the macro argument to an temporary variable outside the critical section.

7.2.3 API Data Types

[SWS_Rte_70087] DRAFT ⌈ The RTE Implementation Plug-In shall determine the <return> type according to the ImplementationDataType applicable for the global copy. ⌋*(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00301)*

Please note, that <return> is only applicable for primitive types, e.g. uint8, float.

[SWS_Rte_70088] DRAFT ⌈ The RTE Implementation Plug-In shall determine the <rips_return_ref> type according to [SWS_Rte_80041]. Thereby the <rips_return_ref> type is a pointer to the *type of the global copy*. ⌋ *(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00301)*

In addition RTE Implementation Plug-In Services may use standard types or RTE specific types, e.g. Rte_TransformerError. Those are not impacted by the usage of an RTE Implementation Plug-In.

7.2.4 API Reference

7.2.4.1 Implicit buffer value access

7.2.4.1.1 Rte_Rips_IRead

Service name:	Rte_Rips_<PlugIn>_IRead_<SwcBswI>_<ExE>_<CGI>	
Syntax:	`<return> Rte_Rips_<PlugIn>_IRead_<SwcBswI>_<ExE>_<CGI>( void )`	
Service ID[hex]:	0xE0	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	None	
Parameters (inout):	None	
Parameters (out):	None	
Return value:	<return>	returns the value of the implicitly read primitive data.
Description:	Rte_Rips_IRead returns the value of the implicitly read primitive data.	
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h	

Table 7.1: Rte_Rips_IRead

[SWS_Rte_70015] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_IRead Service for each VariableAccess of a RunnableEntity in the role dataReadAccess and each VariableAccess in role readLocalVariable to an implicitInterRunnableVariable if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- where the data instance is typed by a primitive data type

  AND

- the data instance is a data element without status according to [SWS_Rte_80041]

  AND

- for the associated RTE Implementation Plug-In the RtePluginSupportsIReadIWrite is true.

⌋*(SRS_Rte_00306, SRS_Rte_00301)*

[SWS_Rte_80010] DRAFT ⌈ The RTE shall call Rte_Rips_IRead Service to implicitly read data if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- where the data instance is typed by a primitive data type

  AND

- the data instance is a data element without status according to [SWS_Rte_80041]

  AND

- for the associated RTE Implementation Plug-In the RtePluginSupportsIReadIWrite is true.

⌋*(SRS_Rte_00306, SRS_Rte_00301)*

7.2.4.1.2 Rte_Rips_IWrite

Service name:	Rte_Rips_<PlugIn>_IWrite_<SwcBswI>_<ExE>_<CGI>	

Syntax:	`void Rte_Rips_<PlugIn>_IWrite_<SwcBswI>_<ExE>_<CGI>(`
	`IN data`
	`)`	

Service ID[hex]:	0xE1	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	data	primitive data to write
Parameters (inout):	None	
Parameters (out):	None	
Return value:	None	
Description:	Rte_Rips_IWrite writes the value of the implicitly written primitive data.	
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h	

Table 7.2: Rte_Rips_IWrite

[SWS_Rte_70016] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_IWrite Service for each VariableAccess of a RunnableEntity in the role dataWriteAccess and each VariableAccess in role writtenLocalVariable to an implicitInterRunnableVariable if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- where the data instance is typed by a primitive data type

  AND

- the data instance is a data element without status according to [SWS_Rte_80041]

  AND

- for the associated RTE Implementation Plug-In the RtePluginSupportsIReadIWrite is true.

⌋*(SRS_Rte_00306, SRS_Rte_00301)*

[SWS_Rte_80011] DRAFT ⌈ The RTE shall call Rte_Rips_IWrite Service to implicitly write data if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- where the data instance is typed by a primitive data type

  AND

- the data instance is a data element without status according to [SWS_Rte_80041]

  AND

- for the associated RTE Implementation Plug-In the RtePluginSupportsIReadIWrite is true.

⌋*(SRS_Rte_00306, SRS_Rte_00301)*

7.2.4.2 Implicit buffer address access

7.2.4.2.1 Rte_Rips_IRBufferRef

Service name:	Rte_Rips_<PlugIn>_IRBufferRef_<SwcBswI>_<ExE>_<CGI>

Syntax:	`<rips_return_ref> Rte_Rips_<PlugIn>_IRBufferRef_<SwcBswI>_<ExE>_<CGI>( void )`	
Service ID[hex]:	0xE2	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	None	
Parameters (inout):	None	
Parameters (out):	None	
Return value:	<rips_return_ref>	Reference to the location in memory where the data values and optionally status can be read.
Description:	Rte_Rips_IRBufferRef returns a pointer to the location in memory where the data value and status can be read. In case the SWC is provided as source code and not multiple instantiable, this macro is not guaranteed to resolve to a reference at compile time. It might also be resolved to a function or expression.	
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h	

Table 7.3: Rte_Rips_IRBufferRef

[SWS_Rte_70017] DRAFT ⌈ The `associated RTE Implementation Plug-In` shall provide the `Rte_Rips_IRBufferRef` Service for each `VariableAccess` of a `RunnableEntity` in the role `dataReadAccess` and each `VariableAccess` in role `readLocalVariable` to an `implicitInterRunnableVariable` if for the related `Data Communication Graph` the `RTE Implementation Plug-In` support is enabled. ⌋*(SRS_Rte_00306, SRS_Rte_00301)*

[SWS_Rte_80012] DRAFT ⌈ The RTE shall call `Rte_Rips_IRBufferRef` Service to get the address of the memory from which the value and status of an implicitly read data instance can be read. Thereby `Rte_Rips_IRBufferRef` shall only be applied if the usage of `Rte_Rips_IRead` is not applicable. (See [SWS_Rte_80010]). ⌋*(SRS_Rte_00306, SRS_Rte_00301)*

[SWS_Rte_80013] DRAFT ⌈ The RTE shall initialize the related data handle for implicit read only access in the CDS with the `Rte_Rips_IRBufferRef` if the implicit data access needs to be implemented via a data handle in a `data handles section` or an `inter runnable variable handles section`. ⌋*(SRS_Rte_00306, SRS_Rte_00301)*

See also [SWS_Rte_70108].

Please note: A read only implicit access is required in case the `RunnableEntity` accesses an data element in an `RPortPrototype` or `PRPortPrototype` or the `RunnableEntity` has exclusive read access to an `implicitInterRunnableVariable`.

7.2.4.2.2 Rte_Rips_IWBufferRef

Service name:	Rte_Rips_<PlugIn>_IWBufferRef_<SwcBswI>_<ExE>_<CGI>	
Syntax:	`<rips_return_ref> Rte_Rips_<PlugIn>_IWBufferRef_<SwcBswI>_<ExE>_<CGI>( void )`	
Service ID[hex]:	0xE3	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	None	
Parameters (inout):	None	
Parameters (out):	None	
Return value:	<rips_return_ref>	Reference to the location in memory where the data values and optionally status can be written.
Description:	Rte_Rips_IWBufferRef returns a pointer to the implicitly written data element. In case the SWC is provided as source code and not multiple instantiable, this macro is not guaranteed to resolve to a reference at compile time. It might also be resolved to a function or expression.	
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h	

Table 7.4: Rte_Rips_IWBufferRef

[SWS_Rte_70018] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_IWBufferRef Service for each VariableAccess of a RunnableEntity in the role dataWriteAccess and each VariableAccess in role writtenLocalVariable to an implicitInterRunnableVariable if for the related Data Communication Graph the RTE Implementation Plug-In support is enabled. ⌋*(SRS_Rte_00306, SRS_Rte_00301)*

[SWS_Rte_80014] DRAFT ⌈ The RTE shall call Rte_Rips_IWBufferRef Service to get the address of the memory to which the value and status of an implicitly written data instance can be written. Thereby Rte_Rips_IWBufferRef shall only be applied if the usage of Rte_Rips_IWrite is not applicable. (See [SWS_Rte_80011]). ⌋ *(SRS_Rte_00306, SRS_Rte_00301)*

[SWS_Rte_80015] DRAFT ⌈ The RTE shall initialize the related data handle for implicit write or implicit read-write access in the CDS with the Rte_Rips_IWBufferRef if the implicit data access needs to be implemented via a data handle in a data handles section or an inter runnable variable handles section. ⌋ *(SRS_Rte_00306, SRS_Rte_00301)*

See also [SWS_Rte_70108].

Please note: A read-write implicit access is required in case the RunnableEntity accesses a data element in an PRPortPrototype or the RunnableEntity has read and write access to an implicitInterRunnableVariable. For read-write implicit access Rte_Rips_IWBufferRef Service applies as well.

7.2.4.3 Implict communication buffer Fill Flush Routines

7.2.4.3.1 Rte_Rips_FillFlushRoutine

Service name:	<name of the Fill-Flush-Routine>

Syntax:	`void <name of the Fill-Flush-Routine>(`
	`void`
	`)`

Service ID[hex]:	0xEF
Sync/Async:	Synchronous
Reentrancy:	Conditional Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Performs buffer fill and flush operations for implicit communication
Available via:	Rte_Rips_<PlugIn>.h

Table 7.5: Rte_Rips_FillFlushRoutine

[SWS_Rte_70078] DRAFT ⌈ The `associated RTE Implementation Plug-In` shall provide the `Rte_Rips_FillFlushRoutine` Service for each configured `RteRipsPluginFillFlushRoutineFnc`. ⌋*(SRS_Rte_00306, SRS_Rte_00301)*

Further details about the RTE usage of `Rte_Rips_FillFlushRoutine` are described in 7.3.4.7.1.

7.2.4.4 Explicit access protection

7.2.4.4.1 Rte_Rips_StartRead

Service name:	Rte_Rips_<PlugIn>_StartRead_<SwcBswI>[_<ExE>]_<CGI>

Syntax:	`void Rte_Rips_<PlugIn>_StartRead_<SwcBswI>[_<ExE>]_<C`
	`GI>(`
	`void`
	`)`

Service ID[hex]:	0xE4
Sync/Async:	Synchronous
Reentrancy:	Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_StartRead starts the protection for explicit read access.
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h

Table 7.6: Rte_Rips_StartRead

[SWS_Rte_70019] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_StartRead Service for each VariableDataPrototype instance in an AbstractRequiredPortPrototype for which an VariableAccess of a RunnableEntity in the role dataReceivePointByArgument or dataReceivePointByValue exists and

for each VariableAccess in role readLocalVariable to an explicitInterRunnableVariable if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_RTE.

⌋*(SRS_Rte_00306, SRS_Rte_00300)*

Please note: In case of protection of explicitInterRunnableVariables the name part [_<ExE>] exists.

[SWS_Rte_70020] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_StartRead Service for each BswVariableAccess of a BswModuleEntity in the role dataReceivePoint if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_RTE.

⌋*(SRS_Rte_00306, SRS_Rte_00300)*

[SWS_Rte_80016] DRAFT ⌈ The RTE shall call Rte_Rips_StartRead at the position and instead of the RTE's regular AUTOSAR get access protection action, e.g. SuspendOsInterrupts() or GetResource(), if for the related Data Communication Graph the RTE Implementation Plug-In support is enabled. ⌋*(SRS_Rte_00306, SRS_Rte_00300)*

7.2.4.4.2 Rte_Rips_StopRead

Service name:	Rte_Rips_<PlugIn>_StopRead_<SwcBswI>[_<ExE>]_<CGI>
Syntax:	void Rte_Rips_<PlugIn>_StopRead_<SwcBswI>[_<ExE>]_<CGI>(void)
Service ID[hex]:	0xE5
Sync/Async:	Synchronous

Reentrancy:	Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_StopRead stops the protection for explicit read access
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h

Table 7.7: Rte_Rips_StopRead

[SWS_Rte_70021] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_StopRead Service for each VariableDataPrototype instance in an AbstractRequiredPortPrototype for which an VariableAccess of a RunnableEntity in the role dataReceivePointByArgument or dataReceivePointByValue exists and

for each VariableAccess in role readLocalVariable to an explicitInterRunnableVariable if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_RTE.

⌋*(SRS_Rte_00306, SRS_Rte_00300)*

Please note: In case of protection of explicitInterRunnableVariables the name part [_<ExE>] exists.

[SWS_Rte_70022] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_StopRead Service for each BswVariableAccess of a BswModuleEntity in the role dataSendPoint if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_RTE.

⌋*(SRS_Rte_00306, SRS_Rte_00300)*

[SWS_Rte_80017] DRAFT ⌈ The RTE shall call Rte_Rips_StopRead at the position and instead of the RTE's regular AUTOSAR release access protection action, e.g. ResumeOsInterrupts() or ReleaseResource(), if for the related Data Communication Graph the RTE Implementation Plug-In support is enabled. ⌋*(SRS_Rte_00306, SRS_Rte_00300)*

7.2.4.4.3 Rte_Rips_StartWrite

Service name:	Rte_Rips_<PlugIn>_StartWrite_<SwcBswI>[_<ExE>]_<CGI>
Syntax:	`void Rte_Rips_<PlugIn>_StartWrite_<SwcBswI>[_<ExE>]_<CGI>( void )`
Service ID[hex]:	0xE6
Sync/Async:	Synchronous
Reentrancy:	Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_StartWrite starts the protection for explicit write access.
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h

Table 7.8: Rte_Rips_StartWrite

[SWS_Rte_70023] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_StartWrite Service for each VariableDataPrototype instance in an AbstractProvidedPortPrototype for which an VariableAccess of a RunnableEntity in the role dataSendPoint exists

and for each VariableAccess in role writtenLocalVariable to an explicitInterRunnableVariable if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_RTE.

⌋*(SRS_Rte_00306, SRS_Rte_00300)*

Please note: In case of protection of explicitInterRunnableVariables the name part [_<ExE>] exists.

[SWS_Rte_70024] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_StartWrite Service for each BswVariableAccess of a BswModuleEntity in the role dataSendPoint if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_RTE.

⌋*(SRS_Rte_00306, SRS_Rte_00300)*

[SWS_Rte_80018] DRAFT ⌈ The RTE shall call Rte_Rips_StartWrite at the position and instead of the RTE's regular AUTOSAR get access protection action, e.g. SuspendOsInterrupts() or GetResource(), if for the related Data Communication Graph the RTE Implementation Plug-In support is enabled. ⌋ *(SRS_Rte_00306, SRS_Rte_00300)*

7.2.4.4.4 Rte_Rips_StopWrite

Service name:	Rte_Rips_<PlugIn>_StopWrite_<SwcBswI>[_<ExE>]_<CGI>
Syntax:	`void Rte_Rips_<PlugIn>_StopWrite_<SwcBswI>[_<ExE>]_<CGI>( void )`
Service ID[hex]:	0xE7
Sync/Async:	Synchronous
Reentrancy:	Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_StopWrite stops the protection for explicit write access.
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h

Table 7.9: Rte_Rips_StopWrite

[SWS_Rte_70025] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_StopWrite Service for each VariableDataPrototype instance in an AbstractProvidedPortPrototype for which an VariableAccess of a RunnableEntity in the role dataSendPoint exists

and for each VariableAccess in role writtenLocalVariable to an explicitInterRunnableVariable if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_RTE.

⌋ *(SRS_Rte_00306, SRS_Rte_00300)*

Please note: In case of protection of explicitInterRunnableVariables the name part [_<ExE>] exists.

[SWS_Rte_70026] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_StopWrite Service for each BswVariableAccess of a BswModuleEntity in the role dataSendPoint if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_RTE.

⌋*(SRS_Rte_00306, SRS_Rte_00300)*

[SWS_Rte_80019] DRAFT ⌈ The RTE shall call Rte_Rips_StopWrite at the position and instead of the RTE's regular AUTOSAR release access protection action, e.g. ResumeOsInterrupts() or ReleaseResource(), if for the related Data Communication Graph the RTE Implementation Plug-In support is enabled. ⌋ *(SRS_Rte_00306, SRS_Rte_00300)*

7.2.4.5 Explicit data access services

7.2.4.5.1 Rte_Rips_Read

Service name:	Rte_Rips_<PlugIn>_Read_<SwcBswI>[_<ExE>]_<CGI>	

Syntax:	`Std_ReturnType Rte_Rips_<PlugIn>_Read_<SwcBswI>[_<ExE>]_<CGI>(`
	`OUT <data>,`
	`[Rte_TransformerError transformerError]`
	`)`	

Service ID[hex]:	0xEA	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	None	
Parameters (inout):	None	
Parameters (out):	<data>	The OUT parameter <data> pass back the received data.
	transformerError	The OUT parameter transformerError contains the transformer error which occurred during execution of the transformer chain.
Return value:	Std_ReturnType	The return value is used to indicate communication errors.
Description:	Rte_Rips_Read Performs an "explicit" read on a sender-receiver communication data element.	
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h	

Table 7.10: Rte_Rips_Read

[SWS_Rte_70050] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_Read Service for each VariableDataPrototype instance in an AbstractRequiredPortPrototype for which an VariableAccess of a RunnableEntity in the role dataReceivePointByArgument or dataReceivePointByValue exists and for each VariableAccess in role readLocalVariable to an explicitInterRunnableVariable if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

  – for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_PLUGIN

    OR

  – a data transformation is configured according [SWS_Rte_08794] or [SWS_Rte_08105].

⌋*(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00303)*

Please note: In case of protection of explicitInterRunnableVariables the name part [_<ExE>] exists.

[SWS_Rte_70051] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_Read Service for each BswVariableAccess of a BswModuleEntity in the role dataReceivePoint if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_PLUGIN.

⌋*(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00303)*

[SWS_Rte_70052] DRAFT ⌈ The optional OUT parameter transformerError of the Rte_Rips_Read service shall be generated according [SWS_Rte_08563]. ⌋*(SRS_Rte_00306, SRS_Rte_00300)*

The return value is used to indicate errors detected by the RTE Implementation Plug-In during execution of the Rte_Rips_Read service call or errors detected by the communication system.

- **[SWS_Rte_70053] DRAFT** ⌈ RTE_E_OK – data read successfully. ⌋*(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00094)*
- **[SWS_Rte_70054] DRAFT** ⌈ RTE_E_HARD_TRANSFORMER_ERROR – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋*(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00094, SRS_Rte_00091)*

- **[SWS_Rte_70055] DRAFT** ⌈ RTE_E_SOFT_TRANSFORMER_ERROR – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋*(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00094, SRS_Rte_00091)*

- **[SWS_Rte_70100] DRAFT** ⌈ RTE_E_NO_DATA – (explicit non-blocking read) no events were received and no other error occurred when the read was attempted. ⌋*(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00094)*

- **[SWS_Rte_70101] DRAFT** ⌈ RTE_E_LOST_DATA – Indicates that some incoming data has been lost due to an overflow of the receive queue or due to an error of the underlying communication layers. This is not an error of the data returned in the parameters. This Overlayed Error can be combined with any other error. ⌋*(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00107, SRS_Rte_00110, SRS_Rte_00094)*

[SWS_Rte_80065] DRAFT ⌈ The RTE shall call Rte_Rips_Read at the position and instead of the RTE's regular read access to the data, if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_PLUGIN.

⌋*(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00303)*

[SWS_Rte_80100] DRAFT ⌈ The RTE shall call Rte_Rips_Read at the position and instead of the RTE's regular access to the transformed data, if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- a data transformation is configured according [SWS_Rte_08794] or [SWS_Rte_08105].

⌋*(SRS_Rte_00306, SRS_Rte_00300)*

7.2.4.5.2 Rte_Rips_Write

Service name:	Rte_Rips_<PlugIn>_Write_<SwcBswI>[_<ExE>]_<CGI>

Syntax:	`Std_ReturnType Rte_Rips_<PlugIn>_Write_<SwcBswI>[_<ExE>]_<CGI>(`
	`IN <data>,`
	`[Rte_TransformerError transformerError]`
	`)`

Service ID[hex]:	0xEB	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	<data>	The IN parameter <data> pass the received data.
Parameters (inout):	None	
Parameters (out):	transformerError	The OUT parameter transformerError contains the transformer error which occurred during execution of the transformer chain.
Return value:	Std_ReturnType	The return value is used to indicate communication errors.
Description:	Rte_Rips_Write Performs an "explicit" write on a sender-receiver communication data element.	
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h	

Table 7.11: Rte_Rips_Write

[SWS_Rte_70056] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_Write Service for each VariableDataPrototype instance in an AbstractProvidedPortPrototype for which an VariableAccess of a RunnableEntity in the role dataSendPoint exists

and for each VariableAccess in role writtenLocalVariable to an explicitInterRunnableVariable if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

  - for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_PLUGIN.

    OR

  - a data transformation is configured according [SWS_Rte_08794] or [SWS_Rte_08105].

⌋*(SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00303)*

Please note: In case of protection of explicitInterRunnableVariables the name part [_<ExE>] exists.

[SWS_Rte_70057] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_Write Service for each BswVariableAccess of a BswModuleEntity in the role dataSendPoint if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_PLUGIN.

⌋(*SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00303*)

[SWS_Rte_70058] DRAFT ⌈ The optional OUT parameter transformerError of the Rte_Rips_Write service shall be generated according to [SWS_Rte_08574]. ⌋(*SRS_Rte_00306, SRS_Rte_00300*)

The return value is used to indicate errors detected by the RTE Implementation Plug-In during execution of the Rte_Rips_Write service call or errors detected by the communication system.

- **[SWS_Rte_70059] DRAFT** ⌈ RTE_E_OK – data written successfully. ⌋(*SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00094*)
- **[SWS_Rte_70060] DRAFT** ⌈ RTE_E_HARD_TRANSFORMER_ERROR – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋(*SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00094, SRS_Rte_00091*)
- **[SWS_Rte_70061] DRAFT** ⌈ RTE_E_SOFT_TRANSFORMER_ERROR – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋(*SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00094, SRS_Rte_00091*)
- **[SWS_Rte_70102] DRAFT** ⌈ RTE_E_LIMIT – an 'event' has been discarded due to a full queue by one of the ECU local receivers (intra ECU communication only). ⌋(*SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00143*)

[SWS_Rte_80066] DRAFT ⌈ The RTE shall call Rte_Rips_Write at the position and instead of the RTE's regular write access to the data, if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_PLUGIN.

⌋(*SRS_Rte_00306, SRS_Rte_00300, SRS_Rte_00303*)

[SWS_Rte_80101] DRAFT ⌈ The RTE shall call Rte_Rips_Write at the position and instead of the RTE's regular access to the data transformer, if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- a data transformation is configured according to [SWS_Rte_08794] or [SWS_Rte_08105].

⌋(*SRS_Rte_00306, SRS_Rte_00300*)

7.2.4.6 ExclusiveArea protection

7.2.4.6.1 Rte_Rips_Enter

Service name:	Rte_Rips_<PlugIn>_Enter_<SwcBswI>[_<Event>/_<ExE>]_<ExclusiveArea>
Syntax:	`void Rte_Rips_<PlugIn>_Enter_<SwcBswI>[_<Event>/_<ExE>]_<ExclusiveArea>( void )`
Service ID[hex]:	0xE8
Sync/Async:	Synchronous
Reentrancy:	Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_Enter starts the protection of an ExclusiveArea.
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h or Rte_Rips_<PlugIn>.h

Table 7.12: Rte_Rips_Enter

[SWS_Rte_70027] DRAFT ⌈ The `associated RTE Implementation Plug-In` shall provide the `Rte_Rips_Enter` Service for all following cases:

- for each `RTEEvent` with a `startOnEvent` to `RunnableEntity` with a `runsInsideExclusiveArea` association with the name parts `<SwcBswI>`, `<Event>`, and `<ExclusiveArea>`
- for each `BswEvent` with a `startsOnEvent` to `BswModuleEntity` with a `runsInsideExclusiveArea` association with the name parts `<SwcBswI>`, `<Event>`, and `<ExclusiveArea>`
- for each `ExecutableEntity` with a `canEnterExclusiveArea` association if the `ExclusiveArea`'s `SwcExclusiveAreaPolicy`/`BswExclusiveAreaPolicy.apiPrinciple` is set to `perExecutable` with the name parts `<SwcBswI>`, `<ExE>`, and `<ExclusiveArea>`
- for each `ExclusiveArea` referenced by a `canEnterExclusiveArea` association if the `ExclusiveArea`'s `SwcExclusiveAreaPolicy`/`BswExclusiveAreaPolicy.apiPrinciple` is set to `common` with the name parts `<SwcBswI>` and `<ExclusiveArea>`

if the `RTE Implementation Plug-In` support is enabled for the related `ExclusiveArea`. ⌋(*SRS_Rte_00302, SRS_Rte_00306, SRS_Rte_00304*)

[SWS_Rte_80020] DRAFT ⌈ The RTE shall call `Rte_Rips_Enter` at the position and instead of the RTE's regular `ExclusiveArea` implementation mechanism, if the `associated RTE Implementation Plug-In` support is enabled for the related `ExclusiveArea`. ⌋*(SRS_Rte_00302, SRS_Rte_00306, SRS_Rte_00304)*

For more details see section 7.3.5.

7.2.4.6.2 Rte_Rips_Exit

Service name:	Rte_Rips_<PlugIn>_Exit_<SwcBswI>[_<Event>/_<ExE>]_<Exclusive Area>
Syntax:	`void Rte_Rips_<PlugIn>_Exit_<SwcBswI>[_<Event>/_<ExE>]_<ExclusiveArea>( void )`
Service ID[hex]:	0xE9
Sync/Async:	Synchronous
Reentrancy:	Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_Exit stops the protection of an ExclusiveArea.
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h or Rte_Rips_<PlugIn>.h

Table 7.13: Rte_Rips_Exit

[SWS_Rte_70028] DRAFT ⌈ The `associated RTE Implementation Plug-In` shall provide the `Rte_Rips_Exit` Service for all following cases:

- for each `RTEEvent` with a `startOnEvent` to `RunnableEntity` with a `runsInsideExclusiveArea` association with the name parts `<SwcBswI>`, `<Event>`, and `<ExclusiveArea>`
- for each `BswEvent` with a `startsOnEvent` to `BswModuleEntity` with a `runsInsideExclusiveArea` association with the name parts `<SwcBswI>`, `<Event>`, and `<ExclusiveArea>`
- for each `ExecutableEntity` with a `canEnterExclusiveArea` association if the `ExclusiveArea`'s `SwcExclusiveAreaPolicy`/`BswExclusiveAreaPolicy.apiPrinciple` is set to `perExecutable` with the name parts `<SwcBswI>`, `<ExE>`, and `<ExclusiveArea>`
- for each `ExclusiveArea` referenced by a `canEnterExclusiveArea` association if the `ExclusiveArea`'s `SwcExclusiveAreaPolicy`/`BswExclusiveAreaPolicy.apiPrinciple` is set to `common` with the name parts `<SwcBswI>` and `<ExclusiveArea>`

⌋*(SRS_Rte_00302, SRS_Rte_00306, SRS_Rte_00304)*

[SWS_Rte_80021] DRAFT ⌈ The RTE shall call Rte_Rips_Exit at the position and instead of the RTE's regular ExclusiveArea implementation mechanism, if the associated RTE Implementation Plug-In support is enabled for the related ExclusiveArea. ⌋*(SRS_Rte_00302, SRS_Rte_00306, SRS_Rte_00304)*

For more details see section 7.3.5.

7.2.4.7 Mode queue protection functions

7.2.4.7.1 Rte_Rips_EnterModeQueue

Service name:	Rte_Rips_<PlugIn>_EnterModeQueue_<MMI/DSMQ>
Syntax:	`void Rte_Rips_<PlugIn>_EnterModeQueue_<MMI/DSMQ>( void )`
Service ID[hex]:	0xF4
Sync/Async:	Synchronous
Reentrancy:	Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_EnterModeQueue starts the protection for enqueue, dequeue, and read operations in a mode machine instance or distributed shared mode queue.
Available via:	Rte_Rips_<PlugIn>.h

Table 7.14: Rte_Rips_EnterModeQueue

[SWS_Rte_70096] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_EnterModeQueue Service if the RTE Implementation Plug-In support is enabled for the related mode machine instance or distributed shared mode queue . ⌋*(SRS_Rte_00315)*

[SWS_Rte_80080] DRAFT ⌈ The RTE shall call Rte_Rips_EnterModeQueue at the position and instead of the RTE's regular AUTOSAR get access protection action for the mode queue, e.g. SuspendOsInterrupts() or GetResource(), if for the related mode machine instance or distributed shared mode queue the RTE Implementation Plug-In support is enabled. ⌋*(SRS_Rte_00315)*

7.2.4.7.2 Rte_Rips_ExitModeQueue

Service name:	Rte_Rips_<PlugIn>_ExitModeQueue_<MMI/DSMQ>
Syntax:	`void Rte_Rips_<PlugIn>_ExitModeQueue_<MMI/DSMQ>( void )`
Service ID[hex]:	0xF5
Sync/Async:	Synchronous

Reentrancy:	Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_ExitModeQueue stops the protection for enqueue, dequeue, and read operations in a mode machine instance or distributed shared mode queue.
Available via:	Rte_Rips_<PlugIn>.h

Table 7.15: Rte_Rips_ExitModeQueue

[SWS_Rte_70097] DRAFT ⌈ The `associated RTE Implementation Plug-In` shall provide the `Rte_Rips_ExitModeQueue` Service if the `RTE Implementation Plug-In` support is enabled for the related `mode machine instance` or `distributed shared mode queue` . ⌋ *(SRS_Rte_00315)*

[SWS_Rte_80081] DRAFT ⌈ The RTE shall call `Rte_Rips_ExitModeQueue` at the position and instead of the RTE's regular AUTOSAR release access protection action, e.g. `ResumeOsInterrupts()` or `ReleaseResource()`, if for the related `mode machine instance` or `distributed shared mode queue` the `RTE Implementation Plug-In` support is enabled. ⌋ *(SRS_Rte_00315)*

7.2.4.8 Distributed Shared Mode Queue schedule synchronization functions

[SWS_Rte_91102] ⌈

Name:	`Rte_DsmqStatusType`		
Type:	`uint8`		
Range:	`RTE_DSMQ_ENQUEUED_FIRST`	`0x01`	mode switch notification is enqueued into an empty distributed shared mode queue
	`RTE_DSMQ_ENQUEUED_NOT_FIRST`	`0x02`	mode switch notification is enqueued into a non empty distributed shared mode queue
	`RTE_DSMQ_ENQUEUE_FAILED`	`0x03`	enqueue operation into a non empty distributed shared mode queue failed
	`RTE_DSMQ_DEQUEUED_LAST`	`0x04`	last mode switch notification was enqueued from distributed shared mode queue
	`RTE_DSMQ_DEQUEUED_NOT_LAST`	`0x05`	mode switch notification was enqueued from distributed shared mode queue, further mode switch notifications are in the queue
Description:	Status of the enqueue operation on a distributed shared mode queue		
Available via:	Rte_Type.h		

Table 7.16: Rte_DsmqStatusType

⌋()

[SWS_Rte_80085] DRAFT ⌈ The RTE shall define the Rte_DsmqStatusType and the belonging literals in the Rte_Type.h file. ⌋*(SRS_Rte_00315)*

7.2.4.8.1 Rte_Rips_DsmqSwitch

Service name:	Rte_Rips_<PlugIn>_DsmqSwitch_<BswSwcI>_<MMI>	
Syntax:	`void Rte_Rips_<PlugIn>_DsmqSwitch_<BswSwcI>_<MMI>( Rte_DsmqStatusType dsmqstatus, uint32 previousmode, uint32 nextmode )`	
Service ID[hex]:	0xF6	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	dsmqstatus	Status of the enqueue operation
	previousmode	The value of the ModeDeclaration of the mode being left
	nextmode	The value of the ModeDeclaration of the mode being entered
Parameters (inout):	None	
Parameters (out):	None	
Return value:	None	
Description:	Rte_Rips_DsmqSwitch notifies the RTE Implementation Plug-In about an enqueue operation in a distributed shared mode queue.	
Available via:	Rte_Rips_<PlugIn>.h	

Table 7.17: Rte_Rips_DsmqSwitch

[SWS_Rte_70103] DRAFT ⌈ The RTE Implementation Plug-In assigned to the distributed shared mode queue shall provide the Rte_Rips_DsmqSwitch Service for each mode machine instance belonging to this distributed shared mode queue. ⌋*(SRS_Rte_00315)*

7.2.4.8.2 Rte_Rips_DsmqTransitionStart

Service name:	Rte_Rips_<PlugIn>_DsmqTransitionStart_<BswSwcI>_<MMI>	
Syntax:	`void Rte_Rips_<PlugIn>_DsmqTransitionStart_<BswSwcI>_<MMI>( uint32 previousmode, uint32 nextmode )`	
Service ID[hex]:	0xF7	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	previousmode	The value of the ModeDeclaration of the mode being left

	nextmode	The value of the ModeDeclaration of the mode being entered
Parameters (inout):	None	
Parameters (out):	None	
Return value:	None	
Description:	Rte_Rips_DsmqTransitionStart notifies the RTE Implementation Plug-In about the start of a specific mode transition in a DSMQ transition OsTask	
Available via:	Rte_Rips_<PlugIn>.h	

Table 7.18: Rte_Rips_DsmqTransitionStart

[SWS_Rte_70104] **DRAFT** ⌈ The `RTE Implementation Plug-In` assigned to the `distributed shared mode queue` shall provide the `Rte_Rips_DsmqTransitionStart` Service for each `mode machine instance` belonging to this `distributed shared mode queue`. ⌋*(SRS_Rte_00315)*

7.2.4.8.3 Rte_Rips_DsmqTransitionSync

Service name:	Rte_Rips_<PlugIn>_DsmqTransitionSync_<DsmqOsTask>	
Syntax:	`boolean Rte_Rips_<PlugIn>_DsmqTransitionSync_<DsmqOsTask>( void )`	
Service ID[hex]:	0xF8	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	None	
Parameters (inout):	None	
Parameters (out):	None	
Return value:	boolean	The return value is used to release the dequeue operation on the distributed shared mode queue
Description:	DsmqTransitionSync synchronizes (when necessary) the end of mode transition in the DSMQ transition OsTask and releases the dequeue operation on the distributed shared mode queue for the last DSMQ transition OsTask which quits this synchronization point.	
Available via:	Rte_Rips_<PlugIn>.h	

Table 7.19: Rte_Rips_DsmqTransitionSync

[SWS_Rte_70105] **DRAFT** ⌈ The `RTE Implementation Plug-In` assigned to the `distributed shared mode queue` shall provide the `Rte_Rips_DsmqTransitionSync` Service for each DSMQ transition `OsTask` belonging to this `distributed shared mode queue`. ⌋*(SRS_Rte_00315)*

7.2.4.8.4 Rte_Rips_DsmqTransitionEnd

Service name:	Rte_Rips_<PlugIn>_DsmqTransitionEnd_<BswSwcI>_<MMI>

Syntax:	void Rte_Rips_<PlugIn>_DsmqTransitionEnd_<BswSwcI>_<MMI>(Rte_DsmqStatusType dsmqstatus, uint32 previousmode, uint32 nextmode)	
Service ID[hex]:	0xF9	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	dsmqstatus	Status of the enqueue operation
	previousmode	The value of the ModeDeclaration of the mode being left
	nextmode	The value of the ModeDeclaration of the mode being entered
Parameters (inout):	None	
Parameters (out):	None	
Return value:	None	
Description:	Rte_Rips_DsmqTransitionEnd notifies the RTE Implementation Plug-In about the end of a specific mode transition in a DSMQ transition OsTask	
Available via:	Rte_Rips_<PlugIn>.h	

Table 7.20: Rte_Rips_DsmqTransitionEnd

[SWS_Rte_70106] **DRAFT** ⌈ The RTE Implementation Plug-In assigned to the distributed shared mode queue shall provide the Rte_Rips_DsmqTransitionEnd Service for each mode machine instance belonging to this distributed shared mode queue. ⌋*(SRS_Rte_00315)*

7.2.4.9 Invocation functions for Transformers

7.2.4.9.1 Rte_Rips_Invoke

Service name:	Rte_Rips_<PlugIn>_Invoke_<SwcBswI>_<CGI>	
Syntax:	Std_ReturnType Rte_Rips_<PlugIn>_Invoke_<SwcBswI>_<CGI>([IN|IN/OUT|OUT] <data_1>, [IN|IN/OUT|OUT] ..., [IN|IN/OUT|OUT] <data_n>, [Rte_TransformerError transformerError])	
Service ID[hex]:	0xEC	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	<data_1>	The Rte_Rips_Invoke API includes zero or more IN, IN/OUT and OUT parameters according SWS_Rte_01102 and none in case of triggers
Parameters (inout):	...	The Rte_Rips_Invoke API includes zero or more IN, IN/OUT and OUT parameters according SWS_Rte_01102 and none in case of triggers

Parameters (out):	<data_n> transformerError	The Rte_Rips_Invoke API includes zero or more IN, IN/OUT and OUT parameters according SWS_Rte_01102 and none in case of triggers The OUT parameter transformerError contains the transformer error which occurred during execution of the transformer chain.
Return value:	Std_ReturnType	The return value is used to indicate communication errors.
Description:	Rte_Rips_Invoke Performs a transformer invocation for clients or trigger sources.	
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h	

Table 7.21: Rte_Rips_Invoke

[SWS_Rte_70062] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_Invoke Service for each operation instance in an AbstractRequiredPortPrototype of a Atomic Software Component if

- for the related Client Server Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- a transformation is configured according [SWS_Rte_08794] or [SWS_Rte_08105].

⌋*(SRS_Rte_00306, SRS_Rte_00304, SRS_Rte_00312)*

[SWS_Rte_70063] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_Invoke Service for each trigger instance in an AbstractProvidedPortPrototype of a Atomic Software Component if

- for the related Trigger Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- a transformation is configured according to [SWS_Rte_08794] or [SWS_Rte_08105].

⌋*(SRS_Rte_00306, SRS_Rte_00304, SRS_Rte_00312)*

[SWS_Rte_70064] DRAFT ⌈ The optional OUT parameter transformerError of the Rte_Rips_Invoke service shall be generated according to [SWS_Rte_08566]. ⌋*(SRS_Rte_00306, SRS_Rte_00312)*

The return value is used to indicate errors detected by the RTE Implementation Plug-In during execution of the Rte_Rips_Invoke service call or errors detected by the communication system.

- **[SWS_Rte_70065] DRAFT** ⌈ RTE_E_OK – The API call completed successfully and the invoked server did not return an error. ⌋*(SRS_Rte_00094)*

- **[SWS_Rte_70066] DRAFT** ⌈ `RTE_E_TRANSFORMER_LIMIT` – The RTE Implementation Plug-In is not able to allocate the buffer needed to transform the data. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_70067] DRAFT** ⌈ `RTE_E_HARD_TRANSFORMER_ERROR` – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_70068] DRAFT** ⌈ `RTE_E_SOFT_TRANSFORMER_ERROR` – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_70069] DRAFT** ⌈ `RTE_E_COM_STOPPED` – the RTE Implementation Plug-In could not perform the operation because the communication service is currently not available. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*

[SWS_Rte_80071] DRAFT ⌈ The RTE shall call `Rte_Rips_Invoke` at the position and instead of the RTE's regular transformer invocation, if for the related Client Server Communication Graph or Trigger Communication Graph the RTE Implementation Plug-In support is enabled. ⌋*(SRS_Rte_00306, SRS_Rte_00304, SRS_Rte_00312)*

7.2.4.9.2 Rte_Rips_ReturnResult

Service name:	Rte_Rips_<PlugIn>_ReturnResult_<SwcBswI>_<CGI>	

Syntax:	`Std_ReturnType Rte_Rips_<PlugIn>_ReturnResult_<SwcBswI>_<CGI>(`
	`[IN/OUT|OUT] <param_1>,`
	`[IN/OUT|OUT] <param_n>,`
	`[Rte_TransformerError transformerError]`
	`)`	

Service ID[hex]:	0xED	
Sync/Async:	Synchronous	
Reentrancy:	Reentrant	
Parameters (in):	None	
Parameters (inout):	<param_1>	The Rte_Rips_ReturnResult API includes zero or more IN/OUT and OUT parameters according SWS_Rte_01111.
Parameters (out):	<param_n> transformerError	The Rte_Rips_ReturnResult API includes zero or more IN/OUT and OUT parameters according SWS_Rte_01111. The OUT parameter transformerError contains the transformer error which occurred during execution of the transformer chain.
Return value:	Std_ReturnType	The return value is used to indicate communication errors
Description:	Rte_Rips_ReturnResult Performs a transformer invocation for clients to get the server results.	
Available via:	Rte_Rips_<PlugIn>_<SwcBswI>.h	

Table 7.22: Rte_Rips_ReturnResult

[SWS_Rte_70070] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_ReturnResult Service for each operation instance in an AbstractRequiredPortPrototype of a Atomic Software Component if

- for the related Client Server Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- a transformation is configured according to [SWS_Rte_08794] or [SWS_Rte_08105].

⌋*(SRS_Rte_00306, SRS_Rte_00304, SRS_Rte_00312)*

[SWS_Rte_70071] DRAFT ⌈ The optional OUT parameter transformerError of the Rte_Rips_ReturnResult service shall be generated according to [SWS_Rte_08567]. ⌋*(SRS_Rte_00306, SRS_Rte_00304, SRS_Rte_00312)*

The return value is used to indicate errors detected by the RTE Implementation Plug-In during execution of the Rte_Rips_ReturnResult service call or errors detected by the communication system:

- **[SWS_Rte_70072] DRAFT** ⌈ RTE_E_OK – The API call completed successfully and the invoked server did not return an error. ⌋*(SRS_Rte_00094)*
- **[SWS_Rte_70073] DRAFT** ⌈ RTE_E_TRANSFORMER_LIMIT – The RTE Implementation Plug-In is not able to allocate the buffer needed to transform the data. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_70074] DRAFT** ⌈ RTE_E_HARD_TRANSFORMER_ERROR – The return value of one transformer in the transformer chain represented a hard transformer error. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_70075] DRAFT** ⌈ RTE_E_SOFT_TRANSFORMER_ERROR – The return value of at least one transformer in the transformer chain was a soft error and no hard error occurred in the transformer chain. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*
- **[SWS_Rte_70076] DRAFT** ⌈ RTE_E_COM_STOPPED – the RTE Implementation Plug-In could not perform the operation because the communication service is currently not available. ⌋*(SRS_Rte_00094, SRS_Rte_00091)*

[SWS_Rte_80072] DRAFT ⌈ The RTE shall call Rte_Rips_ReturnResult at the position and instead of the RTE's regular transformer invocation for transformation of the server results, if for the related Client Server Communication Graph the RTE Implementation Plug-In support is enabled. ⌋*(SRS_Rte_00306, SRS_Rte_00304, SRS_Rte_00312)*

7.2.4.9.3 Rte_Rips_InvocationHandler

Service name:	<name of the Invocation Handler>
Syntax:	`void <name of the Invocation Handler>( void )`
Service ID[hex]:	0xEE
Sync/Async:	Synchronous
Reentrancy:	Conditional Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Performs invocation of server runnables and triggered runnables via a transformer.
Available via:	Rte_Rips_<PlugIn>.h

Table 7.23: Rte_Rips_InvocationHandler

[SWS_Rte_70077] DRAFT ⌈ The `associated RTE Implementation Plug-In` shall provide the `Rte_Rips_InvocationHandler` Service for each configured `RteRipsInvocationHandlerFnc`. ⌋*(SRS_Rte_00306, SRS_Rte_00304, SRS_Rte_00312)*

Further details about the RTE usage of `Rte_Rips_InvocationHandler` are described in 7.3.8.4.

7.2.4.10 Signal notifications for transformer

7.2.4.10.1 Rte_Rips_NotifyRxAck

Service name:	Rte_Rips_<PlugIn>_NotifyRxAck_<CGI>
Syntax:	`void Rte_Rips_<PlugIn>_NotifyRxAck_<CGI>( void )`
Service ID[hex]:	0xFA
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_NotifyRxAck notifies the RTE Implementation Plug-In that the signal used for the Data Communication Graph requiring transformation is ready for reception
Available via:	Rte_Rips_<PlugIn>.h

Table 7.24: Rte_Rips_NotifyRxAck

[SWS_Rte_70110] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_NotifyRxAck Service for each

- dataElement instance in an AbstractRequiredPortPrototype of a Atomic Software Component
- operation instance in an PortPrototype of a Atomic Software Component
- trigger instance in an AbstractRequiredPortPrototype of a Atomic Software Component

if

- for the related Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- a transformation is configured according [SWS_Rte_08794].

⌋*(SRS_Rte_00300, SRS_Rte_00312, SRS_Rte_00317)*

[SWS_Rte_80106] DRAFT ⌈ The RTE Generator shall call all Rte_Rips_NotifyRxAck Services from the Rte_COMCbk_<sn> or Rte_COMCbk_<sg> callback respectively for Communication Graphs where

- Rx signals are configured

  AND

- for the related Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- a transformation is configured according to [SWS_Rte_08794].

⌋*(SRS_Rte_00312)*

7.2.4.10.2 Rte_Rips_NotifyRxTOut

Service name:	Rte_Rips_<PlugIn>_NotifyRxTOut_<CGI>
Syntax:	`void Rte_Rips_<PlugIn>_NotifyRxTOut_<CGI>( void )`
Service ID[hex]:	0xFB
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None

Description:	Rte_Rips_NotifyRxTOut notifies the RTE Implementation Plug-In that for the signal used for the Data Communication Graph requiring transformation the aliveTimeout has expired.
Available via:	Rte_Rips_<PlugIn>.h

Table 7.25: Rte_Rips_NotifyRxTOut

[SWS_Rte_70111] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_NotifyRxTOut Service for each

- dataElement instance in an AbstractRequiredPortPrototype of a Atomic Software Component
- operation instance in an PortPrototype of a Atomic Software Component
- trigger instance in an AbstractRequiredPortPrototype of a Atomic Software Component

if

- for the related Communication Graph the RTE Implementation Plug-In support is enabled

  AND
- a transformation is configured according to [SWS_Rte_08794].

⌋*(SRS_Rte_00300, SRS_Rte_00312, SRS_Rte_00317)*

[SWS_Rte_80107] DRAFT ⌈ The RTE Generator shall call all Rte_Rips_NotifyRxTOut Services from the Rte_COMCbkRxTOut_<sn> or Rte_COMCbkRxTOut_<sg> callback respectively for Communication Graphs where

- Rx signals are configured

  AND
- for the related Communication Graph the RTE Implementation Plug-In support is enabled

  AND
- a transformation is configured according to [SWS_Rte_08794].

⌋*(SRS_Rte_00312)*

7.2.4.10.3 Rte_Rips_NotifyTxAck

Service name:	Rte_Rips_<PlugIn>_NotifyTxAck_<CGI>

Syntax:	`void Rte_Rips_<PlugIn>_NotifyTxAck_<CGI>( void )`
Service ID[hex]:	0xFC
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_NotifyTxAck notifies the Rte Implementation Plug-In that the signal used for the Data Communication Graph requiring transformation is already handed to the PDU router.
Available via:	Rte_Rips_<PlugIn>.h

Table 7.26: Rte_Rips_NotifyTxAck

[SWS_Rte_70112] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_NotifyTxAck Service for each

- dataElement instance in an AbstractProvidedPortPrototype of a Atomic Software Component
- operation instance in an PortPrototype of a Atomic Software Component
- trigger instance in an AbstractProvidedPortPrototype of a Atomic Software Component

if

- for the related Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- a transformation is configured according to [SWS_Rte_08794].

⌋*(SRS_Rte_00300, SRS_Rte_00312, SRS_Rte_00317)*

[SWS_Rte_80108] DRAFT ⌈ The RTE Generator shall call all Rte_Rips_NotifyTxAck Services from the Rte_COMCbkTAck_<sn> or Rte_COMCbkTAck_<sg> callback respectively for Communication Graphs where

- Tx signals are configured

  AND

- for the related Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- a transformation is configured according to [SWS_Rte_08794].

⌋(*SRS_Rte_00312*)

7.2.4.10.4 Rte_Rips_NotifyTxErr

Service name:	Rte_Rips_<PlugIn>_NotifyTxErr_<CGI>

Syntax:	`void Rte_Rips_<PlugIn>_NotifyTxErr_<CGI>(`
	`void`
	`)`

Service ID[hex]:	0xFD
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_NotifyTxErr notifies the RTE Implementation Plug-In that for the signal used for the Data Communication Graph requiring transformation an error occurred when the signal was handed over to the PDU router.
Available via:	Rte_Rips_<PlugIn>.h

Table 7.27: Rte_Rips_NotifyTxErr

[SWS_Rte_70113] DRAFT ⌈ The `associated RTE Implementation Plug-In` shall provide the `Rte_Rips_NotifyTxErr` Service for each

- `dataElement` instance in an `AbstractProvidedPortPrototype` of a `Atomic Software Component`
- `operation` instance in an `PortPrototype` of a `Atomic Software Component`
- `trigger` instance in an `AbstractProvidedPortPrototype` of a `Atomic Software Component`

if

- for the related `Communication Graph` the `RTE Implementation Plug-In` support is enabled

  AND

- a transformation is configured according to [SWS_Rte_08794].

⌋(*SRS_Rte_00300, SRS_Rte_00312, SRS_Rte_00317*)

[SWS_Rte_80109] DRAFT ⌈ The RTE Generator shall call all `Rte_Rips_NotifyTxErr` Services from the `Rte_COMCbkTErr_<sn>` or `Rte_COMCbkTErr_<sg>` callback respectively for `Communication Graph`s where

- Tx signals are configured

  AND

- for the related Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- a transformation is configured according to [SWS_Rte_08794].

⌋(*SRS_Rte_00312*)

7.2.4.10.5 Rte_Rips_NotifyTxTOut

Service name:	Rte_Rips_<PlugIn>_NotifyTxTOut_<CGI>

Syntax:	`void Rte_Rips_<PlugIn>_NotifyTxTOut_<CGI>(`
	`void`
	`)`

Service ID[hex]:	0xFE
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_NotifyTxTOut notifies the RTE Implementation Plug-In that for signal used for the Data Communication Graph requiring transformation the timeout of TransmissionAcknowledgementRequest for sending the signal has expired.
Available via:	Rte_Rips_<PlugIn>.h

Table 7.28: Rte_Rips_NotifyTxTOut

[SWS_Rte_70114] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_NotifyTxTOut Service for each

- dataElement instance in an AbstractProvidedPortPrototype of a Atomic Software Component
- operation instance in an PortPrototype of a Atomic Software Component
- trigger instance in an AbstractProvidedPortPrototype of a Atomic Software Component

if

- for the related Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- a transformation is configured according to [SWS_Rte_08794].

⌋*(SRS_Rte_00300, SRS_Rte_00312, SRS_Rte_00317)*

[SWS_Rte_80110] DRAFT ⌈ The RTE Generator shall call all Rte_Rips_NotifyTxTOut Services from the Rte_COMCbkTOut_<sn> or Rte_COMCbkTOut_<sg> callback respectively for Communication Graphs where

- Tx signals are configured

  AND

- for the related Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- a transformation is configured according to [SWS_Rte_08794].

⌋*(SRS_Rte_00312)*

7.2.4.11 RTE Implementation Plug-In Lifecycle API

RTE Implementation Plug-Ins might need initialization in the same way the RTE might need it. Consequently, there will be init/deinit and start/stop APIs, which the RTE has to call. As the RTE's lifecycle APIs will be called on every core, also the RTE Implementation Plug-In's lifecycle APIs will do so.

[SWS_Rte_70047] DRAFT ⌈ The RTE Implementation Plug-In shall always provide the Lifecycle APIs Rte_Rips_SchM_Init, Rte_Rips_Rte_Start, Rte_Rips_Rte_Stop, and Rte_Rips_SchM_Deinit. ⌋*(SRS_BSW_00101, SRS_BSW_00336, SRS_Rte_00306, SRS_Rte_00304)*

[SWS_Rte_80055] DRAFT ⌈ The RTE shall call the Lifecycle APIs of all participating RTE Implementation Plug-Ins in the order given by index of the RteRipsPluginConfigurationRefs. ⌋*(SRS_BSW_00101, SRS_BSW_00336, SRS_Rte_00306, SRS_Rte_00304)*

7.2.4.11.1 Rte_Rips_SchM_Init

Service name:	Rte_Rips_<PlugIn>_SchM_Init

Syntax:	`void Rte_Rips_<PlugIn>_SchM_Init(`
	`void`
	`)`

Service ID[hex]:	0xF0
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None

Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_SchM_Init initializes those RTE Implementation Plug-In parts which are relevant for the SchM related operations.
Available via:	Rte_Rips_<PlugIn>.h

Table 7.29: Rte_Rips_SchM_Init

[SWS_Rte_80051] DRAFT ⌈ The RTE shall call the init functions `Rte_Rips_SchM_Init` of all participating `RTE Implementation Plug-Ins` in `SchM_Init`. ⌋*(SRS_BSW_00101, SRS_Rte_00306, SRS_Rte_00304)*

7.2.4.11.2 Rte_Rips_Rte_Start

Service name:	Rte_Rips_<PlugIn>_Rte_Start

Syntax:	`void Rte_Rips_<PlugIn>_Rte_Start(`
	`void`
	`)`

Service ID[hex]:	0xF1
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_Rte_Start initializes those RTE Implementation Plug-In parts which are relevant for the RTE related operation.
Available via:	Rte_Rips_<PlugIn>.h

Table 7.30: Rte_Rips_Rte_Start

[SWS_Rte_80052] DRAFT ⌈ The RTE shall call the init functions `Rte_Rips_Rte_Start` of all participating `RTE Implementation Plug-Ins` in `Rte_Start`, after the variable initializations have been performed, but before the execution of any `RunnableEntity` (e.g. `on-entry ExecutableEntitys`). ⌋*(SRS_BSW_00101, SRS_Rte_00306, SRS_Rte_00304)*

7.2.4.11.3 Rte_Rips_Rte_Stop

Service name:	Rte_Rips_<PlugIn>_Rte_Stop

Syntax:	`void Rte_Rips_<PlugIn>_Rte_Stop(`
	`void`
	`)`

Service ID[hex]:	0xF2
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant

Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_Rte_Stop deinitializes those RTE Implementation Plug-In parts which are relevant for the RTE related operation.
Available via:	Rte_Rips_<PlugIn>.h

Table 7.31: Rte_Rips_Rte_Stop

[SWS_Rte_80053] **DRAFT** ⌈ The RTE shall call the stop functions `Rte_Rips_Rte_Stop` of all participating `RTE Implementation Plug-Ins` in `Rte_Stop`. ⌋*(SRS_BSW_00336, SRS_Rte_00306, SRS_Rte_00304)*

7.2.4.11.4 Rte_Rips_SchM_Deinit

Service name:	Rte_Rips_SchM_Deinit

Syntax:	`void Rte_Rips_SchM_Deinit(`
	`void`
	`)`

Service ID[hex]:	0xF3
Sync/Async:	Synchronous
Reentrancy:	Non Reentrant
Parameters (in):	None
Parameters (inout):	None
Parameters (out):	None
Return value:	None
Description:	Rte_Rips_SchM_Deinit deinitializes those RTE Implementation Plug-In parts which are relevant for the SchM related operations.
Available via:	Rte_Rips_<PlugIn>.h

Table 7.32: Rte_Rips_SchM_Deinit

[SWS_Rte_80054] **DRAFT** ⌈ The RTE shall call the deinit functions `Rte_Rips_SchM_Deinit` of all participating `RTE Implementation Plug-Ins` in `SchM_Deinit`. ⌋*(SRS_BSW_00336, SRS_Rte_00306, SRS_Rte_00304)*

7.3 RTE Implementation Plug-Ins Functional Specification

7.3.1 Specializations of `AtomicSwComponentType`s

The `AUTOSAR Metamodel` defines several specializations of `AtomicSwComponentType`s in order to indicate the architectural meaning of such an software component in the AUTOSAR Layered Software Architecture, e.g. an `ApplicationSwComponentType` or an `EcuAbstractionSwComponentType`. In the context of `RTE Implementation Plug-Ins` all specializations of `AtomicSwComponentType`s except for the NvBlockSwComponentType require identical support with respect to protection of port based communication and are just called in the following chapter Atomic Software Component.

7.3.2 Interaction with VFB Tracing

RTE Implementation Plug-In Service opening and closing some protection mechanisms is required to always be called as close as possible to the protected code in order to keep the lock-times low. This especially means that VFB Tracing hooks shall enclose the related RIPS hooks and not vice versa.

[SWS_Rte_80078] DRAFT ⌈ The RTE shall call RTE Implementation Plug-In protection macros closer to the "to be protected" code than the related VFB Tracing hooks. ⌋*(SRS_Rte_00306)*

Please note that [SWS_Rte_80078] applies in particular for Rte_Rips_StartRead, Rte_Rips_StopRead, Rte_Rips_StartWrite, and Rte_Rips_StopWrite services.

Example 7.3

```
uint64 Rte_DRead_myComponent_myRPort1_myExplicitLargePrimitveData(void)
{
    uint64 rtn;
    Rte_DReadHook_myComponent_myRPort1_myExplicitLargePrimitveData_Start
        ();
    Rte_Rips_myPlugin_StartRead_myComponent_myLargePrimitveData1();
    rtn = Rte_Rips_GlobalCopy_myLargePrimitveData1.value;
    Rte_Rips_myPlugin_StopRead_myComponent_myLargePrimitveData1();
    Rte_DReadHook_myComponent_myRPort1_myExplicitLargePrimitveData_Return
        ();
    return rtn;
}
```

7.3.3 Validation Strategy for RTE Implementation Plug-Ins

7.3.3.1 Graduated Validation Strategy

7.3.3.2 Validation Implication w.r.t. Exclusive Areas

Implementing ExclusiveAreas with the means of RTE Implementation Plug-Ins can optimize the ECU software when very selective measures are taken to protect a particular ExclusiveArea. In addition it is easier to ensure the consistency of the ExclusiveArea implementations with the protections applied in RTE APIs using RTE Implementation Plug-Ins.

Nevertheless this kind of optimization cannot overcome the general limitations stated in A.14. Especially since the current capability of RTE Implementation Plug-Ins does not include blocking APIs. Further on the consistent handling of ExclusiveAreas APIs by the software component or Basic Software Module's implementation is still required. The following requirements and constraints are still applicable:

- [SWS_Rte_07524]
- [SWS_Rte_07005]
- [SWS_Rte_02741]
- [SWS_Rte_02740]
- [SWS_Rte_02744]
- [SWS_Rte_CONSTR_09028]
- [SWS_Rte_CONSTR_09029]
- [SWS_Rte_CONSTR_09046]
- [SWS_Rte_CONSTR_09047]

7.3.3.3 Validation Implication w.r.t. Event To Task Mapping

In general, which kind of direct function calls an RTE Generator supports is a property of the RTE Generator. But an important use case of the utilization of RTE Implementation Plug-Ins is the resource optimized scheduling and implementation of data consistency mechanisms in complex scenarios. Therefore it is beneficial if an RTE Generator supports additionally the ExecutableEntity activation via direct function calls in additional scenarios as the already standardized ones, see [SWS_Rte_06798], [SWS_Rte_07409], [SWS_Rte_07173], [SWS_Rte_07214], [SWS_Rte_07224], and [SWS_Rte_07554].

[SWS_Rte_80029] DRAFT ⌈ The RTE and Basic Software Scheduler should support the activation of ExecutableEntity via direct function call for

- DataReceivedEvents
- DataReceiveErrorEvents,
- DataWriteCompletedEvents,
- DataSendCompletedEvents
- OperationInvokedEvents where the client uses SynchronousServerCallPoints as well as AsynchronousServerCallPoints
- AsynchronousServerCallReturnsEvents where the server's OperationInvokedEvent is not mapped to a OsTask.

when the support for RTE Implementation Plug-Ins is globally enabled (RteRipsSupport = true) ⌋(SRS_Rte_00305)

[SWS_Rte_CONSTR_80013] DRAFT ⌈Restrictions on direct function call configurations in the scope of RTE Implementation Plug-Ins If an RTE Generator supports an activation of ExecutableEntitys via direct function call listed in [SWS_Rte_80029] only when the support for RTE Implementation Plug-Ins is enabled the input configuration needs to fulfill following condition:

- all Communication Graphs, ExclusiveAreas and mode machine instances accessed by the to-be-activated ExecutableEntity are assigned to RTE Implementation Plug-Inss

  AND

- the to-be-activated ExecutableEntity do not in turn activate RTEEvents or BswEvents which are mapped to OsTasks.

⌋(SRS_Rte_00305)

Please note: The activation of OsTasks is still a duty of the RTE. [SWS_Rte_CONSTR_80011] shall ensure, that the RTE Generator is not forced to implement OS interacting code in a context which can only occur in an RTE Implementation Plug-Ins specific configuration.

When utilizing RTE Implementation Plug-Ins the RTE Generator is not longer able to validate the overall scenario. This means the RTE Generator can only validate, if the activation of an ExecutableEntity at the configured position in the OsTask or via direct function call can be supported by the RTE Generator. But it can not finally judge whether the utilized RTE Implementation Plug-Ins can support the requested functionality (e.g an implicit communication) in the resulting call context(s).

But the specific validation whether the implementation of the data consistency mechanism or ExclusiveAreas implementations is possible is the task of the utilized RTE Implementation Plug-Ins.

[SWS_Rte_70040] DRAFT ⌈ The RTE Implementation Plug-Ins tool shall validate whether the requested functionality can be implemented with the given Event To Task Mapping. ⌋(SRS_Rte_00305)

[SWS_Rte_80030] DRAFT ⌈ The RTE Generator shall restrict its applied validation on the input configuration w.r.t Event To Task Mapping and the resulting call tree to the aspects concerning the RTE code generation, when the support for RTE Implementation Plug-Ins is globally enabled (RteRipsSupport and all Communication Graphs, ExclusiveAreas, and mode machine instances accessed by the to-be-activated ExecutableEntity are assigned to RTE Implementation Plug-Ins. ⌋(SRS_Rte_00305)

For instance:

According [SWS_Rte_07007] the RTE generator would reject configurations where a RunnableEntity with implicit access gets potentially concurrently invoked. When configuring such a component the RTE Generator would be required to create an implicit buffering which depends on the current invocation context of the RunnableEntity and this is not foreseen in chapter 4.3.1.5.1.

Now when applying RTE Implementation Plug-Ins according [SWS_Rte_80030] the validation scope of the RTE Generator is reduced to the scope of the RTE, which just ensures, that the triggering of the RunnableEntity can be implemented by the RTE Generator. If the implicit buffering strategy can deal with the dynamic side conditions - like a potential concurrent invocation - shall be checked by the RTE Implementation Plug-Ins handling a specific Data Communication Graph accessed by this RunnableEntity with implicit access.

7.3.4 Data Communication

7.3.4.1 Enable RTE Implementation Plug-In support for communication graphs

According Document [8] a Data Communication Graph gets assigned to an RTE Implementation Plug-In with a FlatInstanceDescriptor that points on one hand to the instance of a VariableDataPrototype and on the other hand points via FlatInstanceDescriptor.rtePluginProps.associatedRtePlugin to the container RteRipsPluginProps.

[SWS_Rte_80031] DRAFT ⌈ The RTE Generator shall enable the RTE Implementation Plug-In support for a Data Communication Graph, if a FlatInstanceDescriptor with rtePluginProps references the Data Communication Graph . ⌋*(SRS_Rte_00300, SRS_Rte_00301)*

In the later document this specific FlatInstanceDescriptor is called RIPS FlatInstanceDescriptor.

[SWS_Rte_70042] DRAFT ⌈ The associated RTE Implementation Plug-In shall implement the required implicit communication buffering and data protection for the related Data Communication Graphs. ⌋*(SRS_Rte_00300, SRS_Rte_00301)*

[SWS_Rte_80032] DRAFT ⌈ The RTE Generator shall treat RIPS FlatInstanceDescriptors as regular AUTOSAR FlatInstanceDescriptors, independent of their special meaning for RTE Implementation Plug-In support. ⌋*(SRS_Rte_00300, SRS_Rte_00301)*

Besides the RTE Implementation Plug-In related special meaning, the RIPS FlatInstanceDescriptors keep their AUTOSAR meaning. This especially means that also RIPS FlatInstanceDescriptors can lead to entries in the McSupportData as described in section 4.2.8.4. This has the intended side effect that the globally unique names used for RTE Implementation Plug-In can be kept identical to the names visible in a MCD tool.

Examples of Data Communication Graphs are given in figures 7.3 and 7.4.

7.3.4.2 Details on RIPS FlatInstanceDescriptors for Data Communication Graphs

Since a Data Communication Graph - in case of port based communication - is typically composed out of various PortPrototypes, DataPrototypes in PortInterfaces, and AssemblySwConnectors in theory such a RIPS FlatInstanceDescriptor could point to different locations in the Data Communication Graph . To harmonize the interface between the RTE Generator and the RTE Implementation Plug-In tools [SWS_Rte_CONSTR_80002] regulates the creation of RIPS FlatInstanceDescriptors for Rte Implementation Plug-Ins.

[SWS_Rte_CONSTR_80002] DRAFT ⌈Valid instance reference targets of Rte Implementation Plug-Ins The RIPS FlatInstanceDescriptors for a Data Communication Graph shall reference the data instances according table 7.33 ⌋ *(SRS_Rte_00300, SRS_Rte_00301)*

Data Communication Graph involves NvBlockSwComponent	*Conversion*	*Communication multiplicity*	*RIPS FlatInstanceDescriptors*
No	No	1:n	VariableDataPrototype instance in the AbstractProvidedPortPrototype
No	No	n:1	VariableDataPrototype instance in the RPortPrototype
No	No	n:m where n > 1 and m > 1	VariableDataPrototype instance in any of the PRPortPrototypes
Yes	No	n:m where n >= 1 and m >= 1	VariableDataPrototype instance in the AbstractProvidedPortPrototype at the NvBlockSwComponent
No	Yes	1:n	VariableDataPrototype instance in the AbstractProvidedPortPrototype AND one per different representation of VariableDataPrototype instance in the RPortPrototype
No	Yes	n:1	VariableDataPrototype instance in the AbstractRequiredPortPrototype AND one per different representation of VariableDataPrototype instance in the PPortPrototype

▽

△

Yes	Yes	where n >= 1 and m >= 1	VariableDataPrototype instance in the AbstractProvidedPortPrototype at the NvBlockSwComponent AND one per different representation of VariableDataPrototype instance in the PortPrototype

Table 7.33: Reference targets of RIPS FlatInstanceDescriptors

In case of conversion several RIPS FlatInstanceDescriptors are required to define the interface name spaces for the individual different representations of data and/or data status. Nevertheless it is not possible that the different representations get handled by different RTE Implementation Plug-Ins.

[SWS_Rte_CONSTR_80003] DRAFT ⌈A Data Communication Graph is handled by at most one RTE Implementation Plug-In In the case that a Data Communication Graph is referenced by several RIPS FlatInstanceDescriptors all those RIPS FlatInstanceDescriptors shall reference via FlatInstanceDescriptor.rtePluginProps.associatedRtePlugin the identical RteRipsPluginProps container. ⌋*(SRS_Rte_00300, SRS_Rte_00301)*

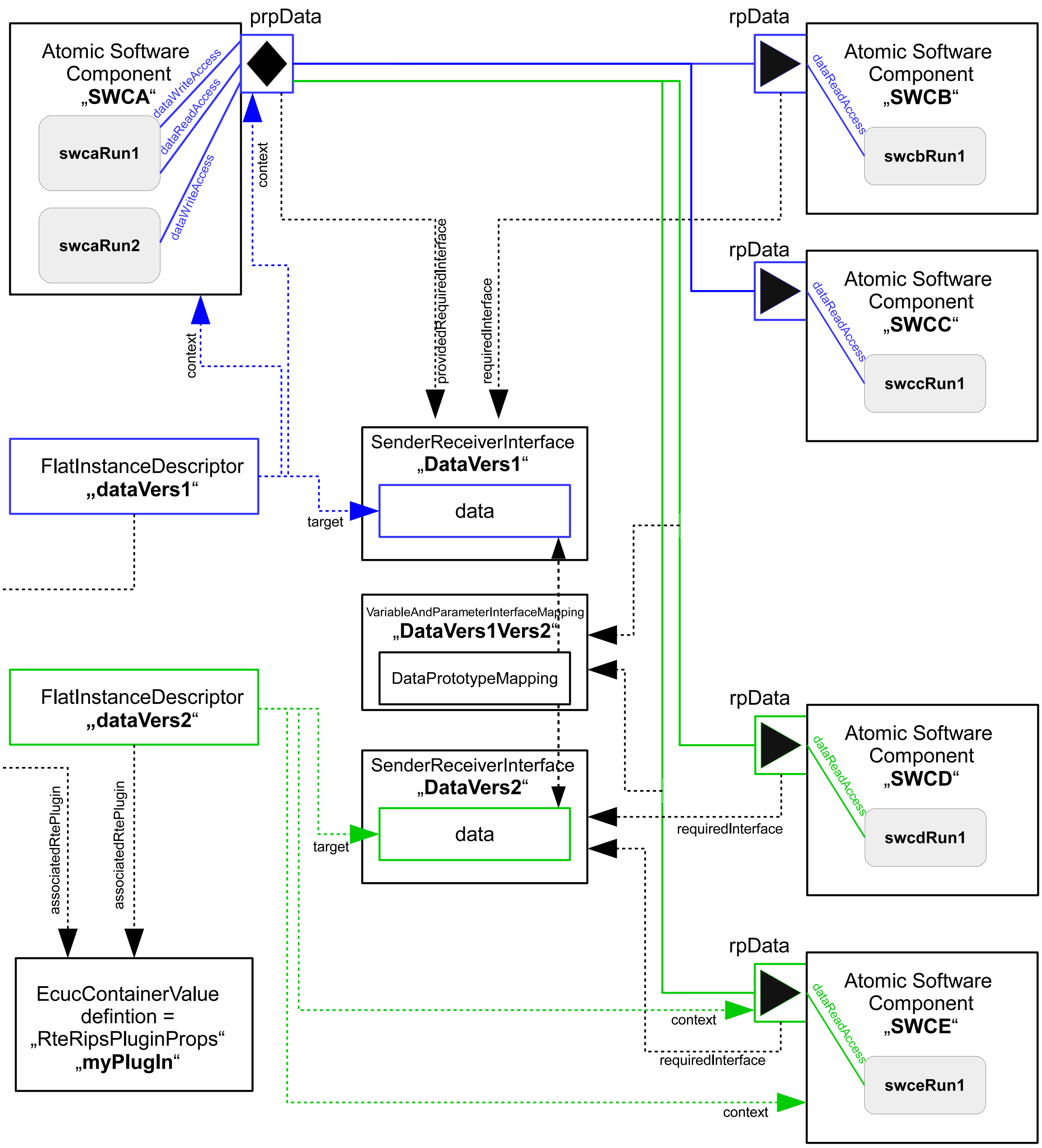

Figure 7.3: Data Communication Graph with conversion

The figure 7.3 illustrates an example for a Data Communication Graph with data conversion. Thereby it shall be assumed, that the dataElements data given in two different SenderReceiverInterfaces are typed by ApplicationDataTypes describing a different resolution (not shown in the figure).

The RIPS FlatInstanceDescriptor dataVers1 assigns the blue part of the Data Communication Graph for the ports of the Atomic Software Components SWCA, SWCB, and SWCC to the RTE Implementation Plug-In. The RIPS

FlatInstanceDescriptor dataVers2 assigns the green part of the Data Communication Graph - with the converted representation of data - for the Atomic Software Components SWCD and SWCE to the RTE Implementation Plug-In.

As demanded by [SWS_Rte_CONSTR_80003] both parts of the Data Communication Graph are assigned to the same RTE Implementation Plug-In myPlugIn.

The RIPS FlatInstanceDescriptor is referencing the targets as demanded by [SWS_Rte_CONSTR_80002].

Please note that the RIPS FlatInstanceDescriptor dataVers2 is applicable for all ports of the Atomic Software Components accessing the Data Communication Graph on the basis of the dataElement data in SenderReceiverInterface DataVers2.

Further details about conversion are described in section 7.3.4.4

7.3.4.3 Data Communication Graphs involving NvBlockSwComponents

In the special case of non volatile data the RIPS FlatInstanceDescriptor will reference the AbstractProvidedPortPrototype of the NvBlockSwComponent. As the protection and buffering always has to consider the complete Data Communication Graph and this Data Communication Graph in this case not only includes the direction from the data element of the ramBlock to the consuming software component, but also from the producing software component to the data element in the ramBlock, this single RIPS FlatInstanceDescriptor also affects the latter connection.

[SWS_Rte_80033] DRAFT ⌈ The RTE Generator and the RTE Implementation Plug-In shall consider all VariableDataPrototype instances in PortPrototypes of Atomic Software Components which are connected to VariableDataPrototype instances in PortPrototypes of the NvBlockSwComponent which in turn are mapped together with the same NvBlockDataMapping to an element of the ramBlock as belonging to the same Data Communication Graph. Additionally the mapped element of the ramBlock belongs to this Data Communication Graph. ⌋ *(SRS_Rte_00300, SRS_Rte_00301)*

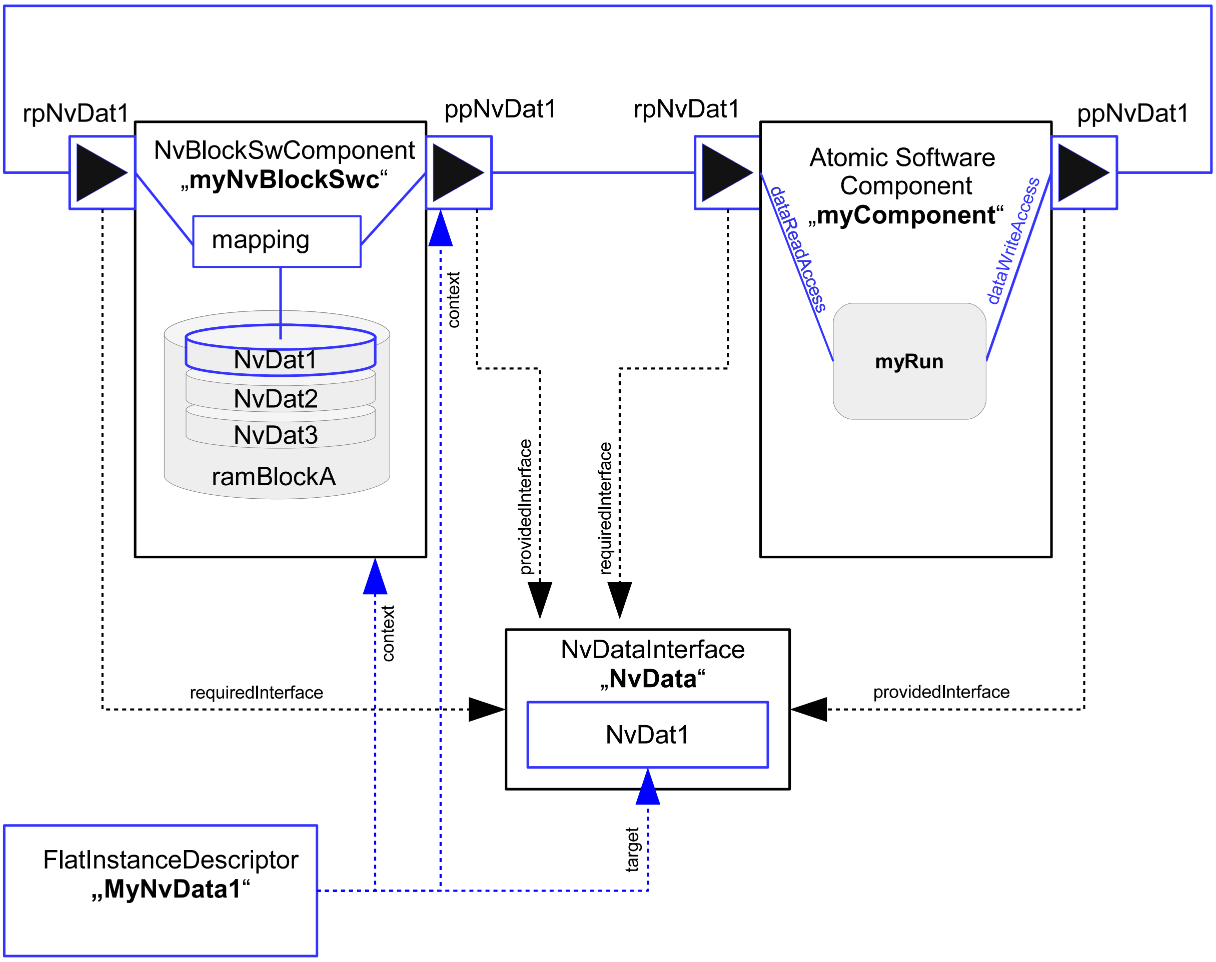

Figure 7.4: Data Communication Graph involving a NvBlockSwComponent

The figure 7.4 illustrates an example for a Data Communication Graph involving a NvBlockSwComponent. Thereby the RIPS FlatInstanceDescriptor MyNvData1 is referencing the p-port ppNvDat1 of the NvBlockSwComponent myNvBlockSwc. This enables the RTE Implementation Plug-In also for the partial Data Communication Graph from the p-port ppNvDat1 of the Atomic Software Component myComponent to the r-port rpNvDat1 of the NvBlockSwComponent. The shortName of this FlatInstanceDescriptor defines the name of the RTE Implementation Plug-In Services for this, not explicitly marked Data Communication Graph.

Due to the structure nature of the ramBlock it is possible, that different Data Communication Graphs overlay within the same ramBlock. There exist valid use cases for such configurations, since it can be required to write (and optionally also read) the whole ramBlock or a larger sub-structure of it via one port whereas the single data elements are provided in distinct p-ports.

[SWS_Rte_80103] DRAFT ⌈ The RTE Generator shall support the overlay of Data Communication Graphs in ramBlocks. ⌋ *(SRS_Rte_00300, SRS_Rte_00301)*

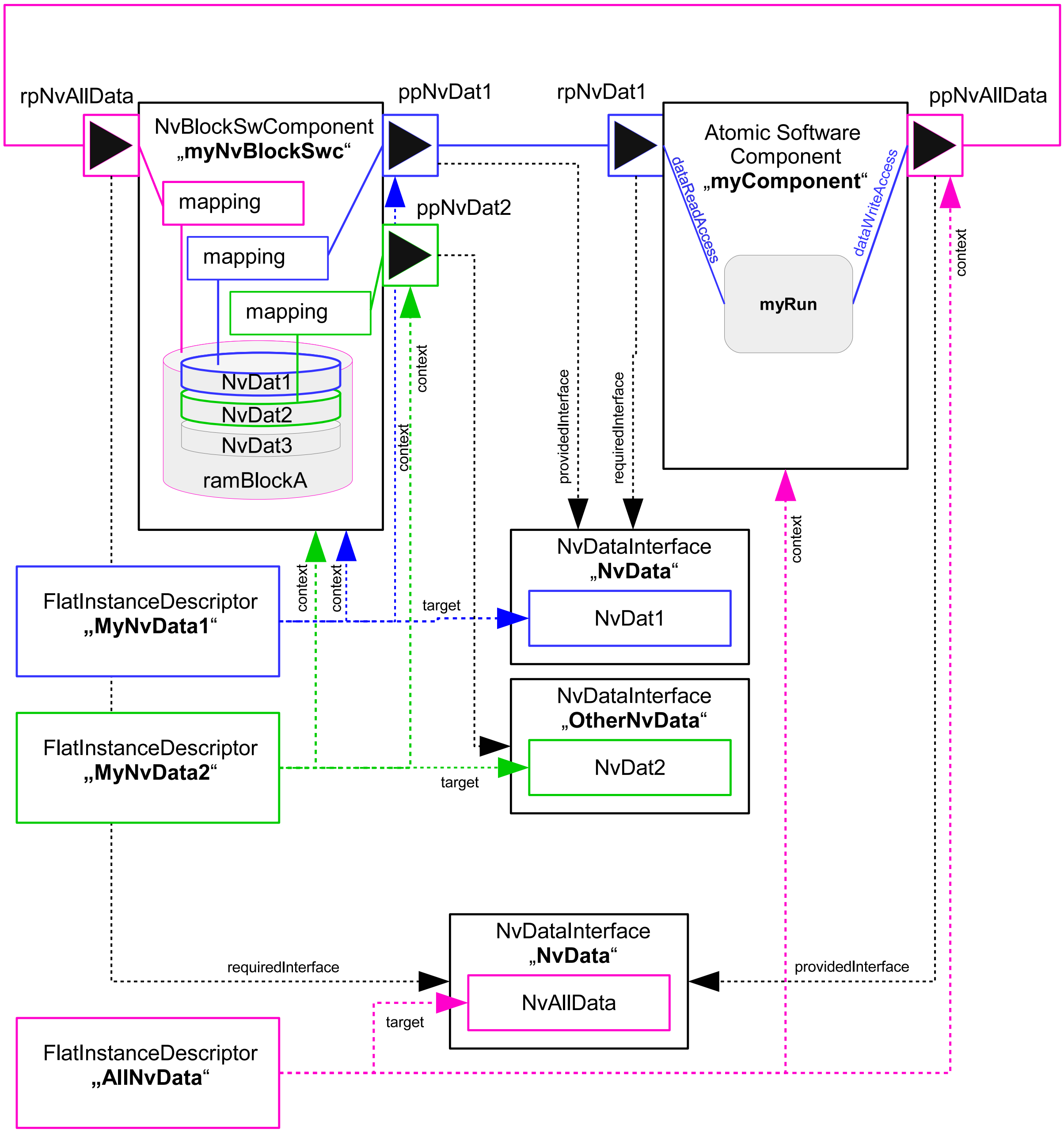

Figure 7.5: Overlay of Data Communication Graphs in a ramBlock

The figure 7.5 illustrates an example for the overlay of Data Communication Graphs in a ramBlock. In this example the Data Communication Graph AllNvData gets written by the Atomic Software Component myComponent via the p-port ppNvAllData. Further on Data Communication Graph AllNvData overlays the Data Communication Graphs MyNvData1 and MyNvData2 which are sub-elements of the ramBlock.

7.3.4.4 Handling of Communication Status and Conversion with RTE Implementation Plug-Ins

In general compatibility of PortInterfaces and PortInterface mapping rules are not affected by the usage of RTE Implementation Plug-In. But as a consequence, besides the buffering or access protection there are some operations the RTE has to perform on the data. These are the online conversion of data, range checks, and status calculations and updates.

Although these are basically RTE internal operations not having any relation to RTE Implementation Plug-Ins, the RTE still needs to know when and where (in terms of memory address) it can perform these operations. Remember that the RTE will not know the buffering decision for the individual data and therefore e.g. also does not know whether to operate on the global or local copy of this data. So there is a need for an agreement between RTE and RTE Implementation Plug-In on this. The first important point to note is that in this sense status calculations of data are treated just as online conversions, although they do not affect the value of the data itself.

For instance such a status conversion occurs when in a Data Communication Graph software components request different settings in ReceiverComSpec attributes, which would lead to a different status value for the individual software components.

[SWS_Rte_80034] DRAFT ⌈ The RTE Generator shall handle a conversion between different VariableDataPrototype instances in PortPrototypes inside a Data Communication Graph if either the data values can differ for the individual Atomic Software Components or if the status belonging to the data can differ for the individual Atomic Software Components as defined in table 7.34. ⌋ *(SRS_Rte_00300, SRS_Rte_00301)*

PRPortPrototype (1)	*PPortPrototype (2)*	*RPortPrototype (3)*	*Status Conversion*
None	None	None	no
None	None	Receiver Status	no
None	Sender Status	None	no
None	Sender Status	Receiver Status	Yes (1,2 -> 3)
Sender Status	None	None	no
Sender Status	None	Receiver Status	Yes (1,2 -> 3)
Sender Status	Sender Status	None	no
Sender Status	Sender Status	Receiver Status	Yes (1,2 -> 3)
Receiver Status	None	None	no
Receiver Status	None	Receiver Status	No
Receiver Status	Sender Status	None	Yes (2 -> 1,3)
Receiver Status	Sender Status	Receiver Status	Yes (2 -> 1,3)
Sender Status Receiver Status	None	None	no

▽

△

Sender Status Receiver Status	None	Receiver Status	No
Sender Status Receiver Status	Sender Status	None	Yes (2 -> 1,3)
Sender Status Receiver Status	Sender Status	Receiver Status	Yes (2 -> 1,3)

Table 7.34: Status Conversion between the provide and the require ports

The existence of the Sender Status and Receiver Status depends on the configuration of the communication features in a Data Communication Graph . The enabling of communication features is controlled by the SenderComSpec, ReceiverComSpec, and the InvalidationPolicy.

[SWS_Rte_80035] DRAFT ⌈ The RTE Generator and the RTE Implementation Plug-In consider the Sender Status as required, if

- InvalidationPolicy.handleInvalid is not set to dontInvalidate

  AND/OR
- SenderComSpec.handleOutOfRange is not set to none

  AND/OR
- SenderComSpec.transmissionAcknowledge is defined

⌋*(SRS_Rte_00300, SRS_Rte_00301)*

[SWS_Rte_80036] DRAFT ⌈ The RTE Generator and the RTE Implementation Plug-In consider the Receiver Status as required, if

- InvalidationPolicy.handleInvalid is not set to dontInvalidate

  AND/OR
- ReceiverComSpec.handleOutOfRange is not set to none

  AND/OR
- NonqueuedReceiverComSpec.aliveTimeout is set to a value greater than zero

  AND/OR
- NonqueuedReceiverComSpec.handleNeverReceived is set to TRUE

  AND/OR
- NonqueuedReceiverComSpec.enableUpdate is set to TRUE

  AND/OR

- NonqueuedReceiverComSpec.handleDataStatus is set to TRUE.

⌋(*SRS_Rte_00300, SRS_Rte_00301*)

Additionally the enabling of communication features can impact the data value which is accessible by the reading software component. Since this value can differ from the written value the setup of following communication attributes requires a conversion between the sender and the receiver in any case.

[SWS_Rte_80037] DRAFT ⌈ The RTE Generator and the RTE Implementation Plug-In consider a conversion between Sender and Receiver, if

- NonqueuedReceiverComSpec.handleTimeoutType is not set to none

  AND/OR

- InvalidationPolicy.handleInvalid is not set to dontInvalidate nor keep.

⌋(*SRS_Rte_00300, SRS_Rte_00301*)

When several AbstractProvidedPortPrototypes are connected in one Data Communication Graph it is possible that the Sender Statuses differ due to different communication attributes.

[SWS_Rte_80038] DRAFT ⌈ The RTE Generator and the RTE Implementation Plug-In consider different Senders Statuses, if the values of SenderComSpec.transmissionAcknowledge.timeout are not set identically. ⌋(*SRS_Rte_00300, SRS_Rte_00301*)

Last but not least when several AbstractRequiredPortPrototypes are connected in one Data Communication Graph it is possible that the Receiver Statuses or the received values differ due to different communication attributes.

[SWS_Rte_80039] DRAFT ⌈ The RTE Generator and the RTE Implementation Plug-In shall consider different Receiver Statuses or received data values, if

- NonqueuedReceiverComSpec.handleTimeoutType is not equal for all AbstractRequiredPortPrototypes

  AND/OR

- NonqueuedReceiverComSpec.handleTimeoutType is set to replaceByTimeoutSubstitutionValue AND timeoutSubstitutionValue is not equal for all AbstractRequiredPortPrototypes

  AND/OR

- InvalidationPolicy.handleInvalid is not equal for all AbstractRequiredPortPrototypes

  AND/OR

- InvalidationPolicy.handleInvalid is set to replace AND initValue is not equal for all AbstractRequiredPortPrototypes

  AND/OR

- InvalidationPolicy.handleInvalid is set to externalReplacement AND replaceWith results in a different data instance providing the replacement value

  AND/OR

- ReceiverComSpec.handleOutOfRange is not equal for all AbstractRequiredPortPrototypes

  AND/OR

- ReceiverComSpec.handleOutOfRange is set to default AND initValue is not equal for all AbstractRequiredPortPrototypes

  AND/OR

- ReceiverComSpec.handleOutOfRange is set to invalid AND invalidValue is not equal for all AbstractRequiredPortPrototypes

  AND/OR

- ReceiverComSpec.handleOutOfRange is set to externalReplacement AND replaceWith results in a different data instance providing the replacement value.

⌋*(SRS_Rte_00300, SRS_Rte_00301)*

If a Data Communication Graph is handled by an RTE Implementation Plug-In, the online data conversion will always be done during the production of the data rather than the consumption. This implies that there will be a separate local or global copy of the data for each of its representations (see also [SWS_Rte_80034]). This might take some optimization potential, but as usually each of the representations will be measurable anyway, the risk is very limited.

Typical examples of different representations are different resolutions or different sets of status bits. On the other hand a pure name mapping of TEXTTABLEs does not represent a different representation. Please note however that this does not mean that the only reason for a RIPS FlatInstanceDescriptors on an RPortPrototype is having a different representation. It could as well happen that the "conversion" between producer and consumer of data in an Data Communication Graph is just a copy.

This means, either the RTE provides an individual data instance per representation (see [SWS_Rte_80040]), or, in case RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_PLUGIN, it is a duty of the RTE Implementation Plug-Ins to do so.

[SWS_Rte_80057] DRAFT ⌈ The RTE shall reject configurations where not for each required representation according [SWS_Rte_80040] a RIPS FlatInstanceDescriptor is provided. ⌋*(SRS_Rte_00300, SRS_Rte_00301)*

Please note: On the opposite side a configuration may contain RIPS FlatInstanceDescriptors which are not needed by the RTE but have to be accepted by the RTE.

As the online conversion shall be done on producer side, it is obvious that for explicit producers this means inside the explicit write API. For implicit producers this is not so obvious. Such a conversion could be done during the whole life cycle of the local copy, including the flush operation. However, as the RTE does not know the buffering decision, it is not clear, whether for certain data there will even be a dedicated flush operation. So the conversion has to be done directly after termination of the producer RunnableEntity.

For explicit communication this means:

[SWS_Rte_80058] DRAFT ⌈ For explicit producers, the RTE generator shall place the conversion or status update code necessary for a Data Communication Graph handled by RTE Implementation Plug-Ins into the explicit write API. The conversion code shall manipulate the global copies of all representations of the written data. ⌋*(SRS_Rte_00300, SRS_Rte_00301)*

Manipulating the other global copies as well will also mean to either protect their write accesses via the Rte_Rips_StartWrite / Rte_Rips_StopWrite or to use the write API Rte_Rips_Write of the RTE Implementation Plug-Ins for all representations of the data.

[SWS_Rte_80059] DRAFT ⌈ In case of explicit write access to a Data Communication Graph handled by RTE Implementation Plug-Ins with RTE_RIPS_INSTANTIATION_BY_RTE where the Data Communication Graph requires status or data conversion , the RTE shall use the explicit access protection macros of all representations to protect the write action of their calculated values or status, just as if the producer ExecutableEntity would have explicit write accesses to all representations. ⌋*(SRS_Rte_00300, SRS_Rte_00301)*

[SWS_Rte_80060] DRAFT ⌈ In case of explicit write access to a Data Communication Graph handled by RTE Implementation Plug-Ins with RTE_RIPS_INSTANTIATION_BY_PLUGIN where the Data Communication Graph requires status or data conversion , the RTE shall use the explicit write service of all representations to implement the write action of their calculated values or status, just as if the producer ExecutableEntity would have explicit write accesses to all representations. ⌋*(SRS_Rte_00300, SRS_Rte_00301)*

[SWS_Rte_70048] DRAFT ⌈ The RTE Implementation Plug-Ins shall provide the set of explicit access protection services or explicit write services for each representation in a Data Communication Graph, even though the producing Runnable only models a single access point. ⌋*(SRS_Rte_00300, SRS_Rte_00301)*

For implicit communication this means:

[SWS_Rte_80061] DRAFT ⌈ For implicit producers, the RTE generator shall place the conversion or status update code necessary for a certain Data Communication Graph handled by RTE Implementation Plug-Ins directly after the call of the implicit producer RunnableEntity. Thereby executing the VFB tracing hook for this RunnableEntity still before the conversion or the status update code is acceptable.
⌋*(SRS_Rte_00300, SRS_Rte_00301)*

As in the implicit case, the RTE Generator still does not know whether the other representations are buffered or not. It needs a clear interface to get access to the locations where the original producer has written the data to and where the consumers will read the converted data from. Note that the unconverted data will be written by the Rte_Rips_IWrite / Rte_Rips_IWBufferRef API or the Flush-Routine, depending on the buffering strategy. A separate name space will be used for the Rte_Rips_IWBufferRef and Rte_Rips_IRBufferRef services used by the RTE conversion and status calculation code. This avoids name clashes as well as it supports source code implementations of the Rte_Rips_IWBufferRef and Rte_Rips_IRBufferRef services used by the RTE, even if the software component is delivered as object code.

[SWS_Rte_80063] DRAFT ⌈ The name space of Rte_Rips_IWBufferRef and Rte_Rips_IRBufferRef services used by the RTE conversion and status calculation code is created by prefixing the <SwcBswI> and <ExE> name part with RteCnv.
⌋*(SRS_Rte_00300, SRS_Rte_00301)*

[SWS_Rte_80064] DRAFT ⌈ In case of implicit write access to a Data Communication Graph handled by RTE Implementation Plug-Ins with data or status conversion, the RTE shall use Rte_Rips_IWrite without RteCnv prefix and Rte_Rips_IWBufferRef without RteCnv prefix to implement the dataWriteAccess of the RunnableEntity, and the implicit Rte_Rips_IWBufferRef service with RteCnv prefix of all representations different to the producer's one to write their calculated values or status. If needed, the unconverted value written by the producer shall be retrieved via the Rte_Rips_IRBufferRef with RteCnv prefix only.
⌋*(SRS_Rte_00300, SRS_Rte_00301)*

[SWS_Rte_70049] DRAFT ⌈ The RTE Implementation Plug-Ins shall provide for the RunnableEntity with the dataWriteAccess for each representation in a Data Communication Graph the set of implicit access services Rte_Rips_IWrite / Rte_Rips_IWBufferRef, Rte_Rips_IRBufferRef, even though the producing Runnable only models a single access point. Thereby following set of RTE Implementation Plug-In Services shall be provided:

- For the data representation in the accessed PPortPrototype:
  - Rte_Rips_IWrite without RteCnv prefix, if applicable due to data type
  - Rte_Rips_IWBufferRef without RteCnv prefix
  - Rte_Rips_IRBufferRef with RteCnv prefix.

- For each to be converted data representation connected to the accessed PPortPrototype: One Rte_Rips_IWBufferRef with RteCnv prefix.

⌋(SRS_Rte_00300, SRS_Rte_00301)

For illustration please note example 7.11.

7.3.4.5 Instantiation of global copy

The RTE Implementation Plug-In interface assumes that the RTE implements a variable that holds the actual value of communication data and where readers and writers can set or get the data value. This variable is called global copy in the RTE Implementation Plug-In relevant sections. In addition the concept of implicit communication requires further buffers to ensure the stability of data for specific accessing RunnableEntitys. Those are called implicit communication buffers.

As described in section 7.3.4.2 one or multiple RIPS FlatInstanceDescriptors can point to a Data Communication Graph to enable the RTE Implementation Plug-In support. Thereby the number of RIPS FlatInstanceDescriptors determines the number of possible different representations of the data. Furthermore the shortName of the RIPS FlatInstanceDescriptor defines the name space of such a global copy and the belonging RTE Implementation Plug-In Services.

[SWS_Rte_80040] DRAFT ⌈ The RTE shall provide an individual global copy for each RIPS FlatInstanceDescriptor referencing the Data Communication Graph, if the associated RTE Implementation Plug-In has set the RteRipsGlobalCopyInstantiationPolicy to RTE_RIPS_INSTANTIATION_BY_RTE. ⌋(SRS_Rte_00300, SRS_Rte_00301)

Please note that the RTE Generator still has the freedom to decide about the naming of the global copy as well as to group several global copies in RTE specific structures. In this case the requirement [SWS_Rte_80006] ensures the accessibility by a defined name.

The typing of the global copies reuses the already existing concept of data handles (see data handles section). This eases encapsulation of the implicit buffering into a RTE Implementation Plug-In, since the types of the handles already fit to the global copy. This supports an easy fill and flash of the data with the belonging status values. Further on it avoids additional RTE Implementation Plug-In Services to access the status of data.

[SWS_Rte_80041] DRAFT ⌈ When the RTE provides an individual global copy for a Data Communication Graph with any implicit access, it shall use the data type according table 7.35. ⌋(SRS_Rte_00300, SRS_Rte_00301)

Sender Status	Receiver Status	Type of global copy
No	No	data element without status
Yes	No	data element with status
No	Yes	data element with status
Yes	Yes	data element with extended status

Table 7.35: Data type of global copy

Please note: [SWS_Rte_80041] ensures a well defined data type for Data Communication Graphs with implicit accesses, but it leaves the data type open for Data Communication Graphs with solely explicit accesses.

To support the coexistence of multiple optimization domains in a single ECU, certain Data Communication Graphs can be assigned to distinct, specialized RTE Implementation Plug-Ins. Those RTE Implementation Plug-Ins could then even take over the responsibility to instantiate the global copies of the related Data Communication Graph.

[SWS_Rte_70043] DRAFT ⌈ The associated RTE Implementation Plug-In shall instantiate the required global copies for a Data Communication Graphs, if the associated RTE Implementation Plug-In has set the RteRipsGlobalCopyInstantiationPolicy to RTE_RIPS_INSTANTIATION_BY_PLUGIN. ⌋ *(SRS_Rte_00300, SRS_Rte_00301, SRS_Rte_00303)*

Please note, that in case of [SWS_Rte_70043] the associated RTE Implementation Plug-In has now freedom to name and group the global copy. It could even implement strategies working with multiple global copies for the same Data Communication Graph .

7.3.4.6 Explicit Communication and RTE Implementation Plug-Ins

The support for handling explicit communication via RTE Implementation Plug-In basically differs whether the RTE Implementation Plug-In provides the global copy or whether the RTE provides the global copy. In the first case the RTE just forwards the explicit accesses via the RTE Implementation Plug-In Services whereas in the second case the RTE has to use the RTE Implementation Plug-In Services to protect potentially non atomic accesses.

7.3.4.6.1 Global copy provided by RTE

In the case the global copy is provided by the RTE the only point of interest for the RTE Implementation Plug-In is the kind of protection. For that purpose for read and write accesses pairs of RTE Implementation Plug-In Services are provided for opening the protection block and another one for closing it. The rest remains like in an RTE code not using an RTE Implementation Plug-In. The RTE Implementation Plug-In only needs to know whether there is an according interruption scenario and whether the data type is atomic in the given platform or not. Special care has to be taken for the data status handling, as this might also lead to a protection need, even though the pure data would be atomic otherwise. So the RTE Implementation Plug-In has to check whether a Sender Status or Receiver Status exists. An RTE in turn has to make sure that the complete buffer manipulation happens under a single protection block.

[SWS_Rte_80043] DRAFT ⌈ The RTE shall use the protecting RTE Implementation Plug-In Services Rte_Rips_StartRead, Rte_Rips_StopRead, Rte_Rips_StartWrite, and Rte_Rips_StopWrite for any access to the Data Communication Graph where the implemented algorithm would suffer from a pre-emption or concurrent execution. The usage shall be independent of the actual pre-emption scenario found in the configuration. ⌋*(SRS_Rte_00300)*

Please note: [SWS_Rte_80043] applies for unqueued and queued communication.

The RTE Implementation Plug-Ins will know the possible pre-emptions and provides an appropriate protection macro implementation.

[SWS_Rte_70044] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the protecting RTE Implementation Plug-In Services Rte_Rips_StartRead, Rte_Rips_StopRead, Rte_Rips_StartWrite, and Rte_Rips_StopWrite with an appropriate protection functionality for any explicit access to the Data Communication Graph. Thereby the RTE Implementation Plug-Ins shall consider whether the access is non-atomic due to the following side conditions

- the size of the data
- the existence of Sender Status or Receiver Status
- potential pre-emptions caused due to configured scheduling during the accesses to the Data Communication Graphs
- usage of queued communication.

⌋*(SRS_Rte_00300)*

Please note, that the associated RTE Implementation Plug-In has to provide the protecting RTE Implementation Plug-In Services regardless whether any protection is needed. In case that no protection is needed the RTE Implementation Plug-In Services can be empty. See also the according existence conditions [SWS_Rte_70019], [SWS_Rte_70020], [SWS_Rte_70021], [SWS_Rte_70022], [SWS_Rte_70023], [SWS_Rte_70024], [SWS_Rte_70025], [SWS_Rte_70026].

The protection blocks can be nested, e.g. when a Runnable uses explicit communication while being executed in an ExclusiveArea. It is therefore recommended to generally use protection block implementations which support nesting. As a minimum, such implementations have to be used where nesting can occur, which would have to be analyzed beforehand. On one hand those ExclusiveAreas are relevant which are directly used by the ExecutableEntity (1) accessing the Data Communication Graphs. Additionally those ExclusiveAreas are relevant which are used by all ExecutableEntitys invoking the ExecutableEntity (1) by a direct function call with the Data Communication Graphs access.

[SWS_Rte_70045] DRAFT ⌈ RTE Implementation Plug-In shall implement the protecting RTE Implementation Plug-In Services Rte_Rips_StartRead, Rte_Rips_StopRead, Rte_Rips_StartWrite, and Rte_Rips_StopWrite in a way, that those support a potential nesting with ExclusiveAreas when it can occur in the call graph. ⌋ *(SRS_Rte_00300)*

7.3.4.6.1.1 Simple example about non-queued read and write

The example code below shows the basic implementation in case the data does not have any assigned status and the software component does not support multiple instantiation and is provided as source code. Additionally, 64bit accesses are not atomic on the underlying platform to demonstrate a protection scenario. In contrast to the others, Rte_DRead is not implemented as a macro in order to show a different implementation flavour.

Example 7.4

Code example for Rte_myComponent.h in case the RTE Generator implements the explicit APIs:

```
extern uint64 Rte_myExplicitSimpleData;

#define Rte_Write_myPPort1_myExplicitSimpleData(data) ( \
  Rte_WriteHook_myComponent_myPPort1_myExplicitSimpleData_Start(data),
      \
  SuspendOSInterrupts(), \
  (Rte_myExplicitSimpleData = data), \
  ResumeOSInterrupts(), \
  Rte_WriteHook_myComponent_myPPort1_myExplicitSimpleData_Return(data),
      \
  RTE_E_OK)

#define Rte_Read_myRPort1_myExplicitSimpleData(data) ( \
 Rte_ReadHook_myComponent_myRPort1_myExplicitSimpleData_Start(data), \
 SuspendOSInterrupts(), \
 ((*(data)) = Rte_myExplicitSimpleData), \
 ResumeOSInterrupts(), \
 Rte_ReadHook_myComponent_myRPort1_myExplicitSimpleData_Return(data), \
 RTE_E_OK)

extern uint64 Rte_DRead_myComponent_myRPort1_myExplicitSimpleData(void)
    ;
#define Rte_DRead_myRPort1_myExplicitSimpleData() (
    Rte_DRead_myComponent_myRPort1_myExplicitSimpleData())
```

Code example for Rte.c in case the RTE Generator implements the explicit APIs:

```
#include "Rte_myComponent.h"

uint64 Rte_myExplicitSimpleData;
uint64 Rte_DRead_myComponent_myRPort1_myExplicitSimpleData(void)
{
    uint64 rtn;
        Rte_DReadHook_myComponent_myRPort1_myExplicitSimpleData_Start()
        ;
    SuspendOSInterrupts();
    rtn = Rte_myExplicitSimpleData;
    ResumeOSInterrupts();
    Rte_DReadHook_myComponent_myRPort1_myExplicitSimpleData_Return();
    return rtn;
}
```

The following example 7.5 shows an equivalent implementation of the explicit APIs via an RTE Implementation Plug-In.

Example 7.5

Code example for Rte_DataHandleType.h in case the RTE Generator redirects towards an RTE Implementation Plug-In to implement the scenario:

```
/* Since the Communication Graph has only explicit accesses
   SWS_Rte_80041 is not applicable */
```

Code example for Rte_myComponent.h in case the RTE Generator redirects towards an RTE Implementation Plug-In to implement the explicit APIs:

```
#include "Rte_Rips_myPlugin_myComponent.h"

extern uint64 Rte_myExplicitSimpleData;

#define Rte_Write_myPPort1_myExplicitSimpleData(data)  ( \
 Rte_WriteHook_myComponent_myPPort1_myExplicitSimpleData_Start(data), \
 Rte_Rips_myPlugin_StartWrite_myComponent_myGlobalData1(), \
 (Rte_myExplicitSimpleData = data), \
 Rte_Rips_myPlugin_StopWrite_myComponent_myGlobalData1(), \
 Rte_WriteHook_myComponent_myPPort1_myExplicitSimpleData_Return(data),
    \
 RTE_E_OK)

#define Rte_Read_myRPort1_myExplicitSimpleData(data)  ( \
 Rte_ReadHook_myComponent_myRPort1_myExplicitSimpleData_Start(data), \
 Rte_Rips_myPlugin_StartRead_myComponent_myGlobalData1(), \
 ((*(data)) = Rte_myExplicitSimpleData), \
 Rte_Rips_myPlugin_StopRead_myComponent_myGlobalData1(), \
 Rte_ReadHook_myComponent_myRPort1_myExplicitSimpleData_Return(data), \
 RTE_E_OK)

extern uint64 Rte_DRead_myComponent_myRPort1_myExplicitSimpleData(void)
    ;

```

```
#define Rte_DRead_myRPort1_myExplicitSimpleData() (
    Rte_DRead_myComponent_myRPort1_myExplicitSimpleData())
```

Code example for `Rte.c` in case the RTE Generator redirects towards an RTE Implementation Plug-In to implement the explicit APIs:

```
#include "Rte_myComponent.h"

uint64 Rte_myExplicitSimpleData;
uint64 Rte_DRead_myComponent_myRPort1_myExplicitSimpleData(void)
{
  uint64 rtn;
  Rte_DReadHook_myComponent_myRPort1_myExplicitSimpleData_Start();
  Rte_Rips_myPlugin_StartRead_myComponent_myGlobalData1();
  rtn = Rte_myExplicitSimpleData;
  Rte_Rips_myPlugin_StopRead_myComponent_myGlobalData1();
  Rte_DReadHook_myComponent_myRPort1_myExplicitSimpleData_Return();
  return rtn;
}
```

Code example for `Rte_Buffers.h` when an RTE Implementation Plug-In is associated to the Data Communication Graph:

```
/* Since the Communication Graph has only explicit accesses
    SWS_Rte_80041 and SWS_Rte_80005 is not applicable */
```

Code example for `Rte_Rips_myPlugin_myComponent.h` when an RTE Implementation Plug-In is associated to the Data Communication Graph:

```
#include "Rte_Buffers.h"

#define Rte_Rips_myPlugin_StartWrite_myComponent_myGlobalData1() \
 SuspendOSInterrupts()

#define Rte_Rips_myPlugin_StopWrite_myComponent_myGlobalData1() \
 ResumeOSInterrupts()

#define Rte_Rips_myPlugin_StartRead_myComponent_myGlobalData1() \
 SuspendOSInterrupts()

#define Rte_Rips_myPlugin_StopRead_myComponent_myGlobalData1() \
 ResumeOSInterrupts()
```

7.3.4.6.1.2 Simple example about queued read and write

The example 7.6 shows the basic implementation in case the data does not have any assigned status and the software component does not support multiple instantiation. The RTE uses own standard queue implementations, but those are not protected.

Example 7.6

Code example for `Rte_myComponent.h` in case the RTE Generator implements the explicit APIs:

```
extern Std_ReturnType
    Rte_Write_myComponent_myPPort1_myExplicitSimpleData(uint32 data);

#define Rte_Write_myPPort1_myExplicitSimpleData(data) (
    Rte_Write_myComponent_myPPort1_myExplicitSimpleData(data))

extern Std_ReturnType
    Rte_Read_myComponent_myRPort1_myExplicitSimpleData(uint32 * data);

#define Rte_Read_myRPort1_myExplicitSimpleData(data) (
    Rte_Read_myComponent_myRPort1_myExplicitSimpleData(data))
```

Code example for `Rte.c` in case the RTE Generator implements the explicit APIs:

```
#include "Rte_myComponent.h"

Rte_QueueType_uint32 Rte_Queue_myExplicitSimpleData;

Std_ReturnType Rte_Write_myComponent_myPPort1_myExplicitSimpleData(
    uint32 data)
{
     Std_ReturnType rtn;
     Rte_WriteHook_myComponent_myPPort1_myExplicitSimpleData_Start(data)
         ;
     SuspendOSInterrupts();
     rtn = Rte_EnqueueUInt32(&Rte_Queue_myExplicitSimpleData, data);
     ResumeOSInterrupts();
     Rte_WriteHook_myComponent_myPPort1_myExplicitSimpleData_Return(data
         );
     return rtn;
}

Std_ReturnType Rte_Read_myComponent_myRPort1_myExplicitSimpleData(
    uint32 * data)
{
     Std_ReturnType rtn;
     Rte_ReadHook_myComponent_myRPort1_myExplicitSimpleData_Start(data);
     SuspendOSInterrupts();
     rtn = Rte_DequeueUInt32(&Rte_Queue_myExplicitSimpleData, data);
     ResumeOSInterrupts();
     Rte_ReadHook_myComponent_myRPort1_myExplicitSimpleData_Return(data)
         ;
     return rtn;
}
```

The following example 7.7 shows an equivalent implementation of the explicit APIs via an `RTE Implementation Plug-In`.

Example 7.7

Code example for `Rte_myComponent.h` in case the RTE Generator redirects towards an `RTE Implementation Plug-In` to implement the explicit APIs:

```
extern Std_ReturnType
    Rte_Write_myComponent_myPPort1_myExplicitSimpleData(uint32 data);

#define Rte_Write_myPPort1_myExplicitSimpleData(data) (
    Rte_Write_myComponent_myPPort1_myExplicitSimpleData(data))

extern Std_ReturnType
    Rte_Read_myComponent_myRPort1_myExplicitSimpleData(uint32 * data);

#define Rte_Read_myRPort1_myExplicitSimpleData(data) (
    Rte_Read_myComponent_myRPort1_myExplicitSimpleData(data))
```

Code example for `Rte.c` in case the RTE Generator redirects towards an RTE Implementation Plug-In to implement the explicit APIs:

```
#include "Rte_myComponent.h"

Rte_QueueType_uint32 Rte_Queue_myExplicitSimpleData;

Std_ReturnType Rte_Write_myComponent_myPPort1_myExplicitSimpleData(
    uint32 data)
{
     Std_ReturnType rtn;
     Rte_WriteHook_myComponent_myPPort1_myExplicitSimpleData_Start(data)
         ;
     Rte_Rips_myPlugin_StartWrite_myComponent_myGlobalData1();
     rtn = Rte_EnqueueUInt32(&Rte_Queue_myExplicitSimpleData, data);
     Rte_Rips_myPlugin_StopWrite_myComponent_myGlobalData1();
     Rte_WriteHook_myComponent_myPPort1_myExplicitSimpleData_Return(data
         );
     return rtn;
}

Std_ReturnType Rte_Read_myComponent_myRPort1_myExplicitSimpleData(
    uint32 * data)
{
     Std_ReturnType rtn;
     Rte_ReadHook_myComponent_myRPort1_myExplicitSimpleData_Start(data);
     Rte_Rips_myPlugin_StartRead_myComponent_myGlobalData1();
     rtn = Rte_DequeueUInt32(&Rte_Queue_myExplicitSimpleData, data);
     Rte_Rips_myPlugin_StopRead_myComponent_myGlobalData1();
     Rte_ReadHook_myComponent_myRPort1_myExplicitSimpleData_Return(data)
         ;
     return rtn;
}
```

Code example for `Rte_Buffers.h` when an RTE Implementation Plug-In is associated to the Data Communication Graph:

```
// empty, as the communication is queued
```

Code example for `Rte_Rips_myPlugin_myComponent.h` when an RTE Implementation Plug-In is associated to the Data Communication Graph:

```
#include "Rte_Buffers.h"

```

```
#define Rte_Rips_myPlugin_StartWrite_myComponent_myGlobalData1()
    SuspendOSInterrupts()

#define Rte_Rips_myPlugin_StopWrite_myComponent_myGlobalData1()
    ResumeOSInterrupts()

#define Rte_Rips_myPlugin_StartRead_myComponent_myGlobalData1()
    SuspendOSInterrupts()

#define Rte_Rips_myPlugin_StopRead_myComponent_myGlobalData1()
    ResumeOSInterrupts()
```

7.3.4.6.2 Global copy provided by RTE Implementation Plug-In

In the case the global copy is provided by the RTE Implementation Plug-In the RTE Implementation Plug-In has to provide the read and write RTE Implementation Plug-In Services Rte_Rips_Read and Rte_Rips_Write. Those access services implement the pure data access in a protected manner to the global copy(s) provided by the RTE Implementation Plug-In. Thereby it is assumed, that a data access in an intra ECU communication scenario is always successful. In case the Rte_Rips_Read and Rte_Rips_Write services are used for transformer access the according error codes can occur. (see section 7.3.8.3).

Further on requirements about existence and usage are already stated in section 7.2.4.5.

The creation of the global copy is described in section 7.3.4.5.

[SWS_Rte_80075] DRAFT ⌈ The RTE shall use the data access RTE Implementation Plug-In Services Rte_Rips_Read and Rte_Rips_Write for any explicit access to the Data Communication Graph. ⌋*(SRS_Rte_00300, SRS_Rte_00306)*

The RTE Implementation Plug-Ins will know the possible pre-emptions and provide an appropriate protection implementation.

[SWS_Rte_70090] DRAFT ⌈ The associated Implementation Plug-In shall provide the data access RTE Implementation Plug-In Services Rte_Rips_Read and Rte_Rips_Write with an appropriate protection functionality for any access to the Data Communication Graph. Thereby the RTE Implementation Plug-In shall consider whether the access is non-atomic due to the size of the data and due to the existence of Sender Status or Receiver Status and whether the configured scheduling causes potential pre-emptions during the accesses to the Data Communication Graph. ⌋*(SRS_Rte_00300, SRS_Rte_00306)*

In case of queued communication the RTE Implementation Plug-Ins is additionally obliged to implement the queue.

[SWS_Rte_70107] DRAFT ⌈ In case the swImplPolicy is set to queued in the Data Communication Graph the associated Implementation Plug-In shall implement the queuing according to section 4.3.1.10.2. ⌋*(SRS_Rte_00300, SRS_Rte_00306)*

The protection blocks can be nested, e.g. when a Runnable uses explicit communication while being executed in an ExclusiveArea. It is therefore recommended, to generally use protection block implementations which support nesting. As a minimum, such implementations have to be used where nesting can occur, which would have to be analysed beforehand. On one hand those ExclusiveAreas are relevant which are directly used by the ExecutableEntity (1) accessing the Data Communication Graphs. Additionally those ExclusiveAreas are relevant which are used by all ExecutableEntitys invoking the ExecutableEntity (1) by direct function call with the Data Communication Graph access.

[SWS_Rte_70091] DRAFT ⌈ RTE Implementation Plug-In shall implement the protecting RTE Implementation Plug-In Services Rte_Rips_Read and Rte_Rips_Write in a way, that those support a potential nesting with ExclusiveAreas when it can occur in the call graph. ⌋*(SRS_Rte_00300, SRS_Rte_00306)*

7.3.4.7 Implicit Communication and RTE Implementation Plug-Ins

Generally, implicit access APIs point directly to or work directly on a memory address (the task buffer or the global copy). The goal is therefore to offer a possibility that the RTE Implementation Plug-In defines this memory address. This implies that also the buffer synchronization (i.e. fill and flush) has to be done by the RTE Implementation Plug-In. To do so, it needs a possibility to insert the respective code at the desired positions in the runnable call context (which might be a task body but also a caller's Rte_Call, Rte_Trigger or Rte_Switch API). The RTE in turn has to disable its respective model checks (e.g. if implicit communication is allowed in a certain interruption scenario) and buffer creation for the Data Communication Graphs handled by an RTE Implementation Plug-In.

In case of source code delivered software components, not for all implicit access macros it is strictly necessary that the implicit access macros work on a memory address, but in case of Rte_IWrite or Rte_IRead there could be some more optimized implementations. To make such implementations possible, the RTE should not provide component data structures in case of software components not requiring the compatibility mode due to source code delivery which it should anyway not do in this case to reduce ROM consumption.

The usage of the according RTE Implementation Plug-In Services is described in section 7.2.4.2 and 7.2.4.1.

[SWS_Rte_80044] DRAFT ⌈ The RTE shall use the Data Handles Section and Inter Runnable Variable Handles Section for implicit communication only if the specific software component requires compatibility mode due to delivery as object code or if the specific software component supports multiple instantiations. ⌋*(SRS_Rte_00301, SRS_Rte_00316)*

[SWS_Rte_80046] DRAFT ⌈ The RTE Generator shall inhibit the creation of implicit buffers and according fill and flush routines for a Data Communication Graph if it is assigned to an RTE Implementation Plug-In. ⌋*(SRS_Rte_00301)*

[SWS_Rte_80056] DRAFT ⌈ The RTE shall reject the configuration if any RteImplicitCommunication buffering related needs (RteCoherentAccess or RteImmediateBufferUpdate) affect a Data Communication Graph which is associated to an RTE Implementation Plug-In. ⌋*(SRS_Rte_00301)*

This refers to the section 4.3.1.5.

7.3.4.7.1 Fill Flush Routines

Nevertheless the RTE needs to invoke the Buffer Fill Routines and Buffer Flush Routines at the right place in the call sequence of ExecutableEntitys. In general an RTE Implementation Plug-In is free to implement both functionalities in one common function. Therefore those functions are called Rte_Rips_FillFlushRoutine. The information whether an Rte_Rips_FillFlushRoutine shall be invoked before or after an ExecutableEntity is given by configuration via RteRipsFillRoutineRef and RteRipsFlushRoutineRef at the related RteEventToTaskMapping / RteBswEventToTaskMapping.

[SWS_Rte_80047] DRAFT ⌈ The RTE shall invoke Rte_Rips_FillFlushRoutines configured via RteRipsFillRoutineRef with the identical activation conditions as the RTEEvent / BswEvent mapped by the owing RteEventToTaskMapping / RteBswEventToTaskMapping before the to-be-activated ExecutableEntity gets invoked and after configured RteSyncPoint given via RteEventPredecessorSyncPointRef / RteBswEventPredecessorSyncPointRef is passed. ⌋ *(SRS_Rte_00301)*

[SWS_Rte_80048] DRAFT ⌈ The RTE shall invoke Rte_Rips_FillFlushRoutines configured via RteRipsFlushRoutineRef with the identical activation conditions as the RTEEvent / BswEvent mapped by the owing RteEventToTaskMapping / RteBswEventToTaskMapping after the to-be-activated ExecutableEntity gets invoked. Thereby the Rte_Rips_FillFlushRoutine runs after a configured RteOsSchedulePoint, but before a configured RteSyncPoint given via RteEventSuccessorSyncPointRef / RteBswEventSuccessorSyncPointRef is entered. ⌋*(SRS_Rte_00301)*

[SWS_Rte_80049] DRAFT ⌈ When the RteRipsModeDisablingHandling is set to RTE_RIPS_IGNORE_MODE_DISABLINGS, the RTE shall invoke the configured Rte_Rips_FillFlushRoutines regardless of currently active mode disabling dependencies. ⌋*(SRS_Rte_00301)*

[SWS_Rte_80050] DRAFT ⌈ When the RteRipsModeDisablingHandling is set to RTE_RIPS_CONSIDER_MODE_DISABLINGS, the RTE shall invoke the configured Rte_Rips_FillFlushRoutines, only if the RTEEvent / BswEvent mapped by the owing RteEventToTaskMapping / RteBswEventToTaskMapping is currently not disabled by a mode disabling dependencies. ⌋*(SRS_Rte_00301)*

Please note: The configuration of Rte_Rips_FillFlushRoutines is applicable for any kind of RTEEvent or BswEvent, regardless whether the activated ExecutableEntity has any access to a Data Communication Graph handled by any RTE Implementation Plug-In, and regardless whether the RteEventToTaskMapping or RteBswEventToTaskMapping is mapped to an OsTask, to a RteInitializationRunnableBatch, or no OsTask at all. This enables the RTE Implementation Plug-In to apply its Rte_Rips_FillFlushRoutines at any level in the call graph in any circumstance of activation.

[SWS_Rte_80084] DRAFT ⌈ The RTE Generator shall create an unconditional call to the Os API *Schedule* after the execution of the Rte_Rips_FillFlushRoutine, if the RteRipsOsSchedulePoint configuration parameter is set to UNCONDITIONAL. In the generated code the call to the Os API *Schedule* shall only be performed when the Rte_Rips_FillFlushRoutine itself has been executed (called). ⌋ *(SRS_Rte_00301)*

Please note: A schedule point according [SWS_Rte_80084] is useful to trigger the scheduler of the OS in a pre-emptive task after the implicit communication buffers are written back to the global copy. Therefore RunnableEntitys executed in tasks which get in running state after such schedule point may already see the latest written value. But this depends on the placement of their fill routines.

In opposite, a schedule point placed at the RteEventToTaskMapping via RteOsSchedulePoint is always executed before the execution of the RteRipsOsSchedulePoint and therefore before the implicit communication buffers are written back to the global copy!

7.3.4.7.2 Simple example about implicit w/o component data structure

The example 7.8 shows the basic implementation in case the data is primitive, the Data Communication Graph does not require Sender Status nor Receiver Status, and the software component does not support multiple instantiation and is provided as source code.

Example 7.8

Code example for Rte_DataHandleType.h in case the RTE Generator implements the implicit communication:

```
typedef struct
{
    uint32 value;
} Rte_DE_uint32;

typedef struct
{
```

```
    Rte_DE_uint32 myImplicitSimpleData;
} Rte_PerTaskBuffers_TASK_COOP_10MS_Type;

typedef struct
{
    Rte_DE_uint32 myImplicitSimpleData;
} Rte_PerTaskBuffers_TASK_PREEMPT_1MS_Type;
```

Code example for `Rte_myComponent.h` in case the RTE Generator implements the implicit communication:

```
#include "Rte_DataHandleType.h"

/* task buffer for TASK_COOP_10MS */
extern Rte_PerTaskBuffers_TASK_COOP_10MS_Type
    Rte_PerTaskBuffers_TASK_COOP_10MS;

/* task buffer for TASK_PREEMPT_1MS */
extern Rte_PerTaskBuffers_TASK_PREEMPT_1MS_Type
    Rte_PerTaskBuffers_TASK_PREEMPT_1MS;
#define Rte_IWrite_myProducerRunnable1_myPPort1_myImplicitSimpleData(
    data) ( \
 Rte_PerTaskBuffers_TASK_COOP_10MS.myImplicitSimpleData.value = (data)
    )

#define Rte_IWriteRef_myProducerRunnable1_myPPort1_myImplicitSimpleData
    () ( \
 &Rte_PerTaskBuffers_TASK_COOP_10MS.myImplicitSimpleData.value )
#define Rte_IRead_myConsumerRunnable_myRPort1_myImplicitSimpleData() (
    \
 Rte_PerTaskBuffers_TASK_PREEMPT_1MS.myImplicitSimpleData.value )
```

Code example for `Rte.c` in case the RTE Generator implements the implicit communication:

```
#include "Rte_myComponent.h"

Rte_DE_uint32 Rte_myImplicitSimpleData;

/* task buffer for TASK_COOP_10MS */
Rte_PerTaskBuffers_TASK_COOP_10MS_Type
    Rte_PerTaskBuffers_TASK_COOP_10MS;

/* task buffer for TASK_PREEMPT_1MS */
Rte_PerTaskBuffers_TASK_PREEMPT_1MS_Type
    Rte_PerTaskBuffers_TASK_PREEMPT_1MS;

TASK(TASK_COOP_10MS)
{
    Rte_Runnable_myComponent_myProducerRunnable1_Start();
    myProducerRunnable1();
    Rte_Runnable_myComponent_myProducerRunnable1_Return();
    Rte_myImplicitSimpleData = Rte_PerTaskBuffers_TASK_COOP_10MS.
        myImplicitSimpleData;
}

```

```
TASK(TASK_PREEMPT_1MS)
{
    Rte_PerTaskBuffers_TASK_PREEMPT_1MS.myImplicitSimpleData =
       Rte_myImplicitSimpleData;
    Rte_Runnable_myComponent_myConsumerRunnable_Start();
    myConsumerRunnable();
    Rte_Runnable_myComponent_myConsumerRunnable_Return();
}
```

In the following example the Data Communication Graph is handled by an RTE Implementation Plug-In named myPlugin having RtePluginSupportsIReadIWrite set to true, a flush-routine with RteRipsPluginFillFlushRoutineFncSymbol set to Rips_Flush_Runnable1, and a fill-routine with RteRipsPluginFillFlushRoutineFncSymbol set to Rips_Fill_Runnable1.

Example 7.9

Code example for Rte_DataHandleType.h in case the RTE Implementation Plug-In implements the implicit communication:

```
typedef struct
{
    uint32 value;
} Rte_DE_uint32;

/* wrapper type according SWS_Rte_80079 */
typedef Rte_DE_uint32 Rte_Rips_GlobalCopy_myGlobalData2_Type;
```

Code example for Rte_myComponent.h in case the RTE Implementation Plug-In implements the implicit communication:

```
#include "Rte_DataHandleType.h"
#include "Rte_Rips_myPlugin_myComponent.h"

#define Rte_IWrite_myProducerRunnable1_
   myPPort1_myImplicitSimpleData(data)  ( \
 Rte_Rips_myPlugin_IWrite_myComponent_
    myProducerRunnable1_myGlobalData2(data) )

#define Rte_IWriteRef_myProducerRunnable1_
   myPPort1_myImplicitSimpleData()  ( \
 &Rte_Rips_myPlugin_IWBufferRef_myComponent_
    myProducerRunnable1_myGlobalData2()->value)

#define Rte_IRead_myConsumerRunnable_
   myRPort1_myImplicitSimpleData()  ( \
 Rte_Rips_myPlugin_IRead_myComponent_
    myConsumerRunnable_myGlobalData2() )
```

Code example for Rte.c in case the RTE Implementation Plug-In implements the implicit communication:

```
#include "Rte_myComponent.h"
#include "Rte.h" /* which will include Rte_Rips_myPlugin.h */
```

```

Rte_DE_uint32 Rte_myGlobalData2;

TASK(TASK_COOP_10MS)
{
    Rte_Runnable_myComponent_myProducerRunnable1_Start();
    myProducerRunnable1();
    Rte_Runnable_myComponent_myProducerRunnable1_Return();
    Rips_Flush_Runnable1();
}

TASK(TASK_PREEMPT_1MS)
{
    Rips_Fill_Runnable1();
    Rte_Runnable_myComponent_myConsumerRunnable_Start();
    myConsumerRunnable();
    Rte_Runnable_myComponent_myConsumerRunnable_Return();
}
```

Code example for `Rte_Buffers.h` in case the `RTE Implementation Plug-In` implements the implicit communication:

```
#include "Rte_DataHandleType.h"
#include "Rte_Rips_myPlugin_Buffers.h"

#extern Rte_DE_uint32 Rte_myGlobalData2;

/* the mapping according SWS_Rte_80006 below can be omitted, if the RTE
    Generator names the variable Rte_Rips_GlobalCopy_myGlobalData2 */
#define Rte_Rips_GlobalCopy_myGlobalData2 Rte_myGlobalData2
```

Code example for `Rte_Rips_myPlugin_myComponent.h` in case the `RTE Implementation Plug-In` implements the implicit communication:

```
#include "Rte_Buffers.h"

#define Rte_Rips_myPlugin_IWrite_myComponent_
   myProducerRunnable1_myGlobalData2(data) \
 (Rte_PerTaskBuffers_TASK_COOP_10MS.myGlobalData2.value = data)

#define Rte_Rips_myPlugin_IWBufferRef_myComponent_
   myProducerRunnable1_myGlobalData2() \
 (&Rte_PerTaskBuffers_TASK_COOP_10MS.myGlobalData2)

#define Rte_Rips_myPlugin_IRead_myComponent_
   myConsumerRunnable_myGlobalData2() \
 (Rte_PerTaskBuffers_TASK_PREEMPT_1MS.myGlobalData2.value)
```

Code example for `Rte_Rips_myPlugin_Buffers.h` in case the `RTE Implementation Plug-In` implements the implicit communication:

```
#include "Rte_DataHandleType.h"

/* task buffer type for TASK_COOP_10MS */
typedef struct
{
```

```
    Rte_DE_uint32 myGlobalData2;
} Rte_PerTaskBuffers_TASK_COOP_10MS_Type;

/* task buffer type for server runnable */
typedef struct
{
    Rte_DE_uint32 myGlobalData2;
} Rte_PerTaskBuffers_TASK_PREEMPT_1MS_Type;

/* task buffer for TASK_COOP_10MS */
extern Rte_PerTaskBuffers_TASK_COOP_10MS_Type
    Rte_PerTaskBuffers_TASK_COOP_10MS;

/* task buffer for TASK_PREEMPT_1MS */
extern Rte_PerTaskBuffers_TASK_PREEMPT_1MS_Type
    Rte_PerTaskBuffers_TASK_PREEMPT_1MS;
```

Code example for `Rte_Rips_myPlugin.c` in case the `RTE Implementation Plug-In` implements the implicit communication:

```
#include "Rte_Buffers.h"

/* task buffer for TASK_COOP_10MS */
Rte_PerTaskBuffers_TASK_COOP_10MS_Type
    Rte_PerTaskBuffers_TASK_COOP_10MS;

/* task buffer for TASK_PREEMPT_1MS */

Rte_PerTaskBuffers_TASK_PREEMPT_1MS_Type
    Rte_PerTaskBuffers_TASK_PREEMPT_1MS;
void Rips_Flush_Runnable1(void)
{
   Rte_Rips_GlobalCopy_myGlobalData2 =
       Rte_PerTaskBuffers_TASK_COOP_10MS.myGlobalData2;
}

void Rips_Fill_Runnable1(void)
{
    Rte_PerTaskBuffers_TASK_PREEMPT_1MS.myGlobalData2 =
        Rte_Rips_GlobalCopy_myGlobalData2;
}
```

7.3.4.7.3 Example of object code software component with conversion

The example 7.10 shows the basic implementation in case the data is primitive, the `Communication Graph` does not require Sender Status nor Receiver Status, but has a different resolution on sender and receiver side, the software component does not support multiple instantiation, but is provided as object code. Besides being an object code delivered software component and showing conversion, the example is identical to example 7.8.

Example 7.10

Code example for `Rte_DataHandleType.h` in case the RTE Generator implements the implicit communication:

```
typedef struct
{
    uint16 value;
} Rte_DE_uint16;

typedef struct
{
    uint32 value;
} Rte_DE_uint32;

typedef struct
{
    Rte_DE_uint32 myImplicitSimpleData;
} Rte_PerTaskBuffers_TASK_COOP_10MS_Type;

typedef struct
{
    Rte_DE_uint16 myImplicitSimpleData2;
} Rte_PerTaskBuffers_TASK_PREEMPT_1MS_Type;
```

Code example for `Rte_myComponent.h` (already compiled into the software component) in case the RTE Generator implements the implicit communication:

```
#include "Rte_DataHandleType.h"

typedef struct
{
    Rte_DE_uint16 * myConsumerRunnable_myRPort1_myImplicitSimpleData2;
    Rte_DE_uint32 * myProducerRunnable1_myPPort1_myImplicitSimpleData;
} Rte_CDS_myComponent;

extern CONSTP2CONST(Rte_CDS_myComponent, RTE_CONST, RTE_CONST)
   Rte_Inst_myComponent;

#define Rte_IWrite_myProducerRunnable1_myPPort1_myImplicitSimpleData(
   data) ( \
 Rte_Inst_myComponent->
    myProducerRunnable1_myPPort1_myImplicitSimpleData->value = (data)
    )

#define Rte_IWriteRef_myProducerRunnable1_myPPort1_myImplicitSimpleData
   () ( \
 &Rte_Inst_myComponent->
    myProducerRunnable1_myPPort1_myImplicitSimpleData->value )

#define Rte_IRead_myConsumerRunnable_myRPort1_myImplicitSimpleData2() (
    \
```

```
Rte_Inst_myComponent->
    myConsumerRunnable_myRPort1_myImplicitSimpleData2->value )
```

Code example for `Rte.c` in case the RTE Generator implements the implicit communication:

```
#include "Rte_myComponent.h"

Rte_DE_uint32 Rte_myImplicitSimpleData;

/* task buffer for TASK_COOP_10MS */
Rte_PerTaskBuffers_TASK_COOP_10MS_Type
    Rte_PerTaskBuffers_TASK_COOP_10MS;

/* task buffer for TASK_PREEMPT_1MS */
Rte_PerTaskBuffers_TASK_PREEMPT_1MS_Type
    Rte_PerTaskBuffers_TASK_PREEMPT_1MS;

const Rte_CDS_myComponent Rte_Inst_myComponent = {
     &Rte_PerTaskBuffers_TASK_PREEMPT_1MS.myImplicitSimpleData2,
     &Rte_PerTaskBuffers_TASK_COOP_10MS.myImplicitSimpleData };

TASK(TASK_COOP_10MS)
{
     Rte_Runnable_myComponent_myProducerRunnable1_Start();
     myProducerRunnable1();
     Rte_Runnable_myComponent_myProducerRunnable1_Return();
     Rte_myImplicitSimpleData = Rte_PerTaskBuffers_TASK_COOP_10MS.
         myImplicitSimpleData;
}

TASK(TASK_PREEMPT_1MS)
{
     Rte_PerTaskBuffers_TASK_PREEMPT_1MS.myImplicitSimpleData2 =
         Rte_myImplicitSimpleData/2;
     Rte_Runnable_myComponent_myConsumerRunnable_Start();
     myConsumerRunnable();
     Rte_Runnable_myComponent_myConsumerRunnable_Return();
}
```

In the following example the `Data Communication Graph` is handled by an `RTE Implementation Plug-In`. Due to data conversion two `RIPS FlatInstanceDescriptor`s need to be configured. The first `RIPS FlatInstanceDescriptor` named `myGlobalData2` points to `myImplicitSimpleData` of `myPPort1`. The second `RIPS FlatInstanceDescriptor` named `myGlobalData1` points to data element `myImplicitSimpleData2` of `RPortPrototype` `myRPort1` of the software component `myComponent`.

There is also an additional flush-routine with `RteRipsPluginFillFlushRoutineFncSymbol` = `Rips_Flush_Runnable1` and configured at the `RteEventToTaskMapping` of the `RunnableEntity` `myProducerRunnable1`.

Furthermore there is a fill-routine with RteRipsPluginFillFlushRoutineFncSymbol = Rips_Fill_Runnable1 and configured at the RteEventToTaskMapping of the RunnableEntity myConsumerRunnable.

Example 7.11

Code example for Rte_DataHandleType.h in case the RTE Implementation Plug-In implements the implicit communication:

```
typedef struct
{
    uint16 value;
} Rte_DE_uint16;

typedef struct
{
    uint32 value;
} Rte_DE_uint32;

/* wrapper type according SWS_Rte_80079 */
typedef Rte_DE_uint16 Rte_Rips_GlobalCopy_myGlobalData1_Type;
typedef Rte_DE_uint32 Rte_Rips_GlobalCopy_myGlobalData2_Type;

/* definition of RTE Task buffers are not necessary any longer */
```

Code example for Rte_myComponent.h from contract phase (already compiled into the software component) in case the RTE Implementation Plug-In implements the implicit communication. Please note, that the contract phase is not impacted by the application of RTE Implementation Plug-Ins.

```
#include "Rte_DataHandleType.h"

typedef struct
{
    Rte_DE_uint16 * myConsumerRunnable_myRPort1_myImplicitSimpleData2;
    Rte_DE_uint32 * myProducerRunnable1_myPPort1_myImplicitSimpleData;
} Rte_CDS_myComponent;

extern CONSTP2CONST(Rte_CDS_myComponent, RTE_CONST, RTE_CONST)
    Rte_Inst_myComponent;

#define Rte_IWrite_myProducerRunnable1_myPPort1_myImplicitSimpleData(
    data) ( \
 Rte_Inst_myComponent->
     myProducerRunnable1_myPPort1_myImplicitSimpleData->value = (data)
     )

#define Rte_IWriteRef_myProducerRunnable1_myPPort1_myImplicitSimpleData
    () ( \
 &Rte_Inst_myComponent->
     myProducerRunnable1_myPPort1_myImplicitSimpleData->value )

#define Rte_IRead_myConsumerRunnable_myRPort1_myImplicitSimpleData2() (
     \
```

```
Rte_Inst_myComponent->
    myConsumerRunnable_myRPort1_myImplicitSimpleData2->value )
```

Code example for Rte.c in case the RTE Implementation Plug-In implements the implicit communication:

```
#include "Rte_myComponent.h"
#include "Rte.h"

/* SWS_Rte_80006 is implemented by suitable naming of the RTE variables
    */
Rte_DE_uint16 Rte_Rips_GlobalCopy_myGlobalData1;
Rte_DE_uint32 Rte_Rips_GlobalCopy_myGlobalData2;

const Rte_CDS_myComponent Rte_Inst_myComponent =
{
   Rte_Rips_myPlugin_IRBufferRef_myComponent_
       myConsumerRunnable_myGlobalData1(),
   Rte_Rips_myPlugin_IWBufferRef_myComponent_
       myProducerRunnable1_myGlobalData2()
};

TASK(TASK_COOP_10MS)
{
   Rte_Runnable_myComponent_myProducerRunnable1_Start();
   myProducerRunnable1();
   (Rte_Rips_myPlugin_IWBufferRef_RteCnvmyComponent_
       RteCnvmyProducerRunnable1_myGlobalData1()->value) =
       (Rte_Rips_myPlugin_IRBufferRef_RteCnvmyComponent_
          RteCnvmyProducerRunnable1_myGlobalData2()->value)/2;
   Rte_Runnable_myComponent_myProducerRunnable1_Return();
   Rips_Flush_Runnable1();
}

TASK(TASK_PREEMPT_1MS)
{
   Rips_Fill_Runnable1();
   Rte_Runnable_myComponent_myConsumerRunnable_Start();
   myConsumerRunnable();
   Rte_Runnable_myComponent_myConsumerRunnable_Return();
}
```

7.3.4.8 Inter Runnable Variables and RTE Implementation Plug-Ins

Besides the fact that InterRunnableVariables are used by a SWC internally and use an own set of APIs (i.e. Rte_IrvIRead, Rte_IrvIWrite and Rte_IrvIWriteRef), there is no difference in their implementing code or their need for protection or buffering compared to regular data instances. They shall therefore not be treated differently to regular inter SWC implicit communication. I.e. the InterRunnableVariable will also be referenced by a RIPS FlatInstanceDescriptor and their access APIs will as well be routed via the same RTE Implementation Plug-In Services as regular implicit accesses would be.

There are no specific requirements on InterRunnableVariables since those are already covered in the requirements for Implicit and Explict communication. For instance [SWS_Rte_70015], [SWS_Rte_70016], [SWS_Rte_70017], [SWS_Rte_70018], [SWS_Rte_70019], [SWS_Rte_70021], [SWS_Rte_70023], [SWS_Rte_70025], [SWS_Rte_70050], [SWS_Rte_70056].

7.3.4.9 RTE Implementation Plug-Ins and NvBlockSwComponents

When a Data Communication Graph involves a NvBlockSwComponent (see also 7.3.4.3), the data gets additionally accessed via the callback functions

- Rte_GetMirror (reading)
- Rte_SetMirror (writing)
- Rte_NvMNotifyInitBlock (writing)

provided by the RTE for the NvBlock.

The access to the data shall be considered as an "explicit" like access. Therefore similar protection services and access services are used. In addition the access to the NvBlock can be seen as an overlay of Data Communication Graphs, the first Data Communication Graph described by the VariableDataPrototype instances in the NvBlockSwComponent's ports and the Data Communication Graph of the whole ramBlock.

Please note, that for all of those Data Communication Graphs individual RIPS FlatInstanceDescriptors need to be provided.

Further on its not required, that all Data Communication Graphs overlaying in a NvBlock are associated to the same RTE Implementation Plug-In nor are handled by an RTE Implementation Plug-In at all.

[SWS_Rte_70082] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide a set of Rte_Rips_StartRead and Rte_Rips_StopRead Services for each Data Communication Graph involving a NvBlockSwComponent, if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_RTE.

Thereby

- <SwcBswI> is the SwComponentPrototype's name of the NvBlockSwComponent,
- <ExE> is the name of the callback GetMirror,
- <CGI> is the name of the *Communication Graph Instance* according to [SWS_Rte_70038].

⌋*(SRS_Rte_00300, SRS_Rte_00301)*

[SWS_Rte_70083] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide a set of Rte_Rips_StartWrite and Rte_Rips_StopWrite Services for each Data Communication Graph involving a NvBlockSwComponent, if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_RTE.

Thereby

- <SwcBswI> is the SwComponentPrototype's name of the NvBlockSwComponent,
- <ExE> is the name of the callbacks SetMirror and NvMNotifyInitBlock,
- <CGI> is the name of the *Communication Graph Instance* according to [SWS_Rte_70038].

⌋*(SRS_Rte_00300, SRS_Rte_00301)*

[SWS_Rte_70084] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide the Rte_Rips_Read Service for each Data Communication Graph involving a NvBlockSwComponent, if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_PLUGIN.

Thereby

- <SwcBswI> is the SwComponentPrototype's name of the NvBlockSwComponent,
- <ExE> is the name of the callback GetMirror,

- <CGI> is the name of the Communication Graph Instance according to [SWS_Rte_70038].

⌋(SRS_Rte_00300, SRS_Rte_00301)

[SWS_Rte_70085] DRAFT ⌈ The associated RTE Implementation Plug-In shall provide a set of Rte_Rips_Write Services for each Data Communication Graph involving a NvBlockSwComponents, if

- for the related Data Communication Graph the RTE Implementation Plug-In support is enabled

  AND

- for the associated RTE Implementation Plug-In the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_PLUGIN.

Thereby

- <SwcBswI> is the SwComponentPrototype's name of the NvBlockSwComponent,
- <ExE> is the name of the callbacks SetMirror and NvMNotifyInitBlock,
- <CGI> is the name of the Communication Graph Instance according to [SWS_Rte_70038].

⌋(SRS_Rte_00300, SRS_Rte_00301, SRS_Rte_00303)

For instance for a single data myNvData mapped into a NvBlock in the NvBlockSwComponent myNvBlockSwc the associated RTE Implementation Plug-In - when it has RteRipsGlobalCopyInstantiationPolicy set to RTE_RIPS_INSTANTIATION_BY_RTE - provides the following set of services:

- Rte_Rips_myPlugin_StartRead_myNvBlockSwc_GetMirror_myNvData
- Rte_Rips_myPlugin_StopRead_myNvBlockSwc_GetMirror_myNvData
- Rte_Rips_myPlugin_StartWrite_myNvBlockSwc_SetMirror_myNvData
- Rte_Rips_myPlugin_StopWrite_myNvBlockSwc_SetMirror_myNvData
- Rte_Rips_myPlugin_StartWrite_myNvBlockSwc_NvMNotifyInitBlock_myNvData
- Rte_Rips_myPlugin_StopWrite_myNvBlockSwc_NvMNotifyInitBlock_myNvData

In case the global copy is provided by the RTE and Data Communication Graphs overlay in the ramBlock of a NvBlockSwComponent the order in which the Rte_Rips_StartRead and Rte_Rips_StopRead Services for the different Data Communication Graphs are called needs to be defined.

[SWS_Rte_80104] **DRAFT** ⌈ The RTE Generator shall call the Rte_Rips_StartRead and Rte_Rips_StopRead Services for overlaid Data Communication Graphs in the following order:

1. The Rte_Rips_StartRead / Rte_Rips_StartWrite Service of a Data Communication Graph containing other Data Communication Graphss is called **before** the Rte_Rips_StartRead / Rte_Rips_StartWrite Services of the contained Data Communication Graphs.
2. The Rte_Rips_StopRead / Rte_Rips_StopWrite Service of a Data Communication Graphs containing other Data Communication Graphs is called **after** the Rte_Rips_StopRead / Rte_Rips_StopWrite Service of the contained Data Communication Graphs.

The calls shall be placed in the callback functions

- Rte_GetMirror
- Rte_SetMirror
- Rte_NvMNotifyInitBlock

belonging to the ramBlock of a NvBlockSwComponent. ⌋*(SRS_Rte_00300, SRS_Rte_00301)*

In case the global copy is provided by the RTE Implementation Plug-In it is not useful to call the Rte_Rips_Read and Rte_Rips_Write Services for the Data Communication Graphs which are already contained in another Data Communication Graph.

[SWS_Rte_80105] **DRAFT** ⌈ In case of overlaid Data Communication Graphs the RTE Generator shall only call the Rte_Rips_Read and Rte_Rips_Write Services for the Data Communication Graphs which are not contained in another Data Communication Graph in the callback functions

- Rte_GetMirror
- Rte_SetMirror
- Rte_NvMNotifyInitBlock

belonging to the ramBlock of a NvBlockSwComponent. ⌋*(SRS_Rte_00300, SRS_Rte_00301)*

7.3.4.9.1 Example about source code software component with complex call tree and NV data

The example 7.12 shows a more complex constellation of implicit communication. That is:

- the software component is delivered as source code and

- the software component does not support multiple instantiation and
- the data writing RunnableEntity is executed conditionally (e.g. due to a SwcModeSwitchEvent) and
- the data reading RunnableEntity is executed as a direct function call server and
- writer and reader are called in interrupting tasks and
- the data is part of a RamBlock of an NvBlockSwComponent and
- the NonqueuedReceiverComSpec has handleNeverReceived set to TRUE, the NonqueuedSenderComSpec does not set any option enforcing a data element status and
- the data is an array.

Example 7.12

Code example for Rte_Type.h in case the RTE Generator implements the implicit communication:

```
typedef uint32 myArrayType[4];
```

Code example for Rte_DataHandleType.h in case the RTE Generator implements the implicit communication:

```
typedef struct
{
    myArrayType value;
    Std_ReturnType status;
} Rte_DES_myArrayType;

typedef struct
{
    myArrayType value;
} Rte_DE_myArrayType;

/* NV block type */
typedef struct
{
    myArrayType myBlockElement1;
} myNvBlockType;

/* task buffer type for TASK_COOP_10MS */

typedef struct
{
    Rte_DE_myArrayType myArrayData;
} Rte_PerTaskBuffers_TASK_COOP_10MS_Type;

/* task buffer type for server runnable */

typedef struct
{
```

```
    Rte_DES_myArrayType myArrayData;
} Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation_Type;
```

Code example for `Rte_myComponent.h` in case the RTE Generator implements the implicit communication:

```
#include "Rte_DataHandleType.h"

/* task buffer for TASK_COOP_10MS */
extern Rte_PerTaskBuffers_TASK_COOP_10MS_Type
    Rte_PerTaskBuffers_TASK_COOP_10MS;

/* task buffer for TASK_PREEMPT_1MS */

extern Rte_PerTaskBuffers_TASK_PREEMPT_1MS_Type
    Rte_PerTaskBuffers_TASK_PREEMPT_1MS;

#define Rte_IWriteRef_myProducerRunnable2_myPPort2_myArrayData() ( \
 (uint32 *)&Rte_PerTaskBuffers_TASK_COOP_10MS.myArrayData.value )

#define Rte_IWrite_myProducerRunnable2_myPPort2_myArrayData(data) ( \
 Rte_MemCopy(&Rte_PerTaskBuffers_TASK_COOP_10MS.myArrayData.value, \
data, \
sizeof data); )

#define Rte_IRead_myServerRunnable_myRPort2_myArrayData() ( \
 (const uint32 *) &
     Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation.
     myArrayData.value )

#define Rte_IStatus_myServerRunnable_myRPort2_myArrayData() ( \
Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation.myArrayData.
    status )

#define Rte_Call_myServerRPort_myOperation() \ (
    Rte_Call_myComponent_myServerRPort_myOperation() )
```

Code example for `Rte.c` in case the RTE Generator implements the implicit communication:

```
#include "Rte_myComponent.h"
#include "Rte.h"

Rte_DES_myArrayType Rte_myArrayData = {{0,1,255,4294967295},
    RTE_E_NEVER_RECEIVED};

/* RomBlock */
const myNvBlockType Rte_RomBlock = {{0,1,255,4294967295}};

/* task buffer for TASK_COOP_10MS */
Rte_PerTaskBuffers_TASK_COOP_10MS_Type
    Rte_PerTaskBuffers_TASK_COOP_10MS;

/* task buffer for server runnable */
Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation_Type \
 Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation;
```

```

Std_ReturnType Rte_Call_myComponent_myServerRPort_myOperation(void)
{
    Std_ReturnType rtn;
    Rte_CallHook_myComponent_myServerRPort_myOperation_Start();
    SuspendOsInterrupts();
    Rte_MemCopy(&
        Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation.
        myArrayData, \
    &Rte_myArrayData, \
    sizeof Rte_myArrayData);
    ResumeOsInterrupts();
    Rte_Runnable_myComponent_myServerRunnable_Start()
    myServerRunnable();
    Rte_Runnable_myComponent_myServerRunnable_Return()
    rtn = RTE_E_OK;
    Rte_CallHook_myComponent_myServerRPort_myOperation_Return();
    return rtn;
}

Std_ReturnType Rte_GetMirror_myNvBlockSwc_myNvBlockDescriptor(void *
    NvmBuffer)
{
    SuspendOSInterrupts();
    Rte_MemCopy(&((myNvBlockType *)NvmBuffer)->myBlockElement1,
                &Rte_myArrayData.value,
                sizeof Rte_myArrayData.value);
    ResumeOSInterrupts();
    return RTE_E_OK;
}

Std_ReturnType Rte_NvMNotifyInitBlock_myNvBlockSwc_myNvBlockDescriptor(
    void)
{
    SuspendOSInterrupts();
    Rte_MemCopy(&Rte_myArrayData.value,
                &Rte_RomBlock->myBlockElement1,
                sizeof Rte_myArrayData.value);
    ResumeOSInterrupts();
    return RTE_E_OK;
}

TASK(TASK_COOP_10MS)
{
   Std_ReturnType ret;
   if (...myProducerRunnable2 execution condition...)
   {
      Rte_Runnable_myComponent_myProducerRunnable2_Start();
      myProducerRunnable2();
      Rte_Runnable_myComponent_myProducerRunnable2_Return();
   }
   ... some unrelated runnables ...
   if (...myProducerRunnable2 execution condition...)
   {
      SuspendOsInterrupts();
      Rte_MemCopy(&Rte_myArrayData.value, \
```

```
        &Rte_PerTaskBuffers_TASK_COOP_10MS.myArrayData.value, \
        sizeof Rte_myArrayData.value);
        Rte_myArrayData.status &= (Std_ReturnType)(~RTE_E_NEVER_RECEIVED)
            ;
        ResumeOsInterrupts();
    }
}

TASK(TASK_PREEMPT_1MS)
{
    Rte_Runnable_myComponent_myClientRunnable_Start();
    myClientRunnable(); // will execute
        Rte_Call_myServerRPort_myOperation()
    Rte_Runnable_myComponent_myClientRunnable_Return();
}
```

The following example 7.13 shows an equivalent implementation of the scenario via an RTE Implementation Plug-In. In this case, there exists additionally a Rte_Rips_FillFlushRoutine as RteRipsFlushRoutineRef at the RteEventToTaskMapping for the RTEEvent activating runnable myProducerRunnable2. The RteRipsPluginFillFlushRoutineFncSymbol of the Rte_Rips_FillFlushRoutine is set to Rips_Flush_Runnable2.

Furthermore there exists additionally a Rte_Rips_FillFlushRoutine as RteRipsFillRoutineRef at the RteEventToTaskMapping for the RTEEvent activating runnable myServerRunnable.

And finally, the RAM block of NvBlockDescriptor myNvBlockDescriptor of NvBlockSwComponent myNvBlockSwc is referenced by a RIPS FlatInstanceDescriptor named myRamBlock, which references the RTE Implementation Plug-In myPlugin.

Example 7.13

Code example for Rte_Type.h in case the RTE Generator redirects towards an RTE Implementation Plug-In to implement the scenario:

```
typedef uint32 myArrayType[4];
```

Code example for Rte_DataHandleType.h in case the RTE Generator redirects towards an RTE Implementation Plug-In to implement the scenario:

```
typedef struct
{
    myArrayType value;
} Rte_DE_myArrayType;

typedef struct
{
    myArrayType value;
    Std_ReturnType status;
} Rte_DES_myArrayType;

```

```
/* NV block type */

typedef struct
{
    myArrayType myBlockElement1;
} myNvBlockType;

/* wrapper type according SWS_Rte_80079 */
typedef Rte_DE_myArrayType Rte_Rips_GlobalCopy_myGlobalData3_Type;
typedef Rte_DES_myArrayType Rte_Rips_GlobalCopy_myGlobalData4_Type;
```

Code example for `Rte_myComponent.h` in case the RTE Generator redirects towards an `RTE Implementation Plug-In` to implement the scenario:

```
#include "Rte_DataHandleType.h"
#include "Rte_Rips_myPlugin_myComponent.h"

#define Rte_IWriteRef_myProducerRunnable2_myPPort2_myArrayData() ( \
 Rte_Rips_myPlugin_IWBufferRef_myComponent_myProducerRunnable2_myGlobalData3
    () )

#define Rte_IWrite_myProducerRunnable2_myPPort2_myArrayData(data) ( \
 Rte_MemCopy( \
 Rte_Rips_myPlugin_IWBufferRef_myComponent_myProducerRunnable2_myGlobalData3
    (), \
 data, \
 sizeof data); )

#define Rte_IRead_myServerRunnable_myRPort2_myArrayData() ( \
 (const uint32 *) &Rte_Rips_myPlugin_IRBufferRef_myComponent
    _myServerRunnable_myGlobalData4()->value )

#define Rte_IStatus_myServerRunnable_myRPort2_myArrayData() ( \
  Rte_Rips_myPlugin_IRBufferRef_myComponent
     _myServerRunnable_myGlobalData4()->status )

#define Rte_Call_myServerRPort_myOperation() \
 (Rte_Call_myComponent_myServerRPort_myOperation() )
```

Code example for `Rte.h` in case the RTE Generator redirects towards an `RTE Implementation Plug-In` to implement the scenario:

```
#include "Rte_Rips_myPlugin.h"
```

Code example for `Rte.c` in case the RTE Generator redirects towards an `RTE Implementation Plug-In` to implement the scenario:

```
#include "Rte.h"
#include "Rte_Buffers.h"
#include "Rte_myComponent.h"

Rte_DES_myArrayType Rte_myGlobalData4 = {{0,1,255,4294967295},
    RTE_E_NEVER_RECEIVED};
Rte_DE_myArrayType Rte_myGlobalData3 = {0,1,255,4294967295};

/* RomBlock */
```

```
const myNvBlockType Rte_RomBlock = {{0,1,255,4294967295}};

Std_ReturnType Rte_Call_myComponent_myServerRPort_myOperation(void)
{
    Std_ReturnType rtn;
    Rte_CallHook_myComponent_myServerRPort_myOperation_Start();
    Rips_Fill_Runnable2();
    Rte_Runnable_myComponent_myServerRunnable_Start();
    myServerRunnable();
    Rte_Runnable_myComponent_myServerRunnable_Return();
    rtn = RTE_E_OK;
    Rte_CallHook_myComponent_myServerRPort_myOperation_Return();
    return rtn;
}

Std_ReturnType Rte_GetMirror_myNvBlockSwc_myNvBlockDescriptor(void *
   NvmBuffer)
{
    /* start protection whole ramBlock */
    Rte_Rips_myPlugin_StartRead_myNvBlockSwc_GetMirror_myRamBlock();
    /* start protection single data element */
    Rte_Rips_myPlugin_StartRead_myNvBlockSwc_GetMirror_myGlobalData3();
    Rte_MemCopy(&((myNvBlockType *)NvmBuffer)->myBlockElement1,
    &Rte_myGlobalData3, sizeof Rte_myGlobalData3);
    /* stop protection single data element */
    Rte_Rips_myPlugin_StopRead_myNvBlockSwc_GetMirror_myGlobalData3();
    /* stop protection whole ramBlock */
    Rte_Rips_myPlugin_StopRead_myNvBlockSwc_GetMirror_myRamBlock();
    return RTE_E_OK;
}

Std_ReturnType Rte_NvMNotifyInitBlock_myNvBlockSwc_myNvBlockDescriptor(
   void)
{
   /* start protection whole ramBlock */
   Rte_Rips_myPlugin_StartWrite_myNvBlockSwc_GetMirror_myRamBlock();
   /* start protection single data element */
   Rte_Rips_myPlugin_StartWrite_myNvBlockSwc_GetMirror_myGlobalData3();

   Rte_MemCopy(&Rte_myGlobalData3,
     &Rte_RomBlock->myBlockElement1,
     sizeof Rte_myGlobalData3);

   /* stop protection single data element */
   Rte_Rips_myPlugin_StopWrite_myNvBlockSwc_GetMirror_myGlobalData3();
   /* start protection single data element */
   Rte_Rips_myPlugin_StartWrite_myNvBlockSwc_GetMirror_myGlobalData4();

   Rte_MemCopy(&Rte_myGlobalData4.value,
     &Rte_RomBlock->myBlockElement1,
     sizeof Rte_myGlobalData4.value);

   /* stop protection single data element */
   Rte_Rips_myPlugin_StopWrite_myNvBlockSwc_GetMirror_myGlobalData4();
   /* stop protection whole ramBlock */
   Rte_Rips_myPlugin_StopWrite_myNvBlockSwc_GetMirror_myRamBlock();
```

```
    return RTE_E_OK;
}

TASK(TASK_COOP_10MS)
{
    Std_ReturnType ret;
    if (...myProducerRunnable2 execution condition...)
    {
        Rte_Runnable_myComponent_myProducerRunnable2_Start();
        myProducerRunnable2();
        Rte_MemCopy(
          Rte_Rips_myPlugin_IWBufferRef_myComponent
              _myProducerRunnable2_myGlobalData4(),
          Rte_Rips_myPlugin_IWBufferRef_myComponent
              _myProducerRunnable2_myGlobalData3(),
          sizeof Rte_myGlobalData4.value);
        Rte_Rips_myPlugin_IWBufferRef_myComponent
            _myProducerRunnable2_myGlobalData4()->status
          &= (Std_ReturnType)(~RTE_E_NEVER_RECEIVED);
        Rte_Runnable_myComponent_myProducerRunnable2_Return();
        Rips_Flush_Runnable2();
    }
    ... some unrelated runnables ...
    /* RTE specifc buffer handling at the end of the task is inhibited
        */
}

TASK(TASK_PREEMPT_1MS)
{
    Rte_Runnable_myComponent_myClientRunnable_Start();
    myClientRunnable(); // will execute
        Rte_Call_myServerRPort_myOperation()
    Rte_Runnable_myComponent_myClientRunnable_Return();
}
```

Code example for `Rte_Buffers.h` in case the RTE Generator redirects towards an `RTE Implementation Plug-In` to implement the scenario:

```
#include "Rte_DataHandleType.h"
#include "Rte_Rips_myPlugin_Buffers.h"

/* the mapping according SWS_Rte_80006 below can be omitted, if the RTE
     Generator names the variable Rte_Rips_GlobalCopy_myGlobalData4 */
extern Rte_DES_myArrayType Rte_myGlobalData4;

#define Rte_Rips_GlobalCopy_myGlobalData4 Rte_myGlobalData4

/* the mapping according SWS_Rte_80006 below can be omitted, if the RTE
     Generator names the variable Rte_Rips_GlobalCopy_myGlobalData3 */
extern Rte_DE_myArrayType Rte_myGlobalData3;

#define Rte_Rips_GlobalCopy_myGlobalData3 Rte_myGlobalData3
```

Code example for `Rte_Rips_myPlugin_myComponent.h` in case the RTE Generator redirects towards an `RTE Implementation Plug-In` to implement the scenario:

```
#include "Rte_Buffers.h"

#define Rte_Rips_myPlugin_IWBufferRef_myComponent
    _myProducerRunnable2_myGlobalData3() \
 &Rte_PerTaskBuffers_TASK_COOP_10MS.myGlobalData3

#define Rte_Rips_myPlugin_IWBufferRef_myComponent
    _myProducerRunnable2_myGlobalData4() \
 &Rte_PerTaskBuffers_TASK_COOP_10MS.myGlobalData4

#define
    Rte_Rips_myPlugin_IRBufferRef_myComponent_myServerRunnable_myGlobalData4
    () \
 &Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation.
     myGlobalData4
```

Code example for `Rte_Rips_myPlugin_Buffers.h` in case the RTE Generator redirects towards an `RTE Implementation Plug-In` to implement the scenario:

```
#include "Rte_DataHandleType.h"

/* task buffer type for TASK_COOP_10MS */

typedef struct
{
    Rte_DE_myArrayType myGlobalData4;
    Rte_DES_myArrayType myGlobalData3;
} Rte_PerTaskBuffers_TASK_COOP_10MS_Type;

/* task buffer type for server runnable */

typedef struct
{
    Rte_DES_myArrayType myGlobalData3;
} Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation_Type;

/* task buffer for TASK_COOP_10MS */

extern Rte_PerTaskBuffers_TASK_COOP_10MS_Type
    Rte_PerTaskBuffers_TASK_COOP_10MS;
/* task buffer for server runnable */

extern Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation_Type \
 Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation;
```

Code example for `Rte_Rips_myPlugin.h` in case the RTE Generator redirects towards an `RTE Implementation Plug-In` to implement the scenario:

```
#define Rte_Rips_myPlugin_FillEnter_Rips_Fill_Runnable2() \
  SuspendOSInterrupts()
#define Rte_Rips_myPlugin_FillExit_Rips_Fill_Runnable2() \
  ResumeOSInterrupts()
#define Rte_Rips_myPlugin_FlushEnter_Rips_Flush_Runnable2() \
  SuspendOSInterrupts()
#define Rte_Rips_myPlugin_FlushExit_Rips_Flush_Runnable2() \
  ResumeOSInterrupts()
```

```
#define Rte_Rips_myPlugin_StartReadCallback_NvM_myRamBlock() \
  SuspendOSInterrupts()
#define Rte_Rips_myPlugin_StopReadCallback_NvM_myRamBlock() \
  ResumeOSInterrupts()
#define Rte_Rips_myPlugin_StartWriteCallback_NvM_myRamBlock() \
  SuspendOSInterrupts()
#define Rte_Rips_myPlugin_StopWriteCallback_NvM_myRamBlock() \
  ResumeOSInterrupts()
```

Code example for `Rte_Rips_myPlugin.c` in case the RTE Generator redirects towards an `RTE Implementation Plug-In` to implement the scenario:

```
#include "Rte_Buffers.h"

/* task buffer for TASK_COOP_10MS */
Rte_PerTaskBuffers_TASK_COOP_10MS_Type
    Rte_PerTaskBuffers_TASK_COOP_10MS;

/* task buffer for server runnable */
Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation_Type \
 Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation;

void Rips_Flush_Runnable2(void)
{
   Rte_MemCopy(&Rte_Rips_GlobalCopy_myGlobalData3, \
     &Rte_PerTaskBuffers_TASK_COOP_10MS.myGlobalData3, \
     sizeof Rte_Rips_GlobalCopy_myGlobalData3);
     Rte_MemCopy(&Rte_Rips_GlobalCopy_myGlobalData4, \
     &Rte_PerTaskBuffers_TASK_COOP_10MS.myGlobalData4, \
     sizeof Rte_Rips_GlobalCopy_myGlobalData4);
}

void Rips_Fill_Runnable2(void)
{
    Rte_MemCopy(&
       Rte_PerTaskBuffers_myComponent_myServerRPort_myOperation.
       myGlobalData3, \
    &Rte_Rips_GlobalCopy_myGlobalData3, \
    sizeof Rte_Rips_GlobalCopy_myGlobalData3);
}
```

7.3.5 Exclusive Areas

7.3.5.1 Exclusive Areas and RTE Implementation Plug-Ins

For `ExclusiveArea`s RTE already offers a possibility to configure which protection mechanism shall be used for any given `ExclusiveArea`. The mechanisms foreseen are described in section 4.2.5.5.1. Nevertheless the AUTOSAR standardized configuration does not foresee a detailed specification of the applied mechanism, e.g. a specific spin lock, nor it defines guaranteed optimizations, e.g. omitting the blocking from the highest prior call context or call contexts which are executed exclusively on the whole ECU. Additionally in complex dynamic architectures (like for multi / many core systems) a fine grained selection - usually tool based - of the appropriate blocking mechanism is beneficial to avoid unnecessary block and unblock activity as well as to avoid the unnecessary blocking of cores without interference to the impacted ExclusiveAreas.

To overcome this limitation the RTE Implementation Plug-In has to choose an appropriate implementation and the RTE has to suspend its related model acceptance checks. As not every ExclusiveArea will need a treatment beyond RTE internal mechanisms, individual ExclusiveAreas can be assigned to a specific RTE Implementation Plug-In.

Regarding ExclusiveAreas there is no difference between source code and object code integrated software components, except that for source code integrated software components the RTE is free to implement the Rte_Enter and Rte_Exit API already in the application header file. Therefore the statements in this chapter are valid for both source and object code integrated software components.

There are two kinds of ExclusiveAreas, the ones which can explicitly be entered and left inside an ExecutableEntity (in canEnterExclusiveArea role) and the ones which protect the complete ExecutableEntity (in runsInsideExclusiveArea role). Related examples are shown in individual chapters.

When invoking the RTE Implementation Plug-In Service to enter or exit an ExclusiveArea, the RTE Generator has to respect the granularity of the Rte_Rips_Enter and Rte_Rips_Exit Services depending on whether the ExclusiveArea is handled as

- runsInsideExclusiveArea
- canEnterExclusiveArea

  AND in the second case whether the respective apiPrinciple is set to

- perExecutable

  OR

- common.

[SWS_Rte_80022] DRAFT ⌈ If an ExecutableEntity defines a canEnterExclusiveArea association, the RTE Generator shall call the corresponding Rte_Rips_Enter and Rte_Rips_Exit Services inside the belonging Rte_Enter and Rte_Exit APIs. ⌋*(SRS_Rte_00302)*

[SWS_Rte_80023] DRAFT ⌈ If an ExecutableEntity defines a runsInsideExclusiveArea association, the RTE shall call the corresponding Rte_Rips_Enter and Rte_Rips_Exit Services where the according RunnableEntity or BswModuleEntity is called due to the activation of a specific RTEEvent or BswEvent. ⌋*(SRS_Rte_00302)*

Please note: If the related event has been mapped as a direct function call, this can be inside another RTE API. In case the event is mapped to a task it is inside the according task body.

7.3.5.2 Enable RTE Implementation Plug-In support for ExclusiveAreas

[SWS_Rte_80024] DRAFT ⌈ The RTE Generator shall enable the RTE Implementation Plug-In support for the related ExclusiveArea, if the related RteExclusiveAreaImplMechanism is set to RTE_PLUGIN. ⌋*(SRS_Rte_00302)*

[SWS_Rte_CONSTR_80000] DRAFT ⌈RTE_PLUGIN in RteExclusiveAreaImplementation requires the configuration of an RTE Implementation Plug-In The usage of the enumeration literal RTE_PLUGIN for the parameter RteExclusiveAreaImplMechanism requires the configuration of the reference RteExclusiveAreaResponsibleRipsPluginRef in the owning container RteExclusiveAreaImplementation. ⌋*(SRS_Rte_00302)*

[SWS_Rte_CONSTR_80001] DRAFT ⌈RTE_PLUGIN in RteBswExclusiveAreaImpl requires the configuration of an RTE Implementation Plug-In The usage of the enumeration literal RTE_PLUGIN for the parameter RteExclusiveAreaImplMechanism requires the configuration of the reference RteBswExclusiveAreaResponsibleRipsPluginRef in the owning container RteBswExclusiveAreaImpl. ⌋*(SRS_Rte_00302)*

7.3.5.3 Exclusive Areas in Role canEnterExclusiveArea

The ExclusiveAreas which a software component or Basic Software Module can explicitly enter and exit are referenced in the ExecutableEntity property canEnterExclusiveArea. The according RTE and SchM APIs only differ in their name, not their content. The examples therefore only show the RTE flavor. The content of the file Rte_myComponent.h represents the version for source code integrated software components and Basic Software Modules. The implementation in Rte.c represents the version for object code integrated software components and Basic Software Modules. This is only to demonstrate the different implementation flavors.

The following example 7.14 shows an implementation of the ExclusiveArea with the RTE Generator where the RTE Generator uses OS_INTERRUPT_BLOCKING.

Example 7.14

Code example for Rte_myComponent.h in case the RTE Generator implements the ExclusiveArea:

```
#define Rte_Enter_myExclusiveArea1() ( \
 (Rte_EnterHook_myComponent_myExclusiveArea1_Start()), \
 SuspendOSInterrupts(), \
 (Rte_EnterHook_myComponent_myExclusiveArea1_Return()) )
```

```
#define Rte_Exit_myExclusiveArea1() ( \
 (Rte_ExitHook_myComponent_myExclusiveArea1_Start()), \
 ResumeOSInterrupts(), \
 (Rte_ExitHook_myComponent_myExclusiveArea1_Return()) )
```

Code example for `Rte.c` in case the RTE Generator implements the `ExclusiveArea`:

```
#include "Rte_myComponent.h"
void Rte_Enter_myComponent_myExclusiveArea1(void)
{
    Rte_EnterHook_myComponent_myExclusiveArea1_Start();
    SuspendOSInterrupts();
    Rte_EnterHook_myComponent_myExclusiveArea1_Return();
}

void Rte_Exit_myComponent_myExclusiveArea1(void)
{
    Rte_ExitHook_myComponent_myExclusiveArea1_Start();
    ResumeOSInterrupts();
    Rte_ExitHook_myComponent_myExclusiveArea1_Return();
}
```

The following example 7.15 shows an equivalent implementation of the `ExclusiveArea` via an `RTE Implementation Plug-In`.

Example 7.15

Code example for `Rte_myComponent.h` in case the RTE Generator redirects towards an `RTE Implementation Plug-In` to implement the `ExclusiveArea`:

```
#include "Rte_Rips_myPlugin_myComponent.h"
#define Rte_Enter_myExclusiveArea1() ( \
  (Rte_EnterHook_myComponent_myExclusiveArea1_Start()), \
  Rte_Rips_myPlugin_Enter_myComponent_myExclusiveArea1(), \
  (Rte_EnterHook_myComponent_myExclusiveArea1_Return()) )

#define Rte_Exit_myExclusiveArea1() ( \
 (Rte_ExitHook_myComponent_myExclusiveArea1_Start()), \
 Rte_Rips_myPlugin_Exit_myComponent_myExclusiveArea1(), \
 (Rte_ExitHook_myComponent_myExclusiveArea1_Return()) )
```

Code example for `Rte.c` in case the RTE Generator redirects towards an `RTE Implementation Plug-In` to implement the `ExclusiveArea`:

```
#include "Rte_myComponent.h"
void Rte_Enter_myComponent_myExclusiveArea1(void)
{
    Rte_EnterHook_myComponent_myExclusiveArea1_Start();
    Rte_Rips_myPlugin_Enter_myComponent_myExclusiveArea1();
    Rte_EnterHook_myComponent_myExclusiveArea1_Return();
}

```

```
void Rte_Exit_myComponent_myExclusiveArea1(void)
{
    Rte_ExitHook_myComponent_myExclusiveArea1_Start();
    Rte_Rips_myPlugin_Exit_myComponent_myExclusiveArea1();
    Rte_ExitHook_myComponent_myExclusiveArea1_Return();
}
```

Code example for `Rte_Rips_myPlugin_myComponent.h` when the Plug-in chooses OS Interrupt suspension to implement the `ExclusiveArea`:

```
#define Rte_Rips_myPlugin_Enter_myComponent_myExclusiveArea1()
    SuspendOSInterrupts()
#define Rte_Rips_myPlugin_Exit_myComponent_myExclusiveArea1()
    ResumeOSInterrupts()
```

7.3.5.4 Exclusive Areas in Role runsInsideExclusiveArea

The `ExclusiveArea`s which enclose the complete `ExecutableEntity` of a software component or Basic Software Modules are referenced in the `ExecutableEntity` property `runsInsideExclusiveArea`. Such `ExclusiveArea`s do not result in the generation of an API, but in protective actions before the `ExecutableEntity` starts and after it terminates.

The following example 7.16 shows an implementation of the `ExclusiveArea` where the whole `RunnableEntity` `runsInsideExclusiveArea` and where the RTE Generator uses `OS_INTERRUPT_BLOCKING`.

Example 7.16

Code example for `Rte.c` in case the RTE Generator implements the `ExclusiveArea`:

```
#include "Rte.h"
TASK(TASK_COOP_10MS)
{
    SuspendOSInterrupts();
    Rte_Runnable_myComponent_EvMyRunnable10ms_Start();
    myRunnable();
    Rte_Runnable_myComponent_EvMyRunnable10ms_Return();
    ResumeOSInterrupts();
}
```

The following example 7.17 shows an equivalent implementation of the `ExclusiveArea` via an `RTE Implementation Plug-In`.:

Example 7.17

Code example for `Rte.c` in case the RTE Generator redirects towards an `RTE Implementation Plug-In` to implement the `ExclusiveArea`:

```
#include "Rte.h"
#include "Rte_Rips_myPlugin_myComponent.h"
TASK(TASK_COOP_10MS)
{
    Rte_Runnable_myComponent_EvMyRunnable10ms_Start();
    Rte_Rips_myPlugin_Enter_myComponent_EvMyRunnable10ms_myExclusiveArea
        ();
    myRunnable();
    Rte_Rips_myPlugin_Exit_myComponent_EvMyRunnable10ms_myExclusiveArea
        ();
    Rte_Runnable_myComponent_EvMyRunnable10ms_Return();
}
```

Code example for `Rte_Rips_myPlugin_myComponent.h` when the Plug-in chooses OS Interrupt suspension to implement the Exclusive Area:

```
#define
    Rte_Rips_myPlugin_Enter_myComponent_EvMyRunnable10ms_myExclusiveArea
    () \
  SuspendOSInterrupts()

#define
    Rte_Rips_myPlugin_Exit_myComponent_EvMyRunnable10ms_myExclusiveArea
    () \
  ResumeOSInterrupts()
```

7.3.6 Modes

7.3.6.1 Modes and RTE Implementation Plug-Ins

Without RTE Implementation Plug-Ins the protection of the mode queues is a duty of the RTE Generator. Due to the requirements on mode machine instances and distributed shared mode queues for queuing and consistent reading of a set of mode values (current mode, previous mode, next mode) via Rte_Mode APIs, it is very likely that the implementation requires a protection mechanism.

But in case RTE Implementation Plug-Ins are applied there is an interest to control the applied protection mechanisms for basically two reasons:

- The applied protection mechanisms shall fit to the overall strategy of protection mechanisms applied for Communication Graphs.
- If RTE Implementation Plug-Ins are used to support a scheduling setup which the RTE Generator cannot handle via its implementation, it is consistently required to move also the protection of mode queues to the responsibility of the RTE Implementation Plug-Ins.

Nevertheless the supporting pattern for those protections deviates from the pattern defined for data communication. There are two rationales for this deviation:

An ECU usually uses a high number of data communications which in turn results in a high frequency of calls to communication APIs. In opposite the number of mode machine instances is significantly lower. Furthermore modes are not switched such frequently. But on the other hand the implementation of mode machine instances and distributed shared mode queues is not purely driven by the accessing ExecutableEntitys. Furthermore the requirements to apply mode disablings and to dequeue mode switch notification at the end of transitions result in mode queue accesses in the context of OsTasks.

For this reason the RTE Implementation Plug-In Service Rte_Rips_EnterModeQueue and Rte_Rips_ExitModeQueue are designed like exclusive areas without a specific name space for the call context.

7.3.6.2 Enable RTE Implementation Plug-In support for mode machine instances

[SWS_Rte_80082] DRAFT ⌈ The RTE Generator shall enable the RTE Implementation Plug-In support for a mode machine instance, if the related RteModeMachineInstanceConfig or RteBswModeMachineInstanceConfig container contains the reference RteModeMachineInstanceResponsibleRipsPluginRef. ⌋ *(SRS_Rte_00315)*

7.3.6.3 Enable RTE Implementation Plug-In support for distributed shared mode queues

[SWS_Rte_80083] DRAFT ⌈ The RTE Generator shall enable the RTE Implementation Plug-In support for a distributed shared mode queue, if the related RteDistributedSharedModeQueue container contains the reference RteDSMQResponsibleRipsPluginRef. ⌋ *(SRS_Rte_00310)*

In case the mode machine instance belongs to a distributed shared mode queue the participating mode machine instances cannot be associated with an RTE Implementation Plug-In. Since the distributed shared mode queue requires a common queue handling for all mode machine instances, a consistent protection mechanism for all mode machine instances is required. Therefore the individual assignment of mode machine instances to RTE Implementation Plug-Ins is not possible.

[SWS_Rte_CONSTR_80012] DRAFT ⌈mode machine instance belonging to a distributed shared mode queue is not allowed to be configured for individual RTE Implementation Plug-In support In case a mode machine instance belongs to a distributed shared mode queue the reference RteModeMachineInstanceResponsibleRipsPluginRef shall not be configured. ⌋ *(SRS_Rte_00310)*

Nevertheless, when a mode machine instance belongs to a distributed shared mode queue which is assigned to an RTE Implementation Plug-In, the protection of all accesses to the mode machine instance which require protection are implemented via the RTE Implementation Plug-In.

7.3.6.4 RTE Implementation Plug-In support for distributed shared mode queues

The RTE Implementation Plug-In support for a distributed shared mode queue has the purpose to connect an external task coordinator functionality implemented as part of the RTE Implementation Plug-In. This enables a well defined ramp-down and ramp-up of the task schedule during a mode switch. Further on such an RTE Implementation Plug-In can actively manage the gap in the periodic schedule in which mode switches are processed. For instances this might be implemented with the means of priority ceiling caused by getting an OsResource.

Each mode switch of a mode machine instance belonging to a distributed shared mode queue causes the following four kind of notifications:

1. Rte_Rips_DsmqSwitch indicates that a mode switch notification was enqueued or discarded.
2. Rte_Rips_DsmqTransitionStart indicates the start of each (non chained) DSMQ transition OsTask.
3. Rte_Rips_DsmqTransitionSync indicates that DSMQ transition OsTask has executed its mapped on-entry ExecutableEntitys, on-transition ExecutableEntitys, and on-exit ExecutableEntitys for this mode switch.
4. Rte_Rips_DsmqTransitionEnd indicates the successful completion of the previous mode switch and (if applicable) the enqueueing of the next mode switch.

7.3.6.4.1 DSMQ transition OsTask activation

In order to ensure a constant number of notification calls to the RTE Implementation Plug-In for any mode switch following requirement applies:

[SWS_Rte_80125] DRAFT ⌈ The RTE shall always activate all non-chained DSMQ transition OsTasks when a new mode transition starts, regardless whether any on-entry ExecutableEntitys, on-transition ExecutableEntitys, or on-exit ExecutableEntitys of the currently switching mode machine instance is mapped to such an OsTask. ⌋*(SRS_Rte_00311)*

7.3.6.4.2 Rte_Rips_DsmqSwitch indication

[SWS_Rte_80111] DRAFT ⌈ The RTE shall call the Rte_Rips_DsmqSwitch Service in the Rte_Switch API of the related mode manager of the mode machine instance , if the RTE Implementation Plug-In support for a distributed shared mode queue is enabled. ⌋*(SRS_Rte_00311)*

Thereby the parameters are set according to the following requirements:

[SWS_Rte_80112] DRAFT ⌈ In case the Rte_Switch API enqueued into an empty distributed shared mode queue, the RTE shall pass the current mode of the related mode machine instance as parameter previousmode, the requested mode as parameter nextmode, and RTE_DSMQ_ENQUEUED_FIRST as parameter dsmqstatus to the Rte_Rips_DsmqSwitch Service. ⌋*(SRS_Rte_00311)*

[SWS_Rte_80113] DRAFT ⌈ In case the Rte_Switch API enqueued into a non empty distributed shared mode queue, the RTE shall pass the requested mode as parameter nextmode and RTE_DSMQ_ENQUEUED_NOT_FIRST as parameter dsmqstatus to the Rte_Rips_DsmqSwitch Service. ⌋*(SRS_Rte_00311)*

[SWS_Rte_80114] DRAFT ⌈ In case the Rte_Switch API could not enqueue into the distributed shared mode queue, the RTE shall pass the requested mode as parameter nextmode and RTE_DSMQ_ENQUEUE_FAILED as parameter dsmqstatus to the Rte_Rips_DsmqSwitch Service. ⌋*(SRS_Rte_00311)*

Please note: In case of [SWS_Rte_80113] and [SWS_Rte_80114] it is possible that a mode transition of this mode machine instance is ongoing. Therefore the parameter previousmode is not reliable since it may change at any time during the execution of the Rte_Rips_DsmqSwitch Service. Therefore the value of the parameter previousmode is implementation specific and will not be evaluated by the RTE Implementation Plug-In.

7.3.6.4.3 Rte_Rips_DsmqTransitionStart indication

[SWS_Rte_80115] DRAFT ⌈ The RTE shall call the Rte_Rips_DsmqTransitionStart Service of the mode machine instance related to the to be performed mode switch in each DSMQ transition OsTask participating in the distributed shared mode queue

- after the RTE examined the mode transition to be performed in this OsTask execution and
- before calling any ExecutableEntity in this task and
- before any operation on the implicit buffers of this task.

⌋*(SRS_Rte_00311)*

[SWS_Rte_80116] DRAFT ⌈ The RTE shall pass the mode from which the mode switch will be performed as parameter previousmode to the Rte_Rips_DsmqSwitch Service. ⌋*(SRS_Rte_00311)*

[SWS_Rte_80117] DRAFT ⌈ The RTE shall pass the mode to which the mode switch will be performed as parameter nextmode to the Rte_Rips_DsmqSwitch Service. ⌋*(SRS_Rte_00311)*

Thereby the the RTE can assume that the Rte_Rips_DsmqSwitch Service will not return before all "non-chained" DSMQ transition OsTasks participating in the distributed shared mode queue called the Rte_Rips_DsmqSwitch Service.

[SWS_Rte_70109] DRAFT ⌈ The RTE Implementation Plug-In shall stay in the Rte_Rips_DsmqSwitch Service until all Rte_Rips_DsmqSwitch Services of "non-chained" DSMQ transition OsTasks are entered. ⌋*(SRS_Rte_00315)*

7.3.6.4.4 Rte_Rips_DsmqTransitionSync indication

[SWS_Rte_80118] DRAFT ⌈ The RTE shall call the Rte_Rips_DsmqTransitionSync Service of the DSMQ transition OsTask

- after termination of any on-exit ExecutableEntitys, on-transition ExecutableEntitys, and on-entry ExecutableEntitys in this task
- and after any operation on the implicit buffers of this task,
- before any manipulation of the distributed shared mode queue (e.g the dequeuing the next transition).

⌋*(SRS_Rte_00311)*

Thereby the Rte_Rips_DsmqTransitionSync Service combines two functionalities. On one hand it is a synchronization point between concurrently executed DSMQ transition OsTasks. On the other hand the return value controls when and in which OsTask the dequeue operation on the distributed shared mode queue is done.

[SWS_Rte_70115] DRAFT ⌈ The RTE Implementation Plug-In shall return for exactly one Rte_Rips_DsmqTransitionSync Service TRUE, and for all others (if present) FALSE. ⌋*(SRS_Rte_00315)*

Please note: The return value of Rte_Rips_DsmqTransitionSync Service is decided at runtime and can change between different mode switches.

[SWS_Rte_80119] DRAFT ⌈ The RTE shall only execute the dequeue operation on the distributed shared mode queue in the DSMQ transition OsTasks in which the Rte_Rips_DsmqTransitionSync Service returned TRUE. ⌋*(SRS_Rte_00311)*

7.3.6.4.5 Rte_Rips_DsmqTransitionEnd indication

[SWS_Rte_80120] DRAFT ⌈ The RTE shall call the Rte_Rips_DsmqTransitionEnd Service in the DSMQ transition OsTask in which the dequeue operation is executed (see [SWS_Rte_80119]) after the distributed shared mode queue has been manipulated and the new mode has been made visible to the mode users, but before the execution of ModeSwitchAck ExecutableEntitys. ⌋ *(SRS_Rte_00311)*

[SWS_Rte_80121] DRAFT ⌈ The RTE shall treat the time between the dequeue operation of the current mode switch and the return of the Rte_Rips_DsmqTransitionEnd Service of the current mode switch as a critical section. Enqueue operations into this distributed shared mode queue occurring during the critical section shall be executed when the critical section is left. ⌋ *(SRS_Rte_00311)*

Note: Since the distributed shared mode queue is protected by a pair of Rte_Rips_EnterModeQueue and Rte_Rips_ExitModeQueue Services, [SWS_Rte_80121] requires the following sequence:

1. call of Rte_Rips_EnterModeQueue
2. manipulation of the distributed shared mode queue (set new current mode, dequeue next mode transition)
3. call of Rte_Rips_DsmqTransitionEnd
4. call of Rte_Rips_ExitModeQueue.

Thereby the parameters are set according to the following requirements:

[SWS_Rte_80122] DRAFT ⌈ In case the distributed shared mode queue was emptied by the mode switch, the RTE shall pass RTE_DSMQ_DEQUEUED_LAST as parameter dsmqstatus, the mode from which the mode switch was performed as parameter previousmode, and the mode to which the mode switch was performed as parameter nextmode to the Rte_Rips_DsmqTransitionEnd Service to the just switched mode machine instance. ⌋ *(SRS_Rte_00311)*

[SWS_Rte_80123] DRAFT ⌈ In case the distributed shared mode queue was not emptied by the mode switch, the RTE shall pass RTE_DSMQ_DEQUEUED_NOT_LAST as parameter dsmqstatus, the mode from which the next mode switch will be performed as parameter previousmode, and the mode to which the next mode switch will be performed as parameter nextmode to the Rte_Rips_DsmqTransitionEnd Service related to the next to be switched mode machine instance. ⌋ *(SRS_Rte_00311)*

[SWS_Rte_80124] DRAFT ⌈ In case the distributed shared mode queue was not emptied by the mode switch, the RTE shall activate the non chained DSMQ transition OsTasks participating in the distributed shared mode queue after the Rte_Rips_DsmqTransitionEnd Service returned. ⌋ *(SRS_Rte_00311)*

7.3.7 Compatibility Mode

7.3.7.1 Detection of source code vs. object code software components

AUTOSAR provides means to describe the delivery content of a software component. It also describes the different behavior in case of source code and object code deliveries. But what is missing there is a rule how to detect the kind of delivery out of the component description. Thereby [SWS_Rte_80045] shall ensure a consistent behavior of RTE Generator and RTE Implementation Plug-Ins.

[SWS_Rte_80045] DRAFT ⌈ The Rte Generator and the RTE Implementation Plug-Ins shall discover a source code delivery of a software component, if the according SwcImplementation mentions at least one codeDescriptor.artifactDescriptor category set to SWSRC and none of category SWOBJ. ⌋ *(SRS_Rte_00316)*

Note: In all other cases the software component is delivered as object code.

7.3.7.2 Compatibility Mode and RTE Implementation Plug-Ins

The usage of the RTE Implementation Plug-In Services by the RTE is transparent for the software component. When a RTE has to support compatibility mode, e.g. due to an object code delivered software component, the RTE Implementation Plug-In Services are used either in the real RTE API C-functions or in the component data structure only.

As a consequence, applying RTE Implementation Plug-Ins does not impact the *contract phase*.

Nevertheless the RTE Implementation Plug-Ins has to consider the usage of the Rte_Rips_IRBufferRef and Rte_Rips_IWBufferRef Services for the initialization of the handles in the component data structure.

[SWS_Rte_70108] DRAFT ⌈ In case an Atomic Software Component requires compatibility mode due to object code integration (see [SWS_Rte_80045]) or the software component supports multiple instantiation, the associated RTE Implementation Plug-In shall implement all Rte_Rips_IRBufferRef and Rte_Rips_IWBufferRef Services for every instance of this Atomic Software Component in a way that those services can be used as static initializer. ⌋ *(SRS_Rte_00306, SRS_Rte_00301)*

7.3.8 Transformers

7.3.8.1 Enable RTE Implementation Plug-In support for client server transformers

In case a Sender Receiver Communication uses data transformation, enabling of the RTE Implementation Plug-In support is exactly as described in section 7.3.4.1.

In case a Client Server Communication uses data transformation, enabling of the RTE Implementation Plug-In support is done as follows:

[SWS_Rte_80067] DRAFT ⌈ The RTE Generator shall enable the RTE Implementation Plug-In support for a Client Server Communication Graph, if a FlatInstanceDescriptor with rtePluginProps references the Client Server Communication Graph. ⌋*(SRS_Rte_00312)*

Please note: Thereby the FlatInstanceDescriptor's target is the operation.

[SWS_Rte_CONSTR_80004] DRAFT ⌈A Client Server Communication Graph is handled by at most one RTE Implementation Plug-In In the case that a Client Server Communication Graph is referenced by several RIPS FlatInstanceDescriptors, all those RIPS FlatInstanceDescriptors shall reference via FlatInstanceDescriptor.rtePluginProps.associatedRtePlugin the same RteRipsPluginProps container. ⌋*(SRS_Rte_00312)*

[SWS_Rte_CONSTR_80005] DRAFT ⌈Valid operation instance reference for Rte Implementation Plug-Ins I The RIPS FlatInstanceDescriptor for a Client Server Communication Graph shall reference the operation instance in the AbstractProvidedPortPrototype, if the configuration contains only the Server or the Clients and Server for the Client Server Communication Graph. ⌋*(SRS_Rte_00312)*

[SWS_Rte_CONSTR_80006] DRAFT ⌈Valid operation instance reference for Rte Implementation Plug-Ins II The RIPS FlatInstanceDescriptor for a Client Server Communication Graph shall reference the operation instance in the RPortPrototype, if the configuration contains only the Clients for the Client Server Communication Graph. ⌋*(SRS_Rte_00312)*

[SWS_Rte_CONSTR_80007] DRAFT ⌈Valid operation instance reference for Rte Implementation Plug-Ins III The RIPS FlatInstanceDescriptor for a Client Server Communication Graph is only applicable, if the client server communication configures a transformer according [SWS_Rte_08794] (inter ECU) or via ClientServerOperationMapping (intra ECU). ⌋*(SRS_Rte_00312)*

7.3.8.2 Enable RTE Implementation Plug-In support for trigger transformers

In case a Trigger Communication uses data transformation, enabling of the RTE Implementation Plug-In support is done as follows:

[SWS_Rte_80102] DRAFT ⌈ The RTE Generator shall enable the RTE Implementation Plug-In support for a Trigger Communication Graph, if a FlatInstanceDescriptor with rtePluginProps references the Trigger Communication Graph. ⌋*(SRS_Rte_00317)*

Please note: Thereby the FlatInstanceDescriptor's target is the trigger.

[SWS_Rte_CONSTR_80014] DRAFT ⌈A Trigger Communication Graph is handled by at most one RTE Implementation Plug-In In the case that a Trigger Communication Graph is referenced by several RIPS FlatInstanceDescriptors, all those RIPS FlatInstanceDescriptors shall reference via FlatInstanceDescriptor.rtePluginProps.associatedRtePlugin the same RteRipsPluginProps container. ⌋*(SRS_Rte_00317)*

[SWS_Rte_CONSTR_80015] DRAFT ⌈Valid trigger instance reference for Rte Implementation Plug-Ins I The RIPS FlatInstanceDescriptor for a Trigger Communication Graph shall reference the trigger instance in the AbstractProvidedPortPrototype, if the configuration contains only the trigger source or the trigger sink(s) and trigger source for the Trigger Communication Graph. ⌋*(SRS_Rte_00317)*

[SWS_Rte_CONSTR_80016] DRAFT ⌈Valid trigger instance reference for Rte Implementation Plug-Ins II The RIPS FlatInstanceDescriptor for a Trigger Communication Graph shall reference the trigger instance in the RPortPrototype, if the configuration contains only the trigger sink for the Trigger Communication Graph. ⌋*(SRS_Rte_00317)*

[SWS_Rte_CONSTR_80017] DRAFT ⌈Valid trigger instance reference for Rte Implementation Plug-Ins III The RIPS FlatInstanceDescriptor for a Trigger Communication Graph is only applicable, if the trigger communication configures a transformer according [SWS_Rte_08794] (inter ECU). ⌋*(SRS_Rte_00317)*

7.3.8.3 Handling of **Data Communication Graphs**

[SWS_Rte_80074] DRAFT ⌈ The RTE Generator shall inhibit the call of the transformers (4.10.1) and the creation of the belonging transformer buffer (4.10.3) for a Data Communication Graph, if it is assigned to an RTE Implementation Plug-In. ⌋*(SRS_Rte_00312)*

Instead of the RTE now the RTE Implementation Plug-In has the duty to call the belonging transformers in the correct order. Nevertheless carving out this functionality into an RTE Implementation Plug-In supports sophisticated buffer reuse optimizations relying on the precise scheduling scenario as well as the distinct transfer of the transformer calls in specific call contexts.

Thereby the RTE Implementation Plug-In Services Rte_Rips_Read and Rte_Rips_Write are called in the context of the related Rte_Read and Rte_Write APIs.

[SWS_Rte_70089] DRAFT ⌈ The RTE Implementation Plug-In assigned to a Data Communication Graph shall call transformers behaving functionally correctly according to section (4.10.1). This includes the handling of the transformerError and return value described in section 7.2.4.5. ⌋*(SRS_Rte_00312)*

7.3.8.4 Handling of Client Server Communication Graphs and Trigger Communication Graphs

[SWS_Rte_80068] DRAFT ⌈ The RTE Generator shall inhibit the call of the transformers (4.10.1) and the creation of the belonging transformer buffer (4.10.3) for a Client Server Communication Graph and Trigger Communication Graph, if it is assigned to an RTE Implementation Plug-In. ⌋*(SRS_Rte_00312, SRS_Rte_00317)*

On the client / trigger source side the RTE calls the according Rte_Rips_Invoke service in the context of the belonging ART API (Rte_Call or Rte_Trigger). In case of AsynchronousServerCallPoints and AsynchronousServerCallResultPoints the RTE calls the Rte_Rips_ReturnResult service from the Rte_Result API.

On the server / trigger sink side the RTE Implementation Plug-In calls the server runnable respectively the triggered runnable instead of the RTE.

In order to support the use case, that these server runnables and triggered runnables in turn invoke an RTE API which is not handled by this RTE Implementation Plug-In or which is not handled by any RTE Implementation Plug-In at all, it is required, that the call of these RunnableEntitys occurs in a defined and predictable call context.

Therefore the according OperationInvokedEvents are still mapped with RteEventToTaskMappings either to an OsTask or to a direct function call. But in addition those RteEventToTaskMappings shall define an RteRipsInvocationHandlerRef.

[SWS_Rte_CONSTR_80009] DRAFT ⌈Mandatory Rte_Rips_InvocationHandler in case of transformers In the case a server runnable or triggered runnable invoked by an RTE Implementation Plug-In handles the transformers the belonging RteEventToTaskMapping shall define an RteRipsInvocationHandlerRef. ⌋*(SRS_Rte_00312, SRS_Rte_00317)*

[SWS_Rte_80069] DRAFT ⌈ The RTE Generator shall inhibit the call of the server runnables and triggered runnables in case the related Client Server Communication Graph or Trigger Communication Graph is assigned to an RTE Implementation Plug-In. ⌋*(SRS_Rte_00312, SRS_Rte_00317)*

[SWS_Rte_80070] DRAFT ⌈ The RTE Generator shall call the configured Rte_Rips_InvocationHandler at the configured position in task or via a direct function call. The call shall be unconditional. ⌋*(SRS_Rte_00312, SRS_Rte_00317)*

[SWS_Rte_70079] DRAFT ⌈ The RTE Implementation Plug-In assigned to a Client Server Communication Graph or Trigger Communication Graph shall call the server runnable respectively the triggered runnable in the context of the Rte_Rips_InvocationHandler configured for the RteRipsInvocationHandlerRef belonging to the server runnable and triggered runnable ⌋*(SRS_Rte_00312, SRS_Rte_00317)*

Instead of the RTE now the RTE Implementation Plug-In has the duty to call the belonging transformers in the correct order. Nevertheless carving out this functionality into an RTE Implementation Plug-In enables support for sophisticated buffer reuse optimizations relying on the precise scheduling scenario as well as the distinct transfer of the transformer calls in specific call contexts.

[SWS_Rte_70080] DRAFT ⌈ The RTE Implementation Plug-In assigned to a Client Server Communication Graph or Trigger Communication Graph shall call transformers behaving functionally correctly according to section (4.10.1). ⌋*(SRS_Rte_00312, SRS_Rte_00317)*

[SWS_Rte_70081] DRAFT ⌈ The RTE Implementation Plug-In assigned to a Client Server Communication Graph or Trigger Communication Graph shall create the belonging transformer buffers with sufficient size according to section (4.10.3). ⌋*(SRS_Rte_00312, SRS_Rte_00317)*

7.3.9 Measurement

In general the usage of RTE Implementation Plug-Ins does not fundamentally change the general functionality to support Measurement as described in section 4.2.8.2.

The only impact occurs when the RTE Implementation Plug-In instantiates the global copy as described in section 7.3.4.5. In this case the RTE Generator is not able to provide the McDataInstance.symbol for the described McDataInstances in the *McSupportData*.

[SWS_Rte_80073] DRAFT ⌈ The RTE Generator shall inhibit the export of McDataInstance.symbol attributes for McDataInstances belonging to Data Communication Graphs associated to an RTE Implementation Plug-In where the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_PLUGIN. ⌋*(SRS_Rte_00153, SRS_Rte_00303)*

In this case it is the responsibility of the associated RTE Implementation Plug-In to provide the symbol information.

[SWS_Rte_70086] DRAFT ⌈ The associated RTE Implementation Plug-In shall enrich the *McSupportData* provided by the RTE Generator with the McDataInstance.symbol information in case

- swCalibrationAccess is set to readOnly or readWrite for the Data Communication Graph

  AND

- the RteRipsGlobalCopyInstantiationPolicy is set to RTE_RIPS_INSTANTIATION_BY_PLUGIN.

⌋*(SRS_Rte_00153, SRS_Rte_00303)*

Please note: To implement [SWS_Rte_70086] the RTE Implementation Plug-In tooling can use the McDataInstance.flatMapEntry reference to the according RIPS FlatInstanceDescriptor to identify the McDataInstances relevant for a Data Communication Graph.

7.3.10 Inter-Partition communication

In general the RTE Implementation Plug-Ins can be applied to Communication Graphs crossing partition borders. This would mean, that an RTE Implementation Plug-In implementation is executed on different cores or capable of supporting different ASIL levels.

Nevertheless currently no support for explicit life-cycle handling of those different partitions is standardized. Therefore as a prerequisite all partitions affecting one RTE Implementation Plug-In need to have the same life-cycle. For instance this excludes the usage of individual termination and restart of partitions.

[SWS_Rte_CONSTR_80010] DRAFT ⌈Partitions shall have the same life-cycle All partitions affecting the same RTE Implementation Plug-In shall have the same life-cycle. ⌋*(SRS_Rte_00307, SRS_Rte_00309)*

[SWS_Rte_80077] DRAFT ⌈ The Rte shall support the implementation of Communication Graphs with inter-partition-communication handled by an RTE Implementation Plug-In. ⌋*(SRS_Rte_00307, SRS_Rte_00309)*

Please note: [SWS_Rte_80077] includes inter-partition-communication between multiple cores as well as inter-partition-communication for the separation of different ASIL levels.

Thereby it is the responsibility of the RTE Implementation Plug-In to check, whether it can handle the according configuration.

[SWS_Rte_70093] DRAFT ⌈ The RTE Implementation Plug-In shall reject configurations which cannot be implemented by the RTE Implementation Plug-In. ⌋*(SRS_Rte_00307, SRS_Rte_00309)*

7.3.11 Bypass Support

When using RTE Implementation Plug-Ins in combination with Bypass Support (see section 4.9) the following principles and restrictions apply.

7.3.11.1 Component wrapper method

The *Component wrapper method* is not impacted by the usage of RTE Implementation Plug-Ins

7.3.11.2 Direct buffer access method

When using the *Direct buffer access method* the RTE Generator can not describe the buffers when the RTE Implementation Plug-In implements the implicit communication in a Data Communication Graph.

[SWS_Rte_70094] DRAFT ⌈ The RTE Implementation Plug-In shall generate the McSupportData for the implicit communication buffers when *Direct buffer access method* is selected as defined in section 4.9.3. ⌋*(SRS_Rte_00244)*

7.3.11.3 Extended buffer access method

In case the *Extended buffer access method* is selected (see section 4.9.4), the responsibility is shared between the RTE and the RTE Implementation Plug-In. For rptPreparationLevels greater than rptLevel1 the RTE implementation and the implementation of the RTE Implementation Plug-In would suffer from a lot of cross dependencies due to the required RP enabler flags.

Therefore those configurations are currently not supported in a standardized manner.

[SWS_Rte_CONSTR_80011] DRAFT ⌈Limitation on RTE Implementation Plug-In support for rptPreparationLevels Data Communication Graphs with rptPreparationLevels greater than rptLevel1 shall not be assigned to an RTE Implementation Plug-In. ⌋*(SRS_Rte_00244)*

Except for implicit communication the bypass support is implemented by the RTE Generator as it is defined in section 4.9.4:

API Class	rptLevel1
Explicit S/R	RTE
Implicit S/R	RTE Implementation Plug-In
C/S	RTE
Mode	RTE
Trigger	No
Explicit IRV	RTE

Implicit IRV	RTE Implementation Plug-In

Table 7.36: Table of API classes and responsibility of implementation

[SWS_Rte_70095] DRAFT ⌈ The RTE Implementation Plug-In shall implement the bypass support for implicit communication as specified in section 4.9.4.3.3, if the *Extended buffer access method* is configured and if rptLevel1 is selected for the Data Communication Graph ⌋*(SRS_Rte_00244)*

7.3.12 Activation of RTEEvents and BswEvents

The chapter 4.2.3 still leaves some freedom when an RTE activates a sequence of ExecutableEntitys exactly in a OsTask. But for the interaction with RTE Implementation Plug-Ins some additional definitions are required in order to preserve certain sequences. In the case RTEEvents and BswEvents for ExecutableEntitys, which do have the same activation condition, are mapped to an OsTask, an unintended out of order execution shall be prevented. For instance such identical activation condition can be

- a set of ExternalTriggerOccurredEvents connected to the same trigger source or
- a set of SwcModeSwitchEvent with the same activation, modes, and connected to the same mode manager.

For illustration assume the following set-up:

- position 1, Run1, condition A
- position 2, Run2, condition A
- position 3, Run3, condition B
- position 4, Run4, condition B
- position 5, Run5, condition A

In the case the OsTask has also mapped RTEEvents and BswEvents with other activation conditions, it is possible that the OsTask is already running when the other activation condition occurs.

Assume now that the OsTask was started due to condition A and now condition B is fulfilled right after the execution sequence has passed already Run3. In this case Run4 might be executed before Run3. But for a stable interference calculation and the deterministic scheduling of Rte_Rips_FillFlushRoutine Services such a situation needs to be avoided.

[SWS_Rte_80076] DRAFT ⌈ The RTE shall preserve the order of execution of ExecutableEntitys mapped to the same OsTask after the common activation condition occurred for all kinds of RTEEvents and BswEvents.

Thereby the order of execution is given by the RtePositionInTask and RteBswPositionInTask parameter values. ⌋*(SRS_Rte_00301)*

8 RTE ECU Configuration

The RTE provides the glue layer between the AUTOSAR software-components and the Basic Software thus enabling several AUTOSAR software-components to be integrated on one ECU. The RTE layer is shown in figure 8.1.

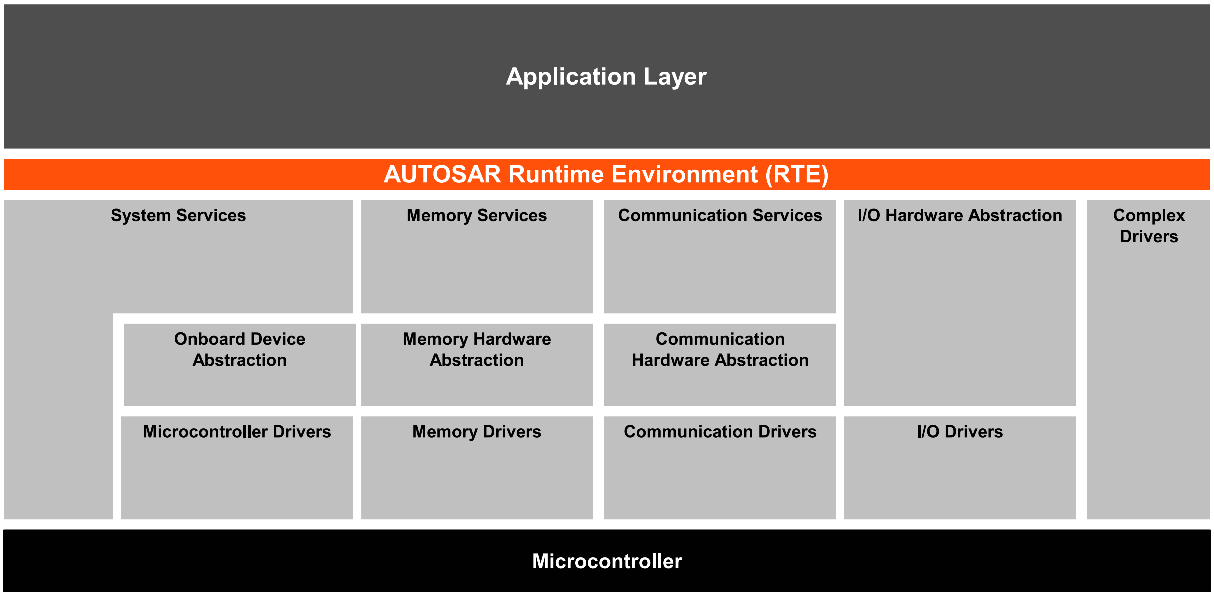

Figure 8.1: ECU Architecture RTE

The overall structure of the RTE configuration parameters is shown in figure 8.2. It has to be distinguished between the configuration parameters for the RTE generator and the configuration parameters for the generated RTE itself.

Most of the information needed to generate an RTE is already available in the ECU Extract of the System Description [8]. From this extract also the links to the AUTOSAR software-component descriptions and ECU Resource description are available. So only additional information not covered by the three aforementioned formats needs to be provided by the ECU Configuration description.

To additionally allow the most flexibility and freedom in the implementations of the RTE, only configuration parameters which are common to all implementations are standardized in the ECU Configuration Parameter definition. Any additional configuration parameters which might be needed to configure a full functional RTE have to be specified using the vendor specific parameter definition mechanism described in the ECU Configuration specification document [5].

8.1 RTE Module Configuration

Figure 8.2 shows the module configuration of the Rte and its sub-containers.

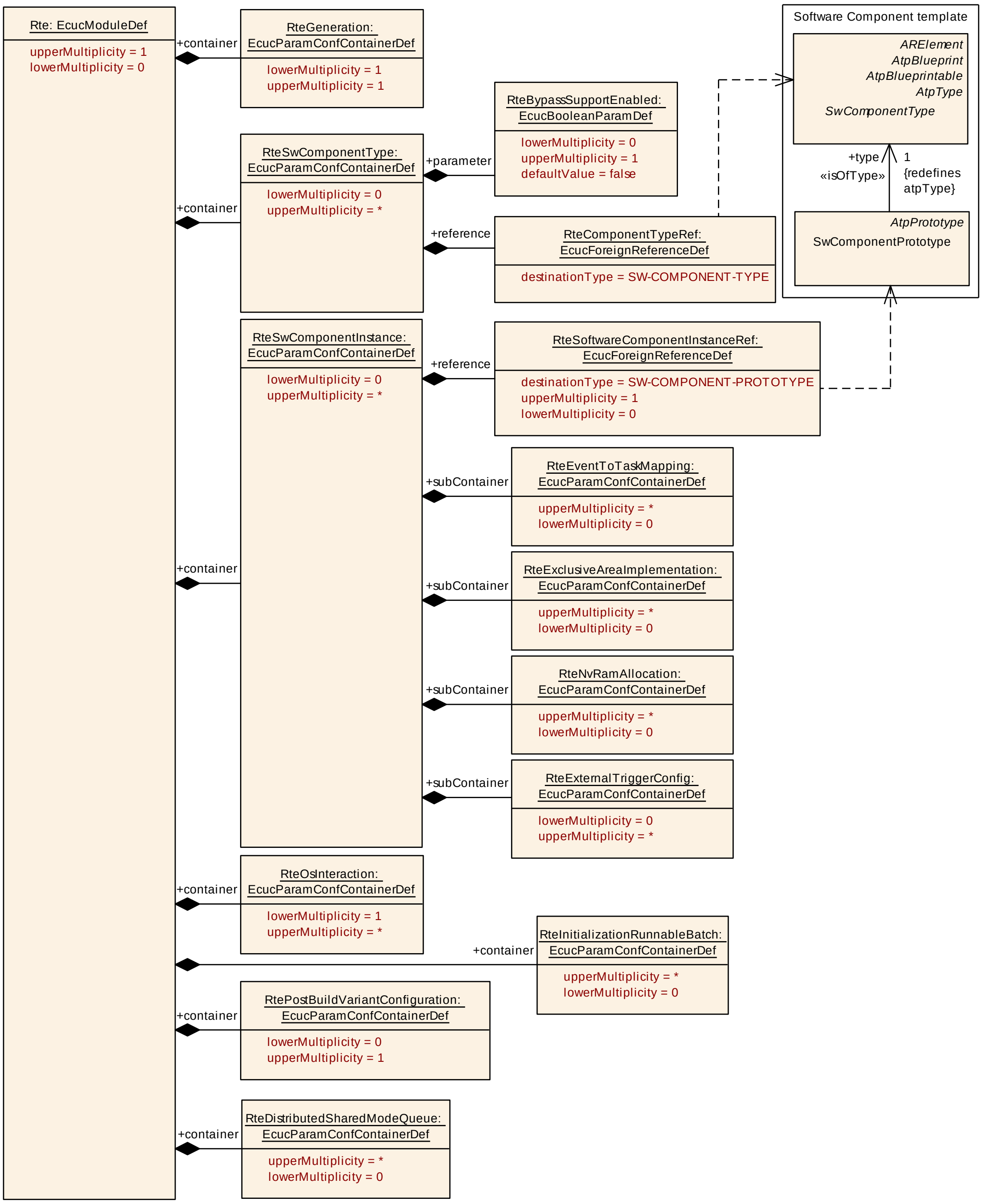

Figure 8.2: RTE configuration overview

Module SWS Item	ECUC_Rte_09000	
Module Name	Rte	
Module Description	Configuration of the Rte (Runtime Environment) module.	
Post-Build Variant Support	true	
Supported Config Variants	VARIANT-POST-BUILD, VARIANT-PRE-COMPILE	
Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
RteBswGeneral	1	General configuration parameters of the Bsw Scheduler section.
RteBswModuleInstance	0..*	Represents one instance of a Bsw-Module configured on one ECU.
RteDistributedSharedModeQueue	0..*	This container holds the configuration of a distributed shared mode queue.
RteGeneration	1	This container holds the parameters for the configuration of the RTE Generation.
RteImplicitCommunication	0..*	Configuration of the Implicit Communication behavior to be generated.
RteInitializationBehavior	1..*	Specifies the initialization strategy for variables allocated by RTE with the purpose to implement VariableDataPrototypes. The container defines a set of RteSectionInitializationPolicys and one RteInitializationStrategy which is applicable for this set.
RteInitializationRunnableBatch	0..*	This container corresponds to an Rte_Init_<shortName of this container> function invoking the mapped RunnableEntities.
RteOsInteraction	1..*	Interaction of the Rte with the Os.
RtePostBuildVariantConfiguration	0..1	Specifies the PostbuildVariantSets for each of the PostBuild configurations of the RTE.
RteRips	0..1	This container provides the configuration of the Rte Implementation Plug-In support by RTE. If the container is NOT defined, the support for Rte Implementation Plug-Ins (RIPS) is globally disabled. **Tags:** atp.Status=draft
RteSwComponentInstance	0..*	Representation of one SwComponentPrototype located on the to be configured ECU. All subcontainer configuration aspects are in relation to this SwComponentPrototype. The RteSwComponentInstance can be associated with either a AtomicSwComponentType or ParameterSwComponentType.
RteSwComponentType	0..*	Representation of one SwComponentType for the base of all configuration parameter which are affecting the whole type and not a specific instance.

8.1.1 RTE Configuration Version Information

In order to identify the RTE Configuration version a dedicated RTE code has been generated from the RTE Configuration information may contain one or more DOC-REVISION elements in the ECUC-MODULE-CONFIGURATION-VALUES element of the RTE Configuration (see example 8.1).

[SWS_Rte_05184] ⌈ The REVISION-LABEL shall be parsed according to the rules defined in the Generic Structure Template [10] for RevisionLabelString allowing to parse the three version informations for AUTOSAR:

- major version: first part of the REVISION-LABEL
- minor version: second part of the REVISION-LABEL
- patch version: third part of the REVISION-LABEL
- optional fourth part shall be used for documentation purposes in the Basic Software Module Description (see section 3.4.3)

If the parsing fails all three version numbers shall be set to zero. ⌋*(SRS_Rte_00233)*

[SWS_Rte_05185] ⌈ If there are several DOC-REVISION elements in the input ECUC-MODULE-CONFIGURATION-VALUES the newest according to the DATE shall be taken into account.

If the search for the newest DOC-REVISION fails three version numbers shall be set to zero. ⌋*(SRS_Rte_00233)*

Example 8.1

```
<AUTOSAR xmlns="http://autosar.org/4.0.0" xmlns:xsi="http://www.w3.org
    /2001/XMLSchema-instance" xsi:schemaLocation="http://autosar.org
    /4.0.0␣AUTOSAR.xsd">
  <AR-PACKAGES>
    <AR-PACKAGE>
      <SHORT-NAME>Rte_Example</SHORT-NAME>
      <ELEMENTS>
        <ECUC-MODULE-CONFIGURATION-VALUES>
          <SHORT-NAME>Rte_Configuration</SHORT-NAME>
          <ADMIN-DATA>
            <DOC-REVISIONS>
              <DOC-REVISION>
                <REVISION-LABEL>2.1.34</REVISION-LABEL>
                <DATE>2009-05-09T00:00:00.0Z</DATE>
              </DOC-REVISION>
              <DOC-REVISION>
                <REVISION-LABEL>2.1.35</REVISION-LABEL>
                <DATE>2009-06-21T09:30:00.0Z</DATE>
              </DOC-REVISION>
            </DOC-REVISIONS>
          </ADMIN-DATA>
          <DEFINITION-REF DEST="ECUC-MODULE-DEF">/AUTOSAR/Rte</
              DEFINITION-REF>
          <CONTAINERS>
```

```
                <!-- ... -->
              </CONTAINERS>
            </ECUC-MODULE-CONFIGURATION-VALUES>
          </ELEMENTS>
        </AR-PACKAGE>
      </AR-PACKAGES>
    </AUTOSAR>
```

8.2 RTE Generation Parameters

The parameters in the container RteGeneration are used to configure the RTE generator. They all need to be defined during pre-compile time.

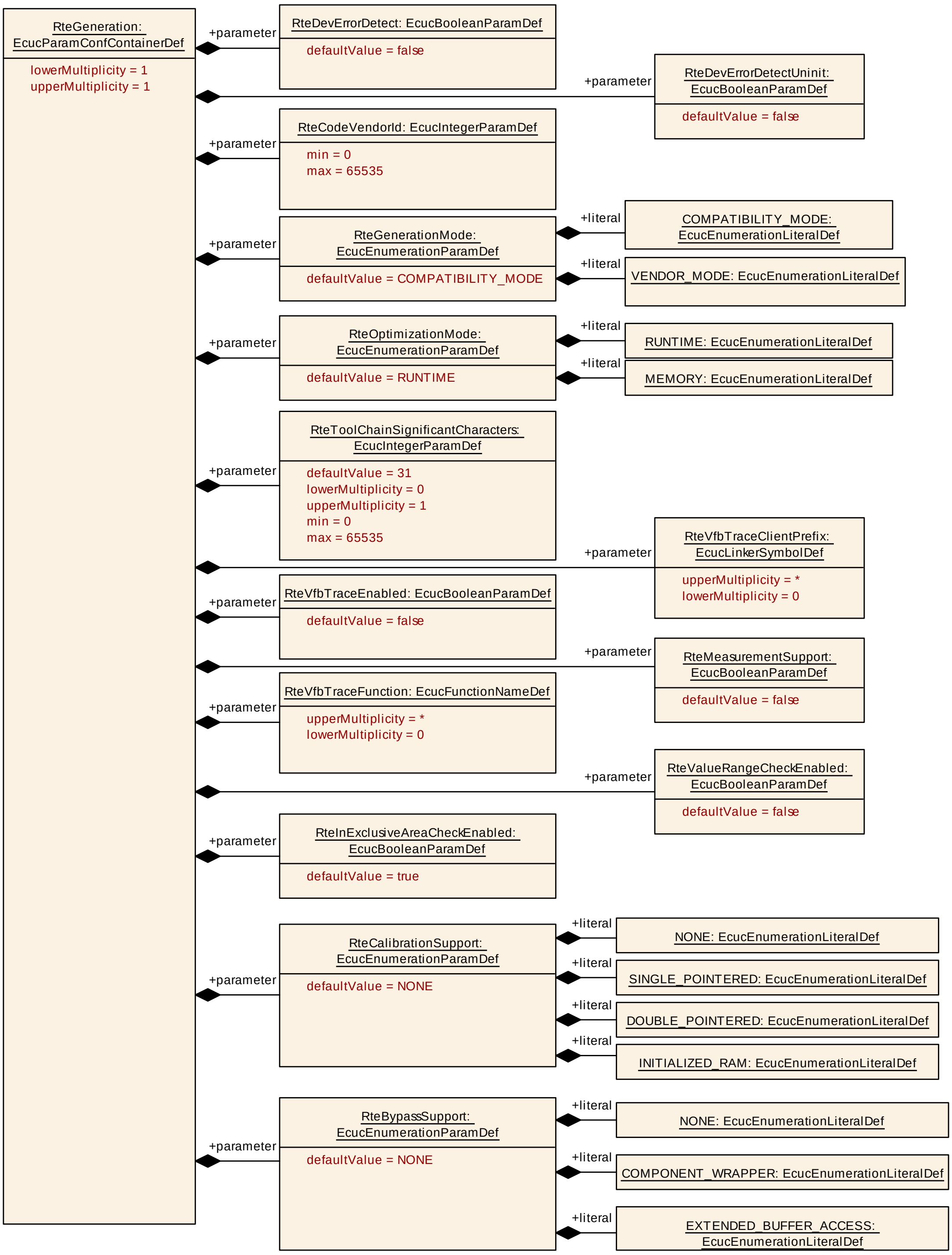

Figure 8.3: RTE generation parameters

SWS Item	[ECUC_Rte_09009]
Container Name	RteGeneration
Description	This container holds the parameters for the configuration of the RTE Generation.
Configuration Parameters	

Name	RteBypassSupport [ECUC_Rte_09113]		
Parent Container	RteGeneration		
Description	General switch to enable and select the bypass support method.		
Multiplicity	1		
Type	EcucEnumerationParamDef		
Range	COMPONENT_WRAPPER		
	EXTENDED_BUFFER_ACCESS		
	NONE		
Default Value	NONE		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteCalibrationSupport [ECUC_Rte_09007]		
Parent Container	RteGeneration		
Description	The RTE generator shall have the option to switch off support for calibration for generated RTE code. This option shall influence complete RTE code at once.		
Multiplicity	1		
Type	EcucEnumerationParamDef		
Range	DOUBLE_POINTERED		
	INITIALIZED_RAM		
	NONE		
	SINGLE_POINTERED		
Default Value	NONE		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteCodeVendorId [ECUC_Rte_09086]	
Parent Container	RteGeneration	
Description	Holds the vendor ID of the generated Rte code.	
Multiplicity	1	
Type	EcucIntegerParamDef	
Range	0 .. 65535	
Default Value		
Post-Build Variant Value	false	

Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteDevErrorDetect [ECUC_Rte_09008]		
Parent Container	RteGeneration		
Description	Switches the development error detection and notification on or off. • true: detection and notification is enabled. • false: detection and notification is disabled.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteDevErrorDetectUninit [ECUC_Rte_09085]		
Parent Container	RteGeneration		
Description	The Rte shall detect if it is started when its APIs are called, and the BSW Scheduler shall check if it is initialized when its APIs are called.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteGenerationMode [ECUC_Rte_09010]	
Parent Container	RteGeneration	
Description	Switch between the two available generation modes of the RTE generator.	
Multiplicity	1	
Type	EcucEnumerationParamDef	
Range	COMPATIBILITY_MODE	
	VENDOR_MODE	
Default Value	COMPATIBILITY_MODE	

Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteInExclusiveAreaCheckEnabled [ECUC_Rte_09126]		
Parent Container	RteGeneration		
Description	Enables the check for RTE_E_IN_EXCLUSIVE_AREA (for blocking APIs).		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	true		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteMeasurementSupport [ECUC_Rte_09011]		
Parent Container	RteGeneration		
Description	The RTE generator shall have the option to switch off support for measurement for generated RTE code. This option shall influence complete RTE code at once.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteOptimizationMode [ECUC_Rte_09012]	
Parent Container	RteGeneration	
Description	Switch between the two available optimization modes of the RTE generator.	
Multiplicity	1	
Type	EcucEnumerationParamDef	
Range	MEMORY	
	RUNTIME	
Default Value	RUNTIME	

Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteToolChainSignificantCharacters [ECUC_Rte_09013]		
Parent Container	RteGeneration		
Description	If present, the RTE generator shall provide the list of C RTE identifiers whose name is not unique when only the first RteToolChainSignificantCharacters characters are considered.		
Multiplicity	0..1		
Type	EcucIntegerParamDef		
Range	0 .. 65535		
Default Value	31		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteValueRangeCheckEnabled [ECUC_Rte_09014]		
Parent Container	RteGeneration		
Description	If set to true the RTE generator shall enable the value range checking for the specified VariableDataPrototypes.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteVfbTraceClientPrefix [ECUC_Rte_09016]		
Parent Container	RteGeneration		
Description	Defines an additional prefix for all VFB trace functions to be generated. With this approach it is possible to have debugging and DLT trace functions at the same time.		
Multiplicity	0..*		
Type	EcucLinkerSymbolDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteVfbTraceEnabled [ECUC_Rte_09015]		
Parent Container	RteGeneration		
Description	The RTE generator shall globally enable VFB tracing when RteVfbTrace is set to "true".		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteVfbTraceFunction [ECUC_Rte_09017]
Parent Container	RteGeneration
Description	The RTE generator shall enable VFB tracing for a given hook function when there is a #define in the RTE configuration header file for the hook function name and tracing is globally enabled. Example: #define Rte_WriteHook_i1_p1_a_Start This also applies to VFB trace functions with a RteVfbTraceClientPrefix, e.g. Rte_Dbg_WriteHook_I1_P1_a_Start.
Multiplicity	0..*
Type	EcucFunctionNameDef
Default Value	

Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

[SWS_Rte_CONSTR_03870] ⌈ In case that RteDevErrorDetectUninit is configured to true, RteDevErrorDetect shall be configured to true. ⌋ *()*

8.3 RTE PreBuild configuration

In order to support PreBuild configuration variation of the Rte input (see also section 4.7) the container EcucVariationResolver is providing a set of references to PredefinedVariant. These define values for SwSystemconst.

Note that the information for the EcucVariationResolver is provided in the EcuC part of the ECU Configuration, since it does not only influence the Rte but also many other BSW Modules.

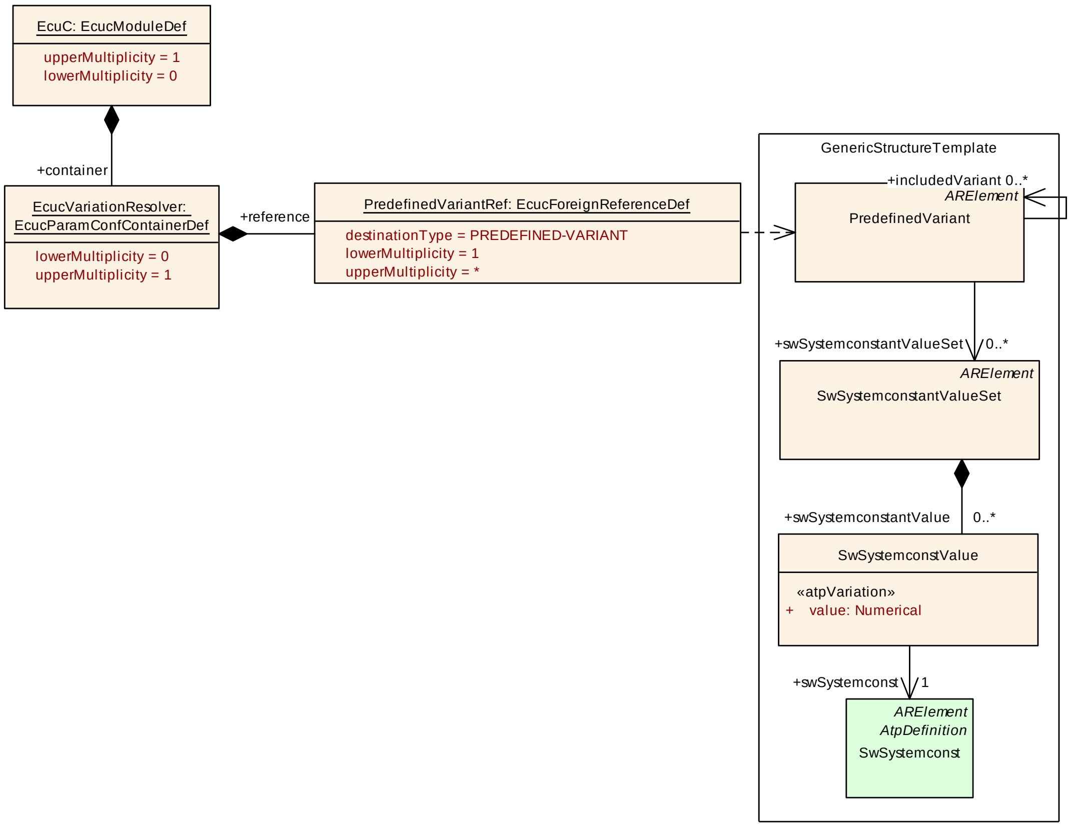

Figure 8.4: RTE PreBuild configuration

SWS Item	[ECUC_EcuC_00009]
Container Name	EcucVariationResolver
Description	Collection of PredefinedVariant elements containing definition of values for SwSystemconst which shall be applied when resolving the variability during ECU Configuration.
Configuration Parameters	

Name	PredefinedVariantRef [ECUC_EcuC_00010]		
Parent Container	EcucVariationResolver		
Description			
Multiplicity	1..*		
Type	Foreign reference to PREDEFINED-VARIANT		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	

Scope / Dependency	

No Included Containers

8.4 RTE PostBuild configuration

In order to support PostBuild configuration variation of the generated Rte (see also section 4.7) the container RtePostBuildVariantConfiguration is used. Each instance of RtePostBuildUsedPredefinedVariant inside this container specifies *one* PostBuild variant of the generated Rte. The shortName of the RtePostBuildUsedPredefinedVariant specifies the variant name.

The actual values for the PostBuildVariantCriterion are defined in a two step approach:

1. The reference RtePostBuildUsedPredefinedVariant collects the PredefinedVariant elements.
2. Each PredefinedVariant element collects a set of PostBuildVariantCriterionValueSet.
3. Each PostBuildVariantCriterionValueSet defines the PostBuildVariantCriterionValues for a set of PostBuildVariantCriterion.

The basic idea is that

- the PostBuildVariantCriterionValueSet can be provided by sub-system engineer,
- the PredefinedVariant can be designed by the Ecu integrator.

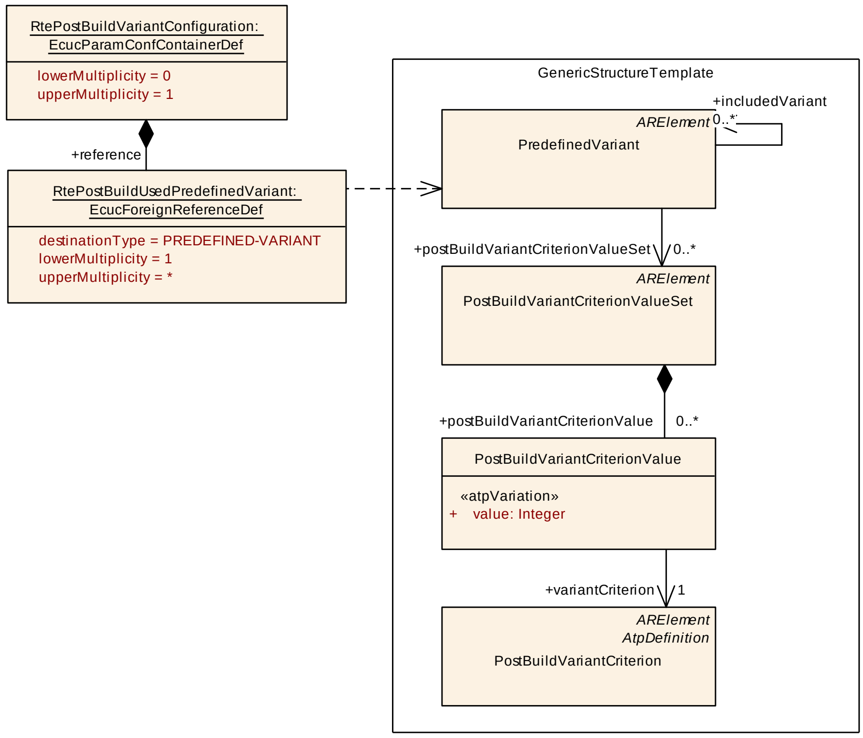

Figure 8.5: RTE PostBuild configuration

SWS Item	[ECUC_Rte_09084]
Container Name	RtePostBuildVariantConfiguration
Description	Specifies the PostbuildVariantSets for each of the PostBuild configurations of the RTE.
Configuration Parameters	

Name	RtePostBuildUsedPredefinedVariant [ECUC_Rte_09083]		
Parent Container	RtePostBuildVariantConfiguration		
Description	Reference to the PredefinedVariant element which defines the values for PostBuildVariationCriterion elements. The shortName of the referenced PredefinedVariant defines the name of the RtePostBuildVariant.		
Multiplicity	1..*		
Type	Foreign reference to PREDEFINED-VARIANT		
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	–	
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	–	
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

No Included Containers

8.5 Handling of Software Component instances

When entities of Software-Components are to be configured there is the need to actually address the instances of the `AtomicSwComponentType`. Since the Ecu Extract of System Description contains a flat view on the Ecu's Software-Components [8] the `SwComponentPrototype`s in the Ecu Extract already represent the instances of the Software Components.

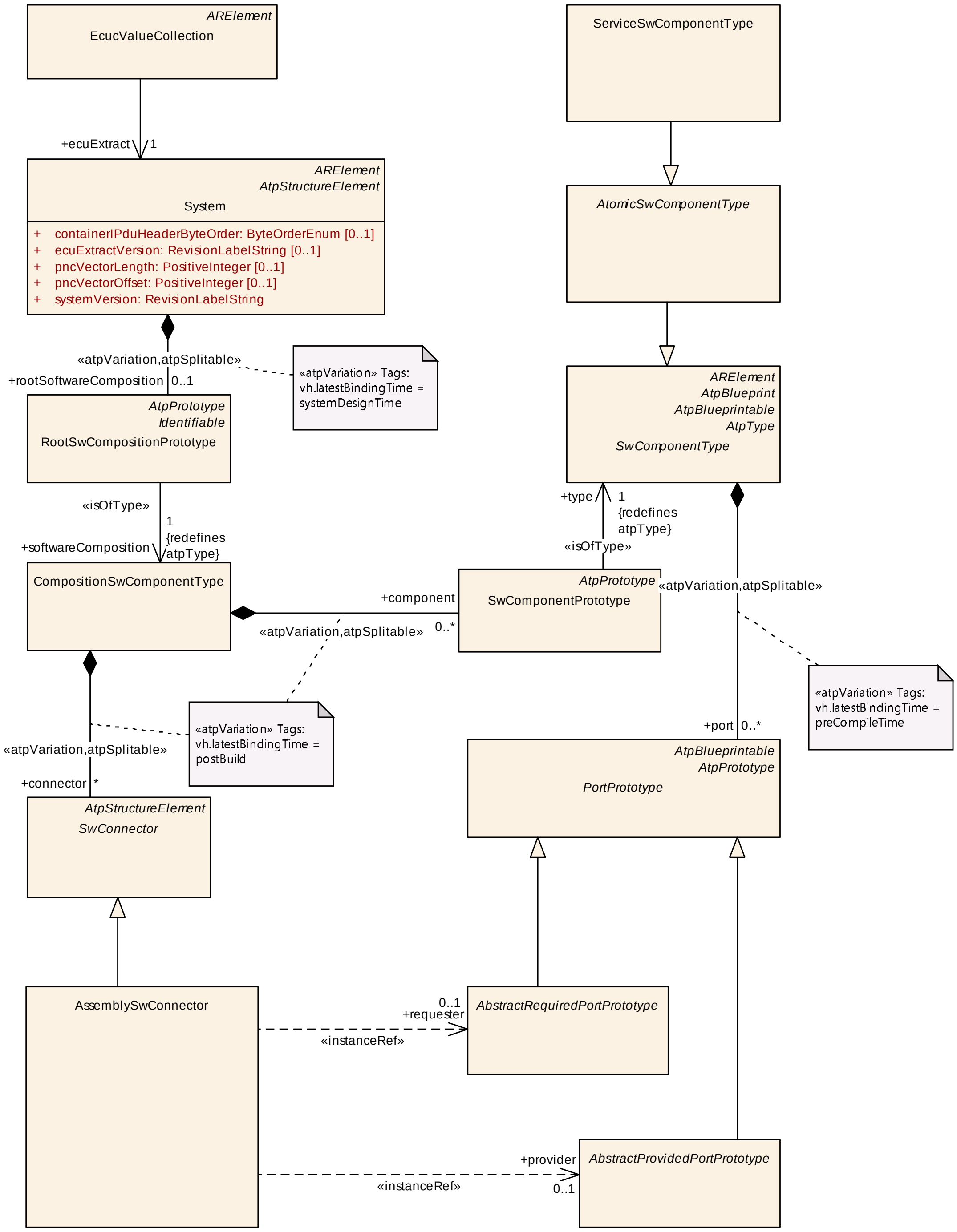

Figure 8.6: Services in the ECU Configuration

SWS Item	[ECUC_Rte_09005]
Container Name	RteSwComponentInstance
Description	Representation of one SwComponentPrototype located on the to be configured ECU. All subcontainer configuration aspects are in relation to this SwComponentPrototype. The RteSwComponentInstance can be associated with either a AtomicSwComponentType or ParameterSwComponentType.
Configuration Parameters	

Name	RteSoftwareComponentInstanceRef [ECUC_Rte_09004]		
Parent Container	RteSwComponentInstance		
Description	Reference to a SwComponentPrototype.		
Multiplicity	0..1		
Type	Foreign reference to SW-COMPONENT-PROTOTYPE		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
RteEventToTaskMapping	0..*	Maps an instance of a RunnableEntity onto one OsTask based on the activating RTEEvent. In the case of a RunnableEntity executed via a direct function call this RteEventToTaskMapping is still specified but no RteMappedToTask element is included. The RtePositionInTask parameter is necessary to provide an ordering of events invoked by the same RTE API.
RteExclusiveArea Implementation	0..*	Specifies the implementation to be used for the data consistency of this ExclusiveArea.
RteExternalTriggerConfig	0..*	Defines the configuration of External Trigger Event Communication for Software Components
RteInternalTriggerConfig	0..*	Defines the configuration of Inter Runnable Triggering for Software Components
RteModeMachine InstanceConfig	0..*	Defines the configuration of RTE assigned (SWS_Rte_07533) mode machine instances.
RteNvRamAllocation	0..*	Specifies the relationship between the AtomicSwComponentType's NVRAMMapping / NVRAM needs and the NvM module configuration.

The container RteSwComponentInstance collects all the configuration information related to one specific instance of a AtomicSwComponentType. The individual aspects will be described in the next sections.

8.5.1 RTE Event to task mapping

One of the major fragments of the RTE configuration is the mapping of AUTOSAR Software-Components' RunnableEntitys to OS Tasks. The parameters defined to achieve this are shown in figure 8.7.

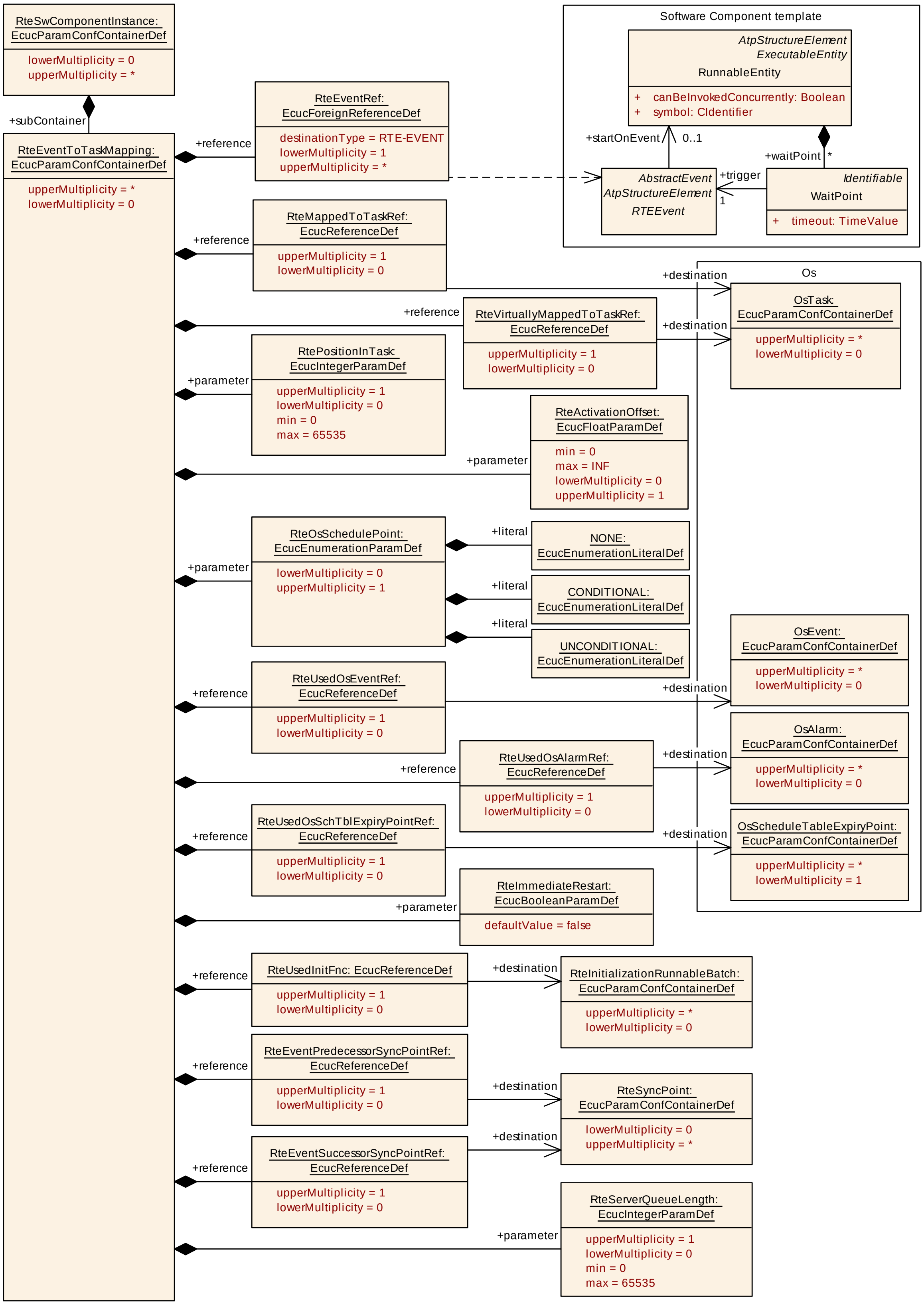

Figure 8.7: RTE Event to task mapping

The mapping is based on the RTEEvent because it is the source of the activation. For each RunnableEntity which belongs to an AUTOSAR Software-Component instance mapped on the ECU there needs to be a mapping container specifying how this RunnableEntity activation shall be handled.

[SWS_Rte_07843] ⌈ The RTE Generator shall reject configurations where the same RTEEvent instance which can start a RunnableEntity is referenced by multiple task mappings. ⌋ *()*

One major constraint is posed by the canBeInvokedConcurrently attribute of each RunnableEntity because data consistency issues have to be considered.

8.5.1.1 Evaluation and execution order

Another important parameter is the RtePositionInTask which provides an order of RunnableEntitys within the associated OsTask. When the task is executed periodically the RtePositionInTask parameter defines the order of execution within the test. When the task is used to define a context for event activated RunnableEntitys the RtePositionInTask parameter defines the order of evaluation which actual RunnableEntity shall be executed. Thus providing means to define a deterministic delay between the beginning of execution of the task and the actual execution of the RunnableEntity's code.

In case of triggered runnables, on-entry ExecutableEntitys, on-transition ExecutableEntitys, on-exit ExecutableEntitys, and ModeSwitchAck ExecutableEntitys the RtePositionInTask parameter defines the order of evaluation which actual RunnableEntity shall be executed. All other parameters or references are not required.

8.5.1.2 Direct function call

[SWS_Rte_06798] ⌈ If the ExecutableEntity is a server ExecutableEntity, triggered ExecutableEntity, on-entry ExecutableEntity, on-transition ExecutableEntity, on-exit ExecutableEntity, or a ModeSwitchAck ExecutableEntity and shall be executed in the context of the caller (i.e. using a direct function call) then the element RteEventToTaskMapping or RteBswEventToTaskMapping still shall be provided to indicate that this RTEEvent / BswEvent has been considered in the mapping. ⌋ *()*

In case of server ExecutableEntitys its not possible that several servers get invoked by the same API call. Therefore no further parameters in the RteEventToTaskMapping or RteBswEventToTaskMapping associated to the RTEEvent / BswEvent are required to configure the direct function call for server ExecutableEntitys.

[SWS_Rte_06799] ⌈ For directly invoked server ExecutableEntitys no further parameters or references are required, in particular RteMappedToTaskRef and RtePositionInTask are omitted. ⌋*()*

In case of ExecutableEntitys which are not server ExecutableEntitys it is possible that several ExecutableEntitys get invoked by the same API call when direct function call configuration is used. Thereby the RteMappedToTaskRef / RteBswMappedToTaskRef is omitted. However the order of invocation needs to be configured with the RtePositionInTask and RteBswPositionInTask parameters.

[SWS_Rte_06800] ⌈ For directly invoked triggered ExecutableEntity, on-entry ExecutableEntity, on-transition ExecutableEntity, on-exit ExecutableEntity, or a ModeSwitchAck ExecutableEntity the RtePositionInTask and RteBswPositionInTask parameter respectively is required to indicate the order of invocation. ⌋*()*

The invocation context for an ExecutableEntity can be either a task or a function call. For ExecutableEntitys invoked from an OsTasks then [SWS_Rte_CONSTR_09082] means that all mapped ExecutableEntities must have unique values for the task to ensure predictable generation of the task body. In the case of RTEEvents or BswEvents invoked by direct invocation from an RTE-generated API function then [SWS_Rte_CONSTR_09082] means that all events invoked by the calling function must have unique values to ensure predictable generation of the calling API.

[SWS_Rte_CONSTR_09082] RtePositionInTask and RteBswPositionInTask values shall be unique in a particular context ⌈ RtePositionInTask and RteBswPositionInTask shall have unique values for any particular task in the case RTEEvents and BswEvents are mapped to OsTasks and shall have unique values for any particular scope of direct invocation in the case that the a direct function call is configured. ⌋*()*

Concerning the mapping of several operations to the same server runnables see [SWS_Rte_08001].

Example 8.2

BSW module BswA defines BswModuleEntity BswA_ProcessBigBang triggered by BswExternalTriggerOccurredEvent Ev_BswA_ProcessBigBang

Software component SwcA defines RunnableEntity SwcA_Run_BigBang triggered by ExternalTriggerOccurredEvent Ev_SwcA_Run_BigBang

Software component SwcB defines RunnableEntity SwcB_Run_BigBang triggered by ExternalTriggerOccurredEvent Ev_SwcB_Run_BigBang

All required Triggers are connected to one common synchronized Trigger.

Scenario A

A configuration:

Ev_BswA_ProcessBigBang is mapped to OsTask T_BIG_BANG with RtePositionInTask = 1

Ev_SwcA_Run_BigBang is mapped to OsTask T_BIG_BANG with RtePositionInTask = 2

Ev_SwcB_Run_BigBang is mapped to OsTask T_BIG_BANG with RtePositionInTask = 3

results in Rte code where the ExecutableEntitys are called in the context of the OsTask T_BIG_BANG in the order:

1. Ev_BswA_ProcessBigBang
2. Ev_SwcA_Run_BigBang
3. Ev_SwcB_Run_BigBang

In addition [SWS_Rte_CONSTR_09082] is fulfilled even if the RtePositionInTask values 1, 2, 3 are used for other RteEventToTaskMappings mapping to other OsTask or configuring a direct function call.

Scenario B

A configuration:

Ev_BswA_ProcessBigBang is not mapped to any OsTask and RtePositionInTask = 1

Ev_SwcA_Run_BigBang is not mapped to any OsTask and RtePositionInTask = 2

Ev_SwcB_Run_BigBang is not mapped to any OsTask and RtePositionInTask =

results in Rte code where the ExecutableEntitys are called in the context of the issuing Trigger API, e.g SchM_Trigger which invokes the ExecutableEntitys in the order:

1. Ev_BswA_ProcessBigBang
2. Ev_SwcA_Run_BigBang
3. Ev_SwcB_Run_BigBang

8.5.1.3 Schedule Points

In order to allow explicit calls to the Os scheduler in an non-preemptive scheduling setup, the configuration element RteOsSchedulePoint shall be used.

[SWS_Rte_05113] ⌈ The RTE Generator shall create an unconditional call to the Os API *Schedule* after the execution call of the RunnableEntity if the RteOsSchedulePoint configuration parameter is set to UNCONDITIONAL. In the generated code the call to the Os API *Schedule* shall always be performed, even when the RunnableEntity itself has not been executed (called). ⌋()

Since the execution of a RunnableEntity may be performed (e.g. due to mode dependent scheduling) the call of the Os API *Schedule* without any RunnableEntity execution in between might occur. in order to prohibit such a call chain the CONDITIONAL schedule point is available.

[SWS_Rte_05114] ⌈ The RTE Generator shall create a conditional call to the Os API *Schedule* after the execution call of the RunnableEntity if the RteOsSchedulePoint configuration parameter is set to CONDITIONAL. In the generated code the call to the Os API *Schedule* shall be omitted when there was already a call to the Os API *Schedule* before without any RunnableEntity execution in between. ⌋()

[SWS_Rte_07042] ⌈ The Os API *Schedule* according [SWS_Rte_05113] and [SWS_Rte_05114] shall be called after the data written with implicit write access by the RunnableEntity are propagated to other RunnableEntitys as specified in [SWS_Rte_07021], [SWS_Rte_03957], [SWS_Rte_07041] and [SWS_Rte_03584] ⌋()

[SWS_Rte_07043] ⌈ The Os API *Schedule* according [SWS_Rte_05113] and [SWS_Rte_05114] shall be called before the preemption area specific buffer used for a implicit read access of the successor RunnableEntity are filled with actual data by a copy action according [SWS_Rte_07020]. ⌋()

[SWS_Rte_05115] ⌈ The RTE Generator shall create no call to the Os API *Schedule* after the execution of the RunnableEntity if the RteOsSchedulePoint configuration parameter is not present or is set to NONE. ⌋()

[SWS_Rte_01373] ⌈ The RTE Generator shall support the independent setting of RteOsSchedulePoint for RteEventToTaskMappings that map the same RunnableEntity. ⌋*(SRS_Rte_00018)*

8.5.1.4 Timeprotection support

[SWS_Rte_07801] ⌈ If RteMappedToTaskRef is configured but RteVirtuallyMappedToTaskRef is not configured, the RTE shall implement/evaluate the RTEEvent that activates the RunnableEntity and execute the RunnableEntity in the OsTask referenced by RteMappedToTaskRef. ⌋()

[SWS_Rte_07802] ⌈ If both RteMappedToTaskRef and RteVirtuallyMappedToTaskRef are configured, the RTE shall implement/evaluate the RTEEvent that activates the RunnableEntity in the OsTask referenced by RteVirtuallyMappedToTaskRef but execute the RunnableEntity in the OsTask referenced by RteMappedToTaskRef. The RTE shall implement this by an activation of the OsTask referenced by RteMappedToTaskRef when the RTEEvent is evaluated as "TRUE" in the OsTask referenced by RteVirtuallyMappedToTaskRef. ⌋*(SRS_Rte_00193)*

[SWS_Rte_07803] ⌈ The RTE shall reject the configuration if RteMappedToTaskRef is not configured but RteVirtuallyMappedToTaskRef is configured. ⌋ *(SRS_Rte_00018)*

8.5.1.5 Os Interaction

When an OsEvent is used to activate the OsTask the reference RteUsedOsEventRef specifies which OsEvent is used.

When an OsAlarm is used to implement a TimingEvent or a BackgroundEvent the reference RteUsedOsAlarmRef specifies which OsAlarm is used.

[SWS_Rte_07806] ⌈ If RteUsedOsAlarmRef is configured and RteEventRef references a TimingEvent the RTE shall implement the TimingEvent with the OsAlarm referenced by RteUsedOsAlarmRef. ⌋ *(SRS_Rte_00232)*

[SWS_Rte_07179] ⌈ If RteUsedOsAlarmRef is configured and RteEventRef references a BackgroundEvent the RTE shall implement the BackgroundEvent with the OsAlarm referenced by RteUsedOsAlarmRef. ⌋ *()*

When an OsScheduleTableExpiryPoint is used to implement a TimingEvent or a BackgroundEvent the reference RteUsedOsSchTblExpiryPointRef specifies which OsScheduleTableExpiryPoint is used.

[SWS_Rte_07807] ⌈ If RteUsedOsSchTblExpiryPointRef is configured and RteEventRef references a TimingEvent the RTE shall implement the TimingEvent with the OsScheduleTableExpiryPoint referenced by RteUsedOsSchTblExpiryPointRef. ⌋ *(SRS_Rte_00232)*

[SWS_Rte_07180] ⌈ If RteUsedOsSchTblExpiryPointRef is configured and RteEventRef references a BackgroundEvent the RTE shall implement the BackgroundEvent with the OsScheduleTableExpiryPoint referenced by RteUsedOsSchTblExpiryPointRef. ⌋ *()*

If neither RteUsedOsSchTblExpiryPointRef nor RteUsedOsAlarmRef are configured and RteEventRef references a TimingEvent the RTE is free to implement the TimingEvent with the OsAlarm or OsScheduleTableExpiryPoint of its choice.

[SWS_Rte_07808] ⌈ The RTE shall reject the configuration if both RteUsedOsAlarmRef and RteUsedOsSchTblExpiryPointRef are configured. ⌋ *(SRS_Rte_00018)*

[SWS_Rte_07809] ⌈ The RTE shall reject the configuration if RteUsedOsAlarmRef or RteUsedOsSchTblExpiryPointRef is configured and RteEventRef doesn't reference a TimingEvent or a BackgroundEvent. ⌋ *(SRS_Rte_00018)*

8.5.1.6 Background activation

If neither RteUsedOsSchTblExpiryPointRef nor RteUsedOsAlarmRef is configured and RteEventRef references a BackgroundEvent the RteMappedToTaskRef has to reference the OsTask used for *Background* activation of *RunnableEntities* and *Basic Software Schedulable Entities* on the related CPU core where the partition of the software component is mapped.

The OsTask used for BackgroundEvent triggering has to have the lowest priority on the core. There can only be one 'Background' OsTask per CPU core.

[SWS_Rte_07181] ⌈ The RTE shall reject the configuration if

- RteEventRef references a BackgroundEvent and
- neither RteUsedOsAlarmRef nor RteUsedOsSchTblExpiryPointRef are configured and
- if RteMappedToTaskRef reference an OsTask which has not the lowest priority of the core.

⌋*(SRS_Rte_00018)*

8.5.1.7 Constraints

There are some constraints which do apply when actually mapping the RunnableEntity to an OsTask:

[SWS_Rte_05082] ⌈ The following restrictions apply to RTEEvents which are used to activate RunnableEntity. OsEvents that are used to wakeUpFromWaitPoint shall not be included in the mapping. ⌋*()*

When a wakeUpFromWaitPoint is occurring the RunnableEntity resumes its execution in the context of the originally activated OsTask.

[SWS_Rte_05083] ⌈ The RTE Generator shall reject configurations where a RunnableEntity has its canBeInvokedConcurrently attribute set to *false*, and this RunnableEntity is mapped to different tasks which can preempt each other. ⌋*()*

[SWS_Rte_07229] ⌈ To evaluate [SWS_Rte_05083] in case of triggered runnables which are activated by a direct function call ([SWS_Rte_07214], [SWS_Rte_07224] and [SWS_Rte_07554]) the OsTask (context of the caller) is defined by the RunnableEntity's containing the activating InternalTriggeringPoint or ExternalTriggeringPoint. ⌋*(SRS_Rte_00162, SRS_Rte_00163, SRS_Rte_00230)*

[SWS_Rte_07155] ⌈ To evaluate [SWS_Rte_05083] in case of on-entry ExecutableEntitys, on-transition ExecutableEntitys, on-exit ExecutableEntitys, and ModeSwitchAck ExecutableEntitys which are activated by a direct function call the OsTask (context of the caller) is defined by the RunnableEntity's containing the activating ModeSwitchPoint. ⌋ (SRS_Rte_00143, SRS_Rte_00144)

[SWS_Rte_CONSTR_03873] ⌈ All OperationInvokedEvents/BswOperationInvokedEvents which are activating the same server ExecutableEntity shall be mapped by at most one RteEventToTaskMapping/RteBswEventToTaskMapping which references an OsTask. ⌋ (SRS_Rte_00019, SRS_Rte_00033)

Note: This shall ensure that direct function calls and server serialization can be mixed for the same server ExecutableEntity. But the server serialization can only be configured at exactly one RtePositionInTask/RteBswPositionInTask.

[SWS_Rte_CONSTR_03874] ⌈ A RteEventToTaskMapping/RteBswEventToTaskMapping shall only own more than one RteEventRef/RteBswEventRef reference if all owned RteEventRefs/RteBswEventRefs refer to OperationInvokedEvents/BswOperationInvokedEvents which in turn are triggering the same server ExecutableEntity. ⌋ (SRS_Rte_00019, SRS_Rte_00033)

SWS Item	[ECUC_Rte_09020]
Container Name	RteEventToTaskMapping
Description	Maps an instance of a RunnableEntity onto one OsTask based on the activating RTEEvent. In the case of a RunnableEntity executed via a direct function call this RteEventToTaskMapping is still specified but no RteMappedToTask element is included. The RtePositionInTask parameter is necessary to provide an ordering of events invoked by the same RTE API.
Configuration Parameters	

Name	RteActivationOffset [ECUC_Rte_09018]		
Parent Container	RteEventToTaskMapping		
Description	Activation offset in seconds.		
Multiplicity	0..1		
Type	EcucFloatParamDef		
Range	[0 .. INF]		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteImmediateRestart [ECUC_Rte_09092]		
Parent Container	RteEventToTaskMapping		
Description	When RteImmediateRestart is set to true the RunnableEntitiy shall be immediately re-started after termination if it was activated by this RTEEvent while it was already started. This parameter shall not be set to true when the mapped RTEEvent refers to a RunnableEntity which minimumStartInterval attribute is > 0.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteOsSchedulePoint [ECUC_Rte_09022]	
Parent Container	RteEventToTaskMapping	
Description	Introduce a schedule point by explicitly calling Os Schedule service after the execution of the ExecutableEntity. The Rte generator is allowed to optimize several consecutive calls to Os schedule into one single call if the ExecutableEntity executions in between have been skipped. The absence of this parameter is interpreted as "NONE". It shall be considered an invalid configuration if the task is preemptable and the value of this parameter is not set to "NONE" or the parameter is absent.	
Multiplicity	0..1	
Type	EcucEnumerationParamDef	
Range	CONDITIONAL	A Schedule Point shall be introduced at the end of the execution of this ExecutableEntity. The Schedule Point can be skipped if several Schedule Points would be called without any ExecutableEntity execution in between.
	NONE	No Schedule Point shall be introduced at the end of the execution of this ExecutableEntity.
	UNCONDITIONAL	A Schedule Point shall always be introduced at the end of the execution of this ExecutableEntity.
Post-Build Variant Multiplicity	false	
Post-Build Variant Value	false	

Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RtePositionInTask [ECUC_Rte_09023]		
Parent Container	RteEventToTaskMapping		
Description	Each RunnableEntity mapped to an OsTask has a specific position within the task execution. For periodic activation this is the order of execution. For event driver activation this is the order of evaluation which actual RunnableEntity has to be executed. In case of direct function calls this parameter is necessary to provide an ordering of events when several ExecutableEntities are invoked by the same RTE API.		
Multiplicity	0..1		
Type	EcucIntegerParamDef		
Range	0 .. 65535		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteServerQueueLength [ECUC_Rte_09133]	
Parent Container	RteEventToTaskMapping	
Description	Specifies the length of the queue for the server call serialization. This value overwrites the queueLength specified at the ServerComSpec.	
Multiplicity	0..1	
Type	EcucIntegerParamDef	
Range	0 .. 65535	
Default Value		
Post-Build Variant Multiplicity	false	
Post-Build Variant Value	false	

Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteEventPredecessorSyncPointRef [ECUC_Rte_09128]		
Parent Container	RteEventToTaskMapping		
Description	The RteEventPredecessorSyncPointRef is necessary to provide a cross core synchronization in case of RteEvents triggered by the same event source but mapped to tasks belonging to different partitions on different cores. The synchronization point must be reached by all referencing RteEvents before the execution in all related tasks is continued. In case of RteEventPredecessorSyncPointRef the RunnableEntity activated by the mapped RteEvent is executed after the synchronization point is passed.		
Multiplicity	0..1		
Type	Reference to RteSyncPoint		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteEventRef [ECUC_Rte_09019]
Parent Container	RteEventToTaskMapping
Description	Reference to the description of the RTEEvent which is pointing to the RunnableEntity being mapped. This allows a fine grained mapping of RunnableEntites based on the activating RTEEvent.
Multiplicity	1..*
Type	Foreign reference to RTE-EVENT
Post-Build Variant Value	false

Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteEventSuccessorSyncPointRef [ECUC_Rte_09129]		
Parent Container	RteEventToTaskMapping		
Description	The RteEventSuccessorSyncPointRef is necessary to provide a cross core synchronization in case of RteEvents triggered by the same event source but mapped to tasks belonging to different partitions on different cores. The synchronization point must be reached by all referencing RteEvents before the execution in all related tasks is continued. In case of RteEventSuccessorSyncPointRef the RunnableEntity activated by the mapped RteEvent is executed before the synchronization point is entered.		
Multiplicity	0..1		
Type	Reference to RteSyncPoint		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteMappedToTaskRef [ECUC_Rte_09021]		
Parent Container	RteEventToTaskMapping		
Description	Reference to the OsTask the RunnableEntity activated by the RteEventRef is mapped to. If no reference to the OsTask is specified the RunnableEntity shall be executed via a direct function call. The fact that no reference to an OsTask is specified for a RunnableEntity does not necessarily imply that every RTE generator has to support the implementation of this RunnableEntity as a direct function call. The standard set of use cases for direct function calls that has to be supported by every RTE generator is explicitly stated as requirements in this document. For further optimization RTE vendors are free to support additional scenarios of direct function call implementations that are not explicitly required in this document.		
Multiplicity	0..1		
Type	Reference to OsTask		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteRipsFillRoutineRef [ECUC_Rte_89005]
Parent Container	RteEventToTaskMapping
Description	Reference to a Buffer-Fill Routine implemented by an RTE Implementation Plug-In. This routine gets invoked directly before the ExecutableEntity is started. **Tags:** atp.Status=draft **Attributes:** requiresIndex=true
Multiplicity	0..*
Type	Reference to destinationUri [RteRipsUriDefSet/RteRipsPluginFillFlush Routine]
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteRipsFlushRoutineRef [ECUC_Rte_89006]		
Parent Container	RteEventToTaskMapping		
Description	Reference to a Buffer-Flush Routine implemented by an RTE Implementation Plug-In. This routine gets invoked directly after the ExecutableEntity has terminated. **Tags:** atp.Status=draft **Attributes:** requiresIndex=true		
Multiplicity	0..*		
Type	Reference to destinationUri [RteRipsUriDefSet/RteRipsPluginFillFlushRoutine]		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteRipsInvocationHandlerRef [ECUC_Rte_89008]		
Parent Container	RteEventToTaskMapping		
Description	Reference to a Buffer-Fill Routine implemented by an RTE Implementation Plug-In. This routine gets invoked directly before the ExecutableEntity is started. **Tags:** atp.Status=draft		
Multiplicity	0..1		
Type	Reference to destinationUri [RteRipsUriDefSet/RteRipsInvocation Handler]		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteUsedInitFnc [ECUC_Rte_09116]		
Parent Container	RteEventToTaskMapping		
Description	The RunnableEntity is executed during initialization in the context of the Rte_Init_<InitContainer> function.		
Multiplicity	0..1		
Type	Reference to RteInitializationRunnableBatch		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteUsedOsAlarmRef [ECUC_Rte_09024]		
Parent Container	RteEventToTaskMapping		
Description	If an OsAlarm is used to activate the OsTask this RteEvent is mapped to it shall be referenced here.		
Multiplicity	0..1		
Type	Reference to OsAlarm		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteUsedOsEventRef [ECUC_Rte_09025]		
Parent Container	RteEventToTaskMapping		
Description	If an OsEvent is used to activate the OsTask this RteEvent is mapped to it shall be referenced here.		
Multiplicity	0..1		
Type	Reference to OsEvent		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteUsedOsSchTblExpiryPointRef [ECUC_Rte_09026]
Parent Container	RteEventToTaskMapping
Description	If an OsScheduleTableExpiryPoint is used to activate the OsTask this RteEvent is mapped to it shall be referenced here.
Multiplicity	0..1
Type	Reference to OsScheduleTableExpiryPoint
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteVirtuallyMappedToTaskRef [ECUC_Rte_09027]		
Parent Container	RteEventToTaskMapping		
Description	Optional reference to an OsTask where the activation of this RteEvent shall be evaluated. The actual execution of the Runnable Entity shall happen in the OsTask referenced by RteMappedToTaskRef.		
Multiplicity	0..1		
Type	Reference to OsTask		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.5.2 Rte Os Interaction

This section contains configuration items which are closely related to the interaction of the Rte with the Os.

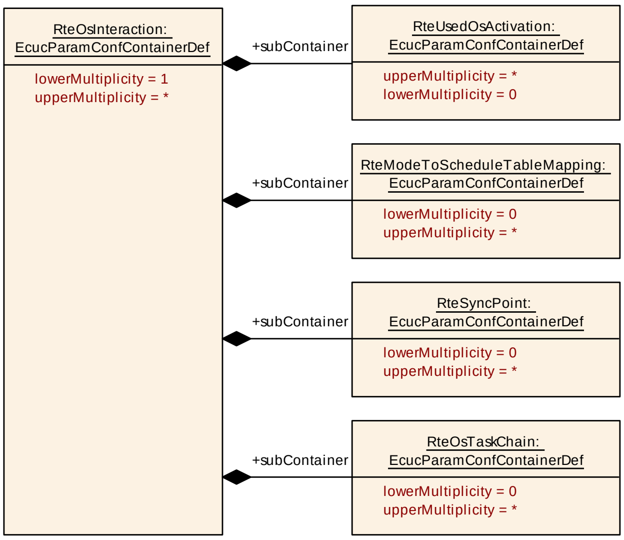

Figure 8.8: Specification of the Rte/Os Interaction

SWS Item	[ECUC_Rte_09059]
Container Name	RteOsInteraction
Description	Interaction of the Rte with the Os.
Configuration Parameters	

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
RteModeToSchedule TableMapping	0..*	Provides configuration input in which Modes of a ModeDeclarionGroupPrototype of a Mode Manager a OsScheudleTable shall be active. The Mode Manager is either specified as a SwComponentPrototype (RteModeSchtblMapSwc) or as a BSW-Module (RteModeSchtblMapBsw).
RteOsTaskChain	0..*	This container holds the configuration of one task chain configuration.
RteSyncPoint	0..*	The RteSyncPoint is necessary to provide an cross core synchronization in case of RteEvents triggered by the same event source but mapped to tasks belonging to different partitions on different cores. The synchronization point must be reached by all referencing RteEvents before the execution in all related tasks is continued. In case of Rte(Bsw)EventSuccessorSyncPointRef the ExecutableEntity activated by the mapped event is executed before the synchronization point is entered. In case of Rte(Bsw)EventPredecessorSyncPointRef the ExecutableEntity activated by the mapped event is executed after the synchronization point is passed.
RteUsedOsActivation	0..*	Attributes used in the activation of OsTasks and Runnable Entities.

8.5.2.1 Activation using Os features

This is a collection of possible ways how the Rte might utilize Os to achieve various activation scenarios. The used Os objects are referenced in these configuration entities.

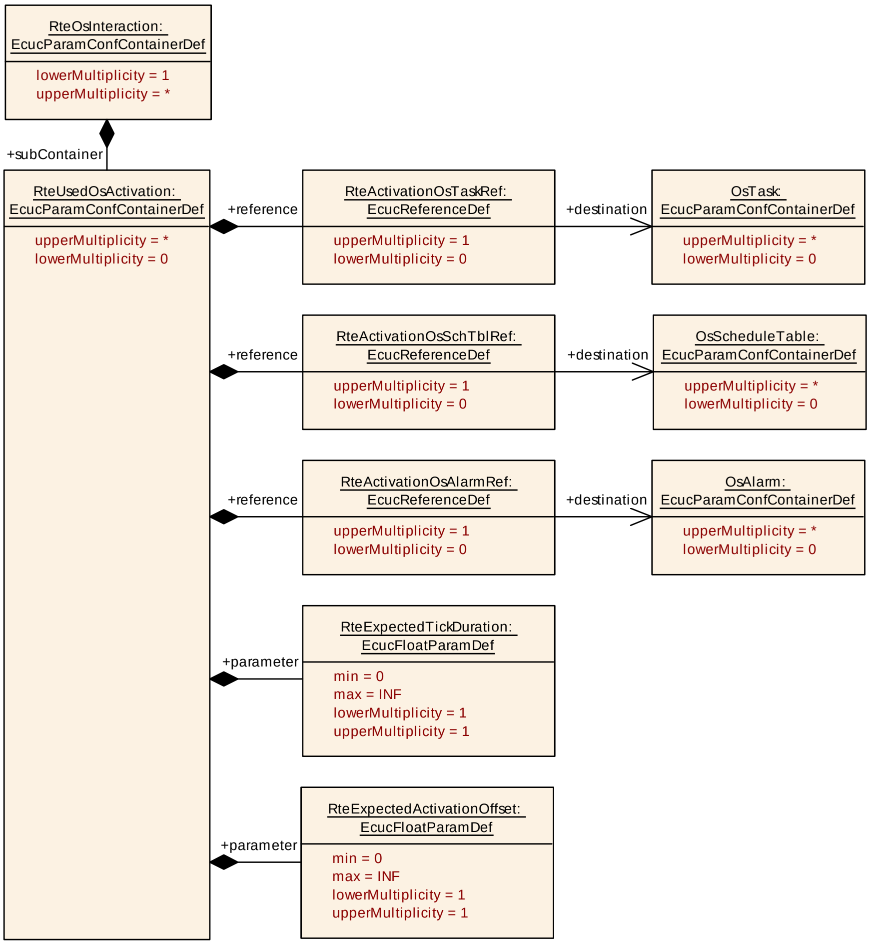

Figure 8.9: Configuration how activation is implemented

SWS Item	[ECUC_Rte_09060]
Container Name	RteUsedOsActivation
Description	Attributes used in the activation of OsTasks and Runnable Entities.
Configuration Parameters	

Name	RteExpectedActivationOffset [ECUC_Rte_09048]	
Parent Container	RteUsedOsActivation	
Description	Activation offset in seconds. Important: This is a requirement from the Rte towards the Os/Mcu setup. The Rte Generator shall assume this activation offset to be fulfilled.	
Multiplicity	1	
Type	EcucFloatParamDef	
Range	[0 .. INF]	
Default Value		

Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteExpectedTickDuration [ECUC_Rte_09049]		
Parent Container	RteUsedOsActivation		
Description	The expected tick duration in seconds which shall be configured to drive the OsScheduleTables or OsAlarm. Important: This is a requirement from the Rte towards the Os/Mcu setup. The Rte Generator shall assume this tick duration to be fulfilled.		
Multiplicity	1		
Type	EcucFloatParamDef		
Range	[0 .. INF]		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteActivationOsAlarmRef [ECUC_Rte_09045]		
Parent Container	RteUsedOsActivation		
Description	Reference to an OsAlarm.		
Multiplicity	0..1		
Type	Reference to OsAlarm		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteActivationOsSchTblRef [ECUC_Rte_09046]		
Parent Container	RteUsedOsActivation		
Description	Reference to an OsScheduleTable.		
Multiplicity	0..1		
Type	Reference to OsScheduleTable		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteActivationOsTaskRef [ECUC_Rte_09047]		
Parent Container	RteUsedOsActivation		
Description	Reference to an OsTask.		
Multiplicity	0..1		
Type	Reference to OsTask		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.5.2.2 Modes and Schedule Tables

Optional configuration of the Rte to support the mapping of modes and Os' schedule tables.

[SWS_Rte_05146] ⌈ The referenced schedule table of RteModeScheduleTableRef shall be activated if one of the modes referenced in RteModeSchtblMapModeDeclarationRef is active in the mode machine instances from the references of

- RteModeSchtblMapSwc or
- RteModeSchtblMapBsw.

⌋ *()*

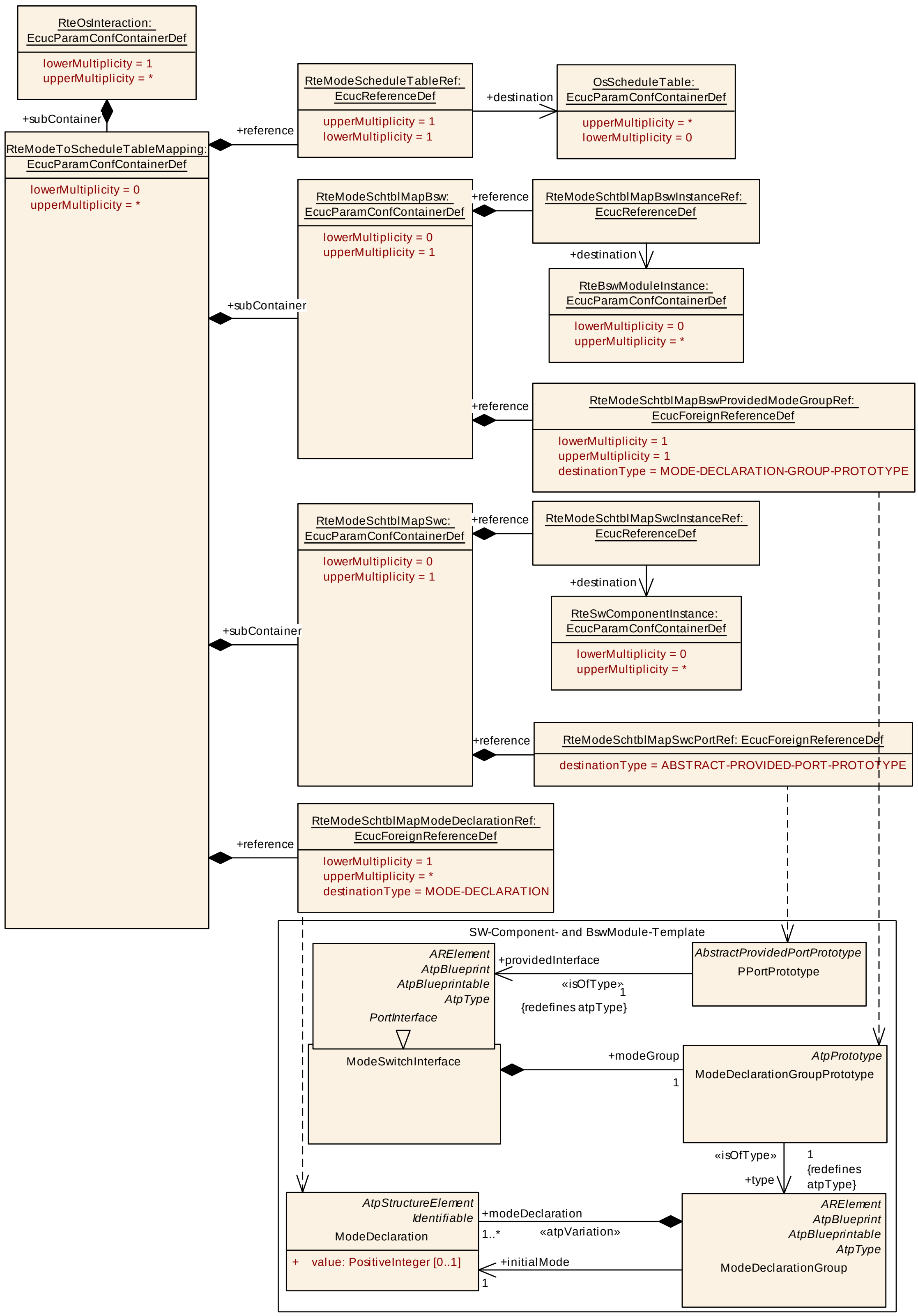

Figure 8.10: Configuration how modes are interacting with schedule tables

[SWS_Rte_02759] ⌈ RTE shall reject a configuration, if the RteModeSchtblMapSwcPortRef : EcucForeignReferenceDef does not reference a PPortPrototype or PRPortPrototype of the type of an ModeSwitchInterface. ⌋()

[SWS_Rte_02760] ⌈ RTE shall reject a configuration, if the ModeDeclarationGroupPrototype referenced by a RteModeSchtblMapBswProvidedModeGroupRef:EcucForeignReferenceDef is not in the role of a providedModeGroup. ⌋()

SWS Item	[ECUC_Rte_09058]
Container Name	RteModeToScheduleTableMapping
Description	Provides configuration input in which Modes of a ModeDeclarionGroupPrototype of a Mode Manager a OsScheudleTable shall be active. The Mode Manager is either specified as a SwComponentPrototype (RteModeSchtblMapSwc) or as a BSW-Module (RteModeSchtblMapBsw).
Configuration Parameters	

Name	RteModeScheduleTableRef [ECUC_Rte_09050]		
Parent Container	RteModeToScheduleTableMapping		
Description	Reference to the OsScheduleTable which shall be active in the specified RteModeSchblMapModeDeclarationRefs.		
Multiplicity	1		
Type	Reference to OsScheduleTable		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteModeSchtblMapModeDeclarationRef [ECUC_Rte_09054]		
Parent Container	RteModeToScheduleTableMapping		
Description	Reference to the ModeDeclarations.		
Multiplicity	1..*		
Type	Foreign reference to MODE-DECLARATION		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	

Scope / Dependency	scope: local

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
RteModeSchtblMapBsw	0..1	Specifies an instance of a ModeDeclarationGroupPrototype of a Bsw-Module.
RteModeSchtblMapSwc	0..1	Specifies an instance of a ModeDeclarationGroupPrototype of a SwComponentPrototype.

SWS Item	[ECUC_Rte_09055]
Container Name	RteModeSchtblMapSwc
Description	Specifies an instance of a ModeDeclarationGroupPrototype of a SwComponentPrototype.
Configuration Parameters	

Name	RteModeSchtblMapSwcInstanceRef [ECUC_Rte_09056]		
Parent Container	RteModeSchtblMapSwc		
Description	Reference to an instance specification of a SwComponentPrototype.		
Multiplicity	1		
Type	Reference to RteSwComponentInstance		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteModeSchtblMapSwcPortRef [ECUC_Rte_09057]		
Parent Container	RteModeSchtblMapSwc		
Description	Reference to the PPortPrototype of a SwComponentPrototype.		
Multiplicity	1		
Type	Foreign reference to ABSTRACT-PROVIDED-PORT-PROTOTYPE		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

SWS Item	[ECUC_Rte_09051]

Container Name	RteModeSchtblMapBsw
Description	Specifies an instance of a ModeDeclarationGroupPrototype of a Bsw-Module.
Configuration Parameters	

Name	RteModeSchtblMapBswInstanceRef [ECUC_Rte_09052]		
Parent Container	RteModeSchtblMapBsw		
Description	Reference to an instance specification of a Bsw-Module.		
Multiplicity	1		
Type	Reference to RteBswModuleInstance		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteModeSchtblMapBswProvidedModeGroupRef [ECUC_Rte_09053]		
Parent Container	RteModeSchtblMapBsw		
Description	Reference to an instance of a ModeDeclarationGroupPrototype of a Bsw-Module.		
Multiplicity	1		
Type	Foreign reference to MODE-DECLARATION-GROUP-PROTOTYPE		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.5.3 Exclusive Area implementation

The RTE Generator can be configured to implement a different data consistency mechanism for each `ExclusiveArea` defined for an AUTOSAR software-component.

In figure 8.11 the configuration of the actually selected data consistency mechanism is shown.

[SWS_Rte_CONSTR_03510] Exclude usage of `OS_SPINLOCK` in `RteExclusiveAreaImplementation` ⌈ The usage of the enumeration literal `OS_SPINLOCK` for the parameter RteExclusiveAreaImplMechanism shall be excluded if the parameter RteExclusiveAreaImplMechanism is used in the context of the container RteExclusiveAreaImplementation. ⌋()

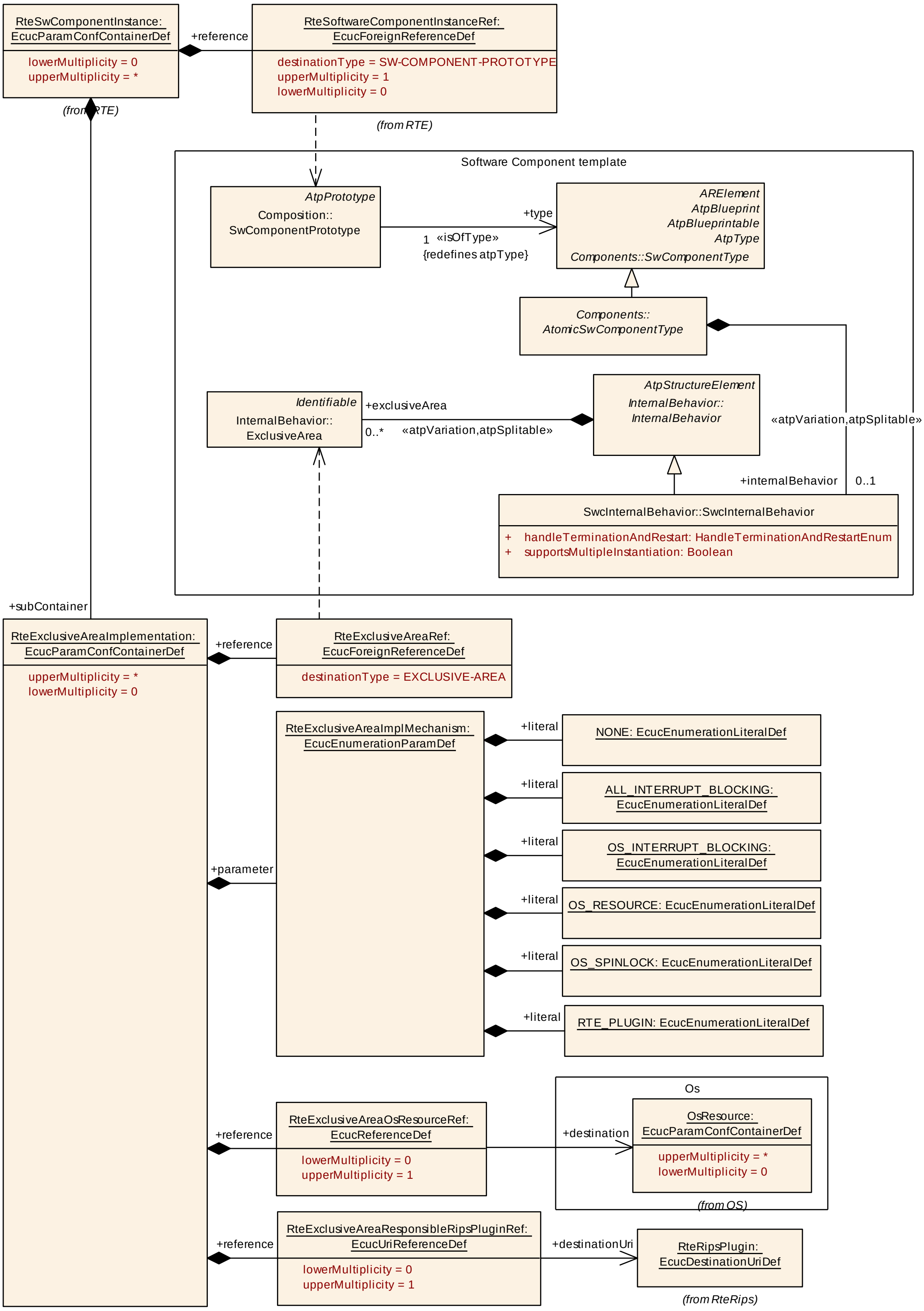

Figure 8.11: Configuration of the ExclusiveArea implementation

SWS Item	[ECUC_Rte_09030]		
Container Name	RteExclusiveAreaImplementation		
Description	Specifies the implementation to be used for the data consistency of this ExclusiveArea.		
Configuration Parameters			

Name	RteExclusiveAreaImplMechanism [ECUC_Rte_09029]		
Parent Container	RteExclusiveAreaImplementation		
Description	To be used implementation mechanism for the specified ExclusiveArea.		
Multiplicity	1		
Type	EcucEnumerationParamDef		
Range	ALL_INTERRUPT_BLOCKING		
	NONE		
	OS_INTERRUPT_BLOCKING		
	OS_RESOURCE		
	OS_SPINLOCK		
	RTE_PLUGIN	RTE Implementation Plug-in	
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteExclusiveAreaOsResourceRef [ECUC_Rte_09031]		
Parent Container	RteExclusiveAreaImplementation		
Description	Optional reference to an OsResource in case RteExclusiveAreaImplMechanism is configured to OS_RESOURCE for this ExclusiveArea.		
Multiplicity	0..1		
Type	Reference to OsResource		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteExclusiveAreaRef [ECUC_Rte_09032]		
Parent Container	RteExclusiveAreaImplementation		
Description	Reference to the ExclusiveArea.		
Multiplicity	1		
Type	Foreign reference to EXCLUSIVE-AREA		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteExclusiveAreaResponsibleRipsPluginRef [ECUC_Rte_89010]		
Parent Container	RteExclusiveAreaImplementation		
Description	Optional reference to the configuration container of the RTE Implementation Plug-in implementing the ExclusiveArea. It's required in case RteExclusiveAreaImplMechanism is configured to RTE_PLUGIN for this ExclusiveArea. **Tags:** atp.Status=draft		
Multiplicity	0..1		
Type	Reference to destinationUri [RteRipsUriDefSet/RteRipsPlugin]		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

No Included Containers

8.5.4 NVRam Allocation

The configuration of the NVRam access does involve several templates, because it closes the gap between the AUTOSAR software-components, the NVRAM Manager Services and the BSW Modules.

In figure 8.12 the related information from the AUTOSAR Software Component Template is shown.

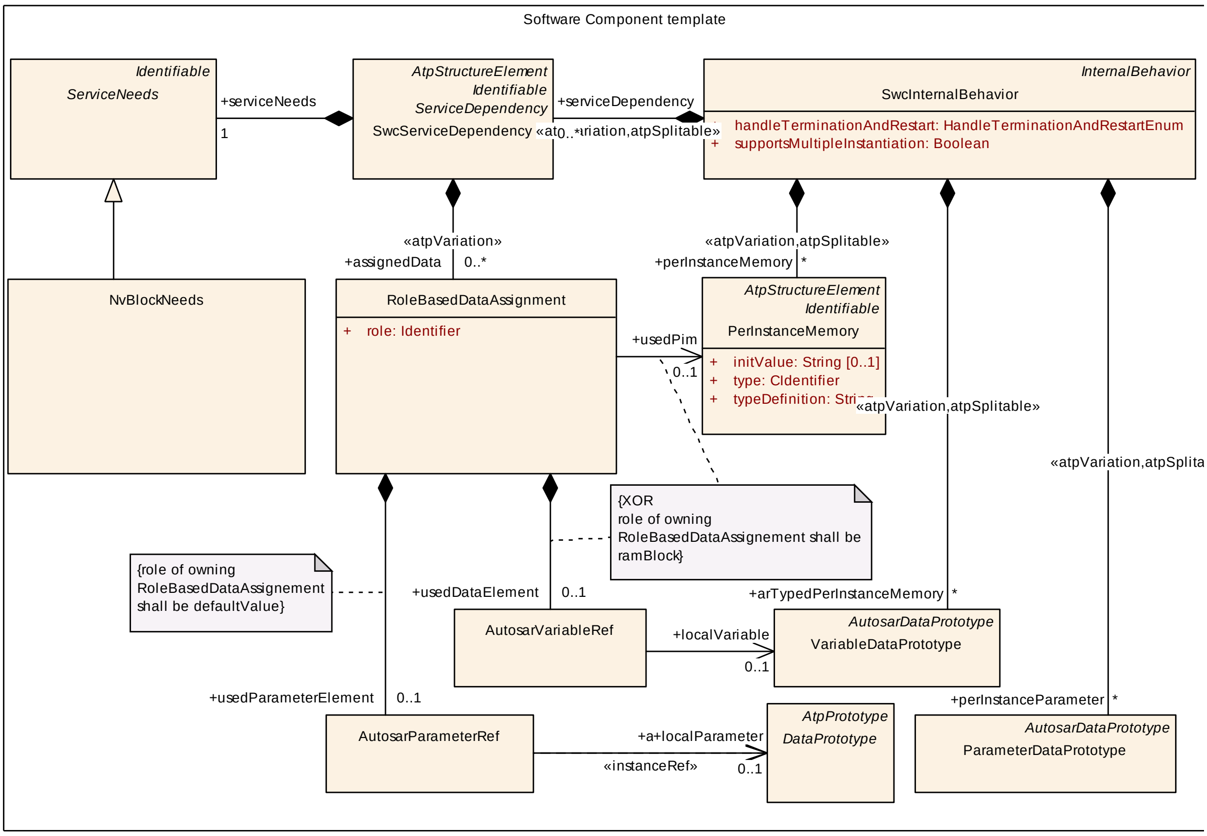

Figure 8.12: software-component information of NVRam Service needs

In figure 8.13 the ECU Configuration part of the NVRam allocation is shown. It relates the software-components' `SwcServiceDependency` and `NvBlockNeeds` information with the NVRam Managers `NvMBlockDescriptor` and the linker symbols of the RAM and ROM sections to be used.

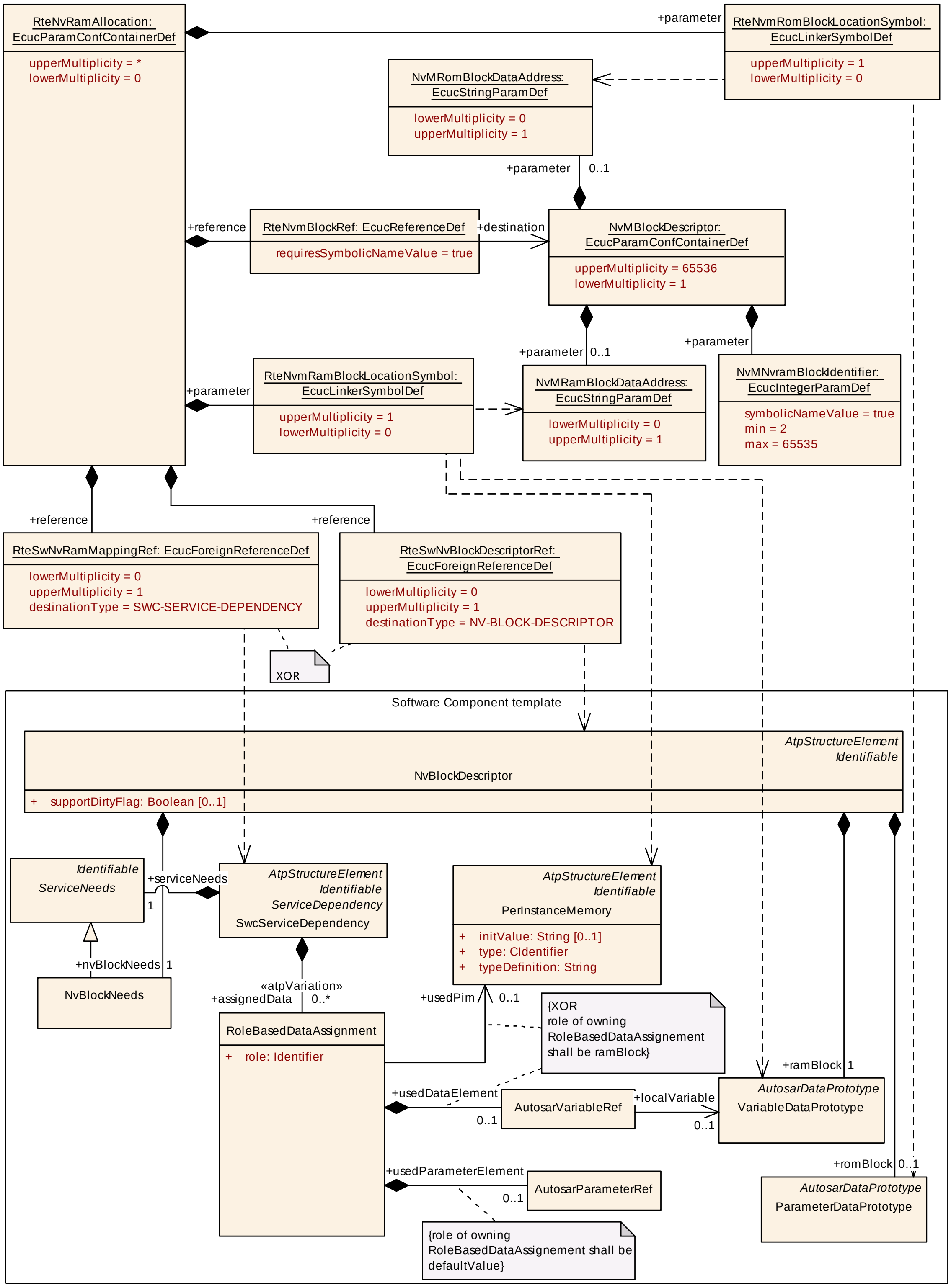

Figure 8.13: ECU Configuration of the NVRam Service

[SWS_Rte_CONSTR_09091] **`RteSwNvRamMappingRef` and `RteSwNvBlockDescriptorRef` are excluding each other** ⌈ If an `RteSwNvBlockDescriptorRef` is defined there shall be no RteSwNvRamMappingRef, RteNvmRomBlockLocationSymboland RteNvmRamBlockLocationSymbol defined. If an RteSwNvRamMappingRef is defined there shall be no RteSwNvBlockDescriptorRef defined. ⌋()

SWS Item	[ECUC_Rte_09040]
Container Name	RteNvRamAllocation
Description	Specifies the relationship between the AtomicSwComponentType's NVRAMMapping / NVRAM needs and the NvM module configuration.
Configuration Parameters	

Name	RteNvmRamBlockLocationSymbol [ECUC_Rte_09042]		
Parent Container	RteNvRamAllocation		
Description	This is the name of the linker object name where the NVRam Block will be mirrored by the Nvm. This symbol will be resolved into the parameter "NvmRamBlockDataAddress" from the "NvmBlockDescriptor".		
Multiplicity	0..1		
Type	EcucLinkerSymbolDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteNvmRomBlockLocationSymbol [ECUC_Rte_09043]
Parent Container	RteNvRamAllocation
Description	This is the name of the linker object name where the NVRom Block will be accessed by the Nvm. This symbol will be resolved into the parameter "NvmRomBlockDataAddress" from the "NvmBlockDescriptor".
Multiplicity	0..1
Type	EcucLinkerSymbolDef
Default Value	
Regular Expression	
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteNvmBlockRef [ECUC_Rte_09041]		
Parent Container	RteNvRamAllocation		
Description	Reference to the used NvM block for storage of the NVRAMMapping information.		
Multiplicity	1		
Type	Symbolic name reference to NvMBlockDescriptor		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteSwNvBlockDescriptorRef [ECUC_Rte_09132]		
Parent Container	RteNvRamAllocation		
Description	Reference to the NvBlockDescriptor in case the RTE needs to call the NvM directly (e.g. for the supportDirtyFlag feature, storeCyclic feature, server invocation for NV data management or mode switch based invocation NvM services).		
Multiplicity	0..1		
Type	Foreign reference to NV-BLOCK-DESCRIPTOR		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteSwNvRamMappingRef [ECUC_Rte_09044]		
Parent Container	RteNvRamAllocation		
Description	Reference to the SwSeriveDependency which is used to specify the NvBlockNeeds. XOR		
Multiplicity	0..1		
Type	Foreign reference to SWC-SERVICE-DEPENDENCY		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.5.5 SWC Trigger queuing

This configuration determine the size of the queue queuing the issued triggers.

The `RteExternalTriggerConfig` container and `RteInternalTriggerConfig` container is defined in the context of the `RteSwComponentInstance` which already predefines the context of the `Trigger` / `InternalTriggeringPoint`.

[SWS_Rte_CONSTR_09005] The references `RteSwcTriggerSourceRef` has to be consistent with the `RteSoftwareComponentInstanceRef` ⌈ The references `RteSwcTriggerSourceRef` has to be consistent with the `RteSoftwareComponentInstanceRef`. This means the referenced `Trigger` / `InternalTriggeringPoint` has to belong to the `AtomicSwComponentType` which is referenced by the related `SwComponentPrototype`. ⌋*()*

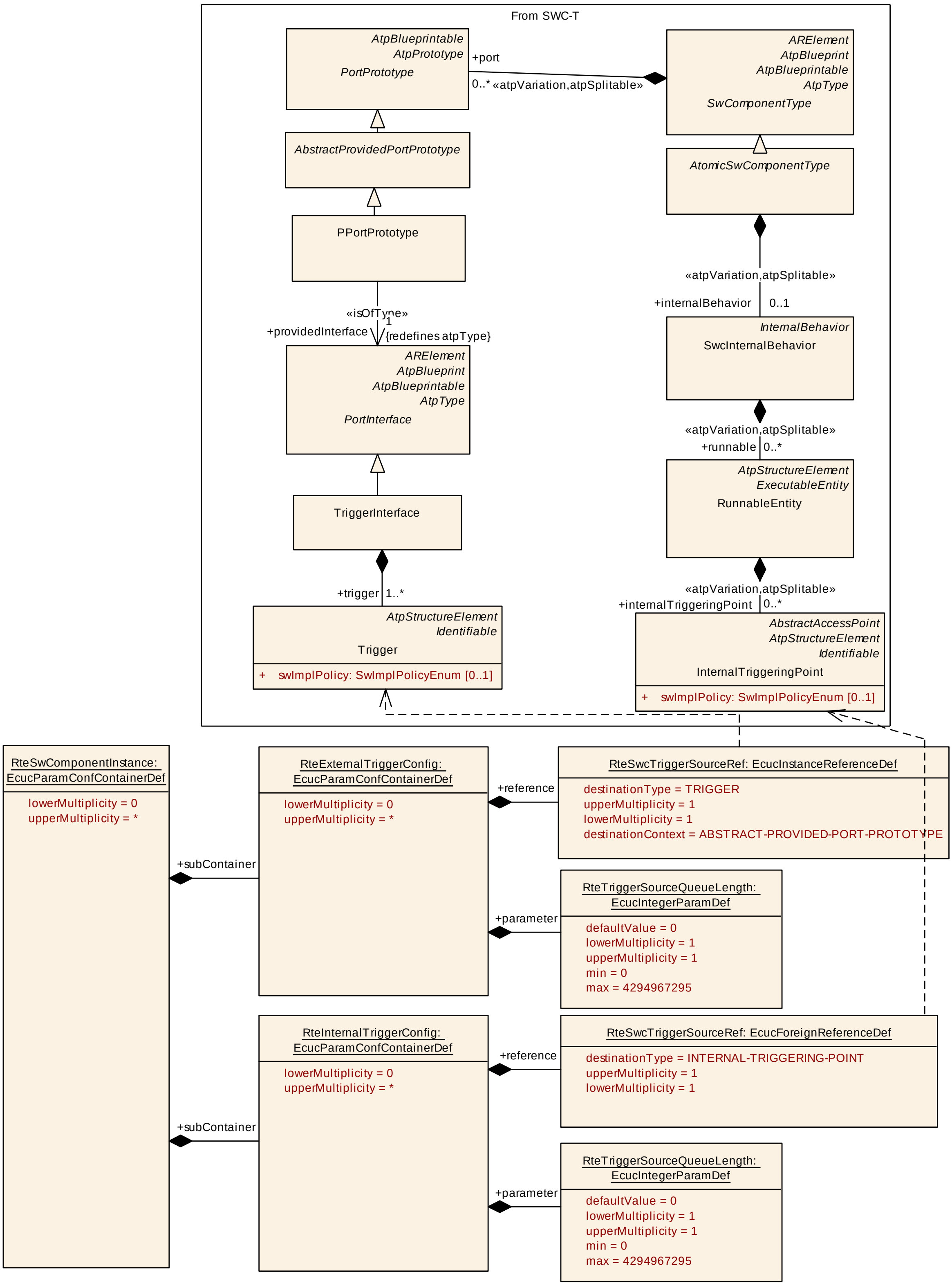

Figure 8.14: Configuration of SWC Trigger queuing

SWS Item	[ECUC_Rte_09105]
Container Name	RteExternalTriggerConfig

Description	Defines the configuration of External Trigger Event Communication for Software Components		
Configuration Parameters			

Name	RteTriggerSourceQueueLength [ECUC_Rte_09095]		
Parent Container	RteExternalTriggerConfig		
Description	Length of trigger queue on the trigger source side. The queue is implemented by the RTE. A value greater or equal to 1 requests an queued behavior. Setting the value of RteTriggerSourceQueueLength to 0 requests an none queued implementation of the trigger communication. If there is no RteTriggerSourceQueueLength configured for a Trigger Emitter the default value of 0 applies as well.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 4294967295		
Default Value	0		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteSwcTriggerSourceRef [ECUC_Rte_09106]		
Parent Container	RteExternalTriggerConfig		
Description	Reference to a Trigger instance in the pPortPrototype of the related component instance. The referenced Trigger instance has to belong to the same software component instance as the RteSwComponentInstance owning this parameter configures.		
Multiplicity	1		
Type	Instance reference to TRIGGER context: ABSTRACT-PROVIDED-PORT-PROTOTYPE		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

SWS Item	[ECUC_Rte_09096]		
Container Name	RteInternalTriggerConfig		
Description	Defines the configuration of Inter Runnable Triggering for Software Components		
Configuration Parameters			

Name	RteTriggerSourceQueueLength [ECUC_Rte_09098]		
Parent Container	RteInternalTriggerConfig		
Description	Length of trigger queue on the trigger source side. The queue is implemented by the RTE. A value greater or equal to 1 requests an queued behavior. Setting the value of RteTriggerSourceQueueLength to 0 requests an none queued implementation of the trigger communication. If there is no RteTriggerSourceQueueLength configured for a Trigger Emitter the default value of 0 applies as well.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 4294967295		
Default Value	0		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteSwcTriggerSourceRef [ECUC_Rte_09097]		
Parent Container	RteInternalTriggerConfig		
Description	Reference to an InternalTriggeringPoint of the related component instance. The referenced InternalTriggeringPoint has to belong to the same software component instance as the RteSwComponentInstance owning this parameter configures.		
Multiplicity	1		
Type	Foreign reference to INTERNAL-TRIGGERING-POINT		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.5.6 SWC Mode Machine Instance configuration

This configuration provides the settings for the implementation of a RTE assigned mode machine instance (see [SWS_Rte_07533].

The RteModeMachineInstanceConfig container is defined in the context of the RteSwComponentInstance which already predefines the context of the ModeDeclarationGroupPrototype in the RteSwcModeManagerRef .

[SWS_Rte_CONSTR_09100] The reference RteSwcModeManagerRef has to be consistent with the RteSoftwareComponentInstanceRef ⌈ The reference RteSwcModeManagerRef has to be consistent with the RteSoftwareComponentInstanceRef. This means the referenced ModeDeclarationGroupPrototype shall be instantiated in the context of an AbstractProvidedPortPrototype owned by the AtomicSwComponentType which is referenced by the related SwComponentPrototype. ⌋ *()*

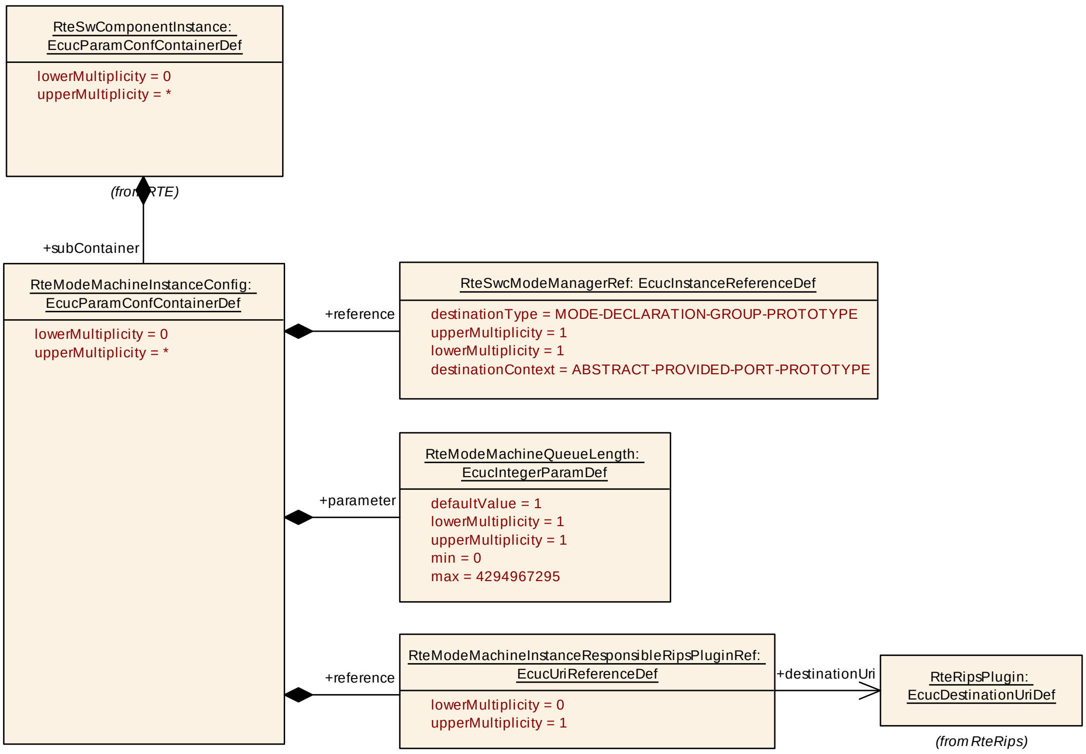

Figure 8.15: Configuration of a RTE assigned mode machine instance

SWS Item	[ECUC_Rte_09142]
Container Name	RteModeMachineInstanceConfig
Description	Defines the configuration of RTE assigned (SWS_Rte_07533) mode machine instances.
Configuration Parameters	

Name	RteModeMachineQueueLength [ECUC_Rte_09144]		
Parent Container	RteModeMachineInstanceConfig		
Description	Length of mode machine instance queue on the trigger source side. If there is no RteModeMachineQueueLength configured for a mode machine instance the value given in the ModeSwitchSenderComSpec.queueLength applies.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 4294967295		
Default Value	1		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteModeMachineInstanceResponsibleRipsPluginRef [ECUC_Rte_89013]		
Parent Container	RteModeMachineInstanceConfig		
Description	Optional reference to the configuration container of the RTE Implementation Plug-in implementing the protection of the mode machine instance. **Tags:** atp.Status=draft		
Multiplicity	0..1		
Type	Reference to destinationUri [RteRipsUriDefSet/RteRipsPlugin]		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

Name	RteSwcModeManagerRef [ECUC_Rte_09143]		
Parent Container	RteModeMachineInstanceConfig		
Description	Reference to a ModeDeclarationGroupPrototype instance in the provided PortPrototype (AbstractProvidedPortPrototype) of the related component instance. The referenced ModeDeclarationGroupPrototype instance has to belong to the same software component instance as the RteSwComponentInstance owning this parameter configures.		
Multiplicity	1		
Type	Instance reference to MODE-DECLARATION-GROUP-PROTOTYPE context: ABSTRACT-PROVIDED-PORT-PROTOTYPE		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.6 Handling of Software Component types

8.6.1 Selection of Software-Component Implementation

During the system development there is no need to select the actual implementation which will be later integrated on one ECU. Therefore the *ECU Extract of System Description* may not specify the SwcImplementation information yet.

For RTE Generation the information about the to be used SwcImplementation for each SwComponentType needs be provided to the RTE Generator (regardless whether the information is from the Ecu Extract or the Ecu Configuration.

The mapping of SwcImplementation to SwComponentType is done in the Ecu Configuration of the Rte using the two references RteComponentTypeRef and RteImplementationRef (see figure 8.16). For the mapping in the Ecu Extract please refer to the Specification of the System Template [8].

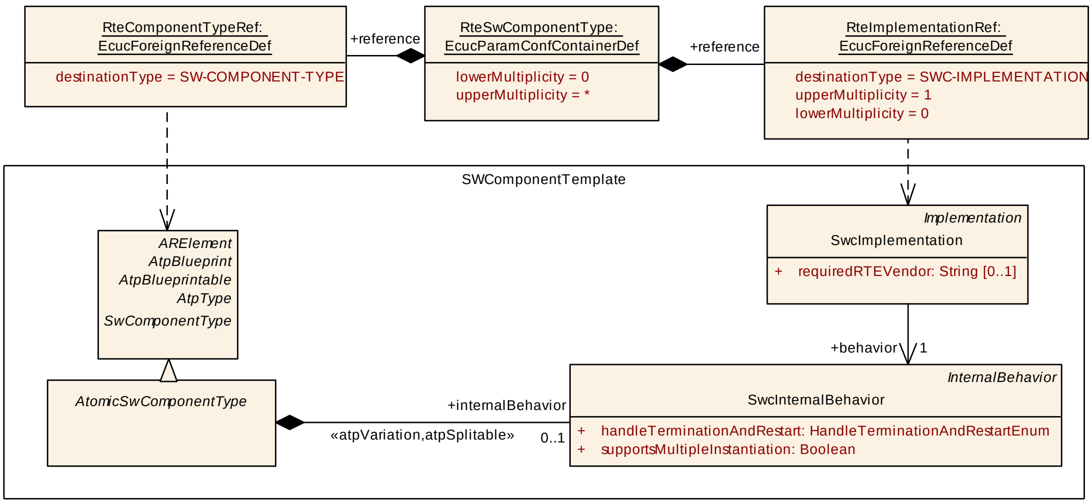

Figure 8.16: Selection of the Implementation for an AtomicSwComponentType

SWS Item	[ECUC_Rte_09006]
Container Name	RteSwComponentType
Description	Representation of one SwComponentType for the base of all configuration parameter which are affecting the whole type and not a specific instance.
Configuration Parameters	

Name	RteBypassSupportEnabled [ECUC_Rte_09114]
Parent Container	RteSwComponentType
Description	Individual switch to enable the bypass support for this software component type.
Multiplicity	0..1
Type	EcucBooleanParamDef
Default Value	false
Post-Build Variant Multiplicity	false

Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteComponentTypeRef [ECUC_Rte_09003]		
Parent Container	RteSwComponentType		
Description	Reference to either AtomicSwComponentType or ParameterSwComponentType.		
Multiplicity	1		
Type	Foreign reference to SW-COMPONENT-TYPE		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteImplementationRef [ECUC_Rte_09028]		
Parent Container	RteSwComponentType		
Description	The Implementation which shall be assigned to the SwComponentType.		
Multiplicity	0..1		
Type	Foreign reference to SWC-IMPLEMENTATION		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
RteComponentType Calibration	0..1	Specifies for each ParameterSwComponentType or AtomicSwComponentType whether calibration is enabled. If references to SwAddrMethod are provided in RteCalibrationSwAddrMethodRef only ParameterDataPrototypes with the referenced SwAddrMethod shall have software calibration support enabled.

8.6.2 Component Type Calibration

In the AUTOSAR Software Component Template two places may provide calibration data: the `ParameterSwComponentType` and the `AtomicSwComponentType` (or more precisely the subclasses of `AtomicSwComponentType`). Whether the calibration is enabled for a specific `SwComponentType` can be configured as shown in figure 8.17.

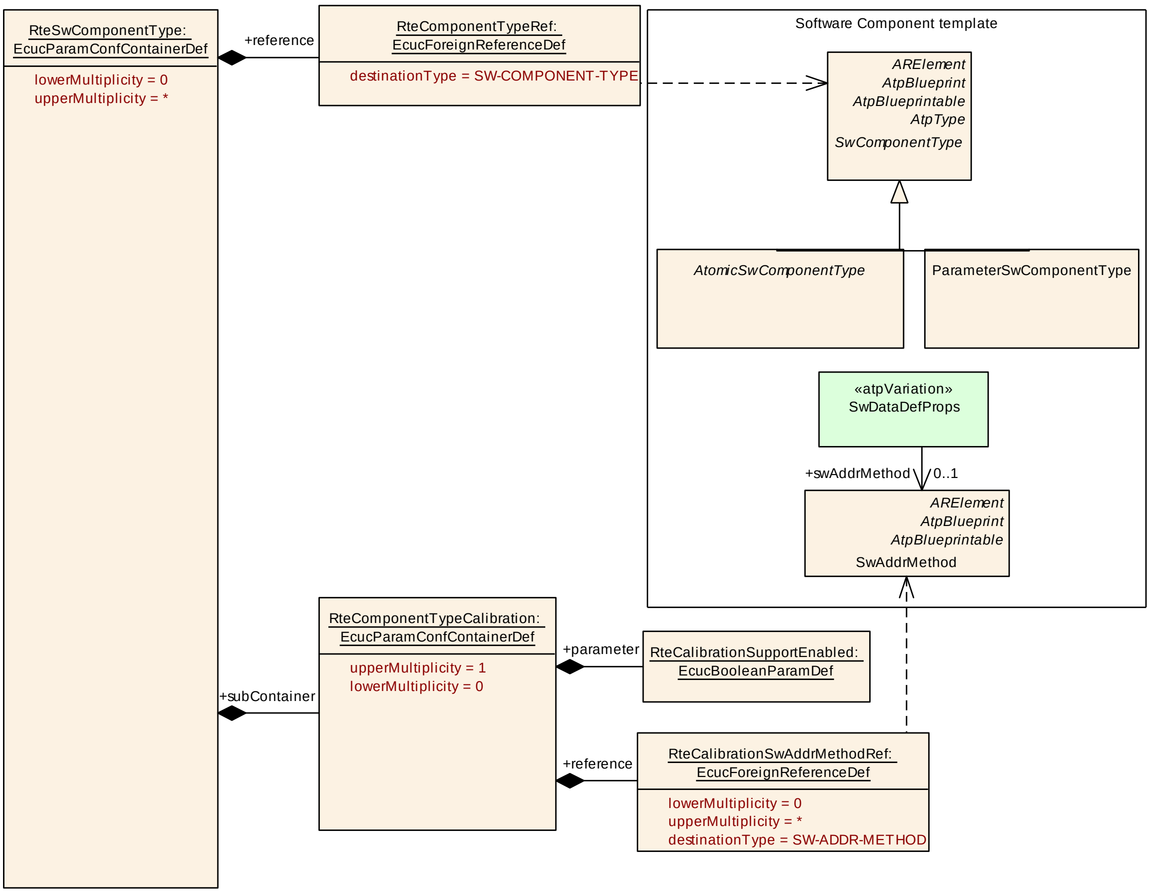

Figure 8.17: Configuration of the calibration for the ParameterSwComponentType

The foreign reference `RteComponentTypeRef` identifies the `SwComponentType` (which is limited to `ParameterSwComponentType` and `AtomicSwComponentType`).

The boolean parameter `RteCalibrationSupportEnabled` specifies whether calibration shall be enabled for the specified `SwComponentType`.

[SWS_Rte_05145] ⌈ For a `ParameterDataPrototype` of the referenced `SwComponentType` software calibration support shall be enabled if the parameter `RteCalibrationSupportEnabled` is set to *true* and in the corresponding container `RteComponentTypeCalibration`

- not a single `RteCalibrationSwAddrMethodRef` exists or
- a reference `RteCalibrationSwAddrMethodRef` to the `SwAddrMethod` of the `ParameterDataPrototype` exists.

⌋ *(SRS_Rte_00154, SRS_Rte_00156, SRS_Rte_00158)*

SWS Item	[ECUC_Rte_09039]
Container Name	RteComponentTypeCalibration
Description	Specifies for each ParameterSwComponentType or AtomicSwComponentType whether calibration is enabled. If references to SwAddrMethod are provided in RteCalibrationSwAddrMethodRef only ParameterDataPrototypes with the referenced SwAddrMethod shall have software calibration support enabled.
Configuration Parameters	

Name	RteCalibrationSupportEnabled [ECUC_Rte_09037]		
Parent Container	RteComponentTypeCalibration		
Description	Enables calibration support for the specified ParameterSwComponentType or AtomicSwComponentType.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteCalibrationSwAddrMethodRef [ECUC_Rte_09038]
Parent Container	RteComponentTypeCalibration
Description	Reference to the SwAddrMethod for which software calibration support shall be enabled.
Multiplicity	0..*
Type	Foreign reference to SW-ADDR-METHOD
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.7 Implicit communication configuration

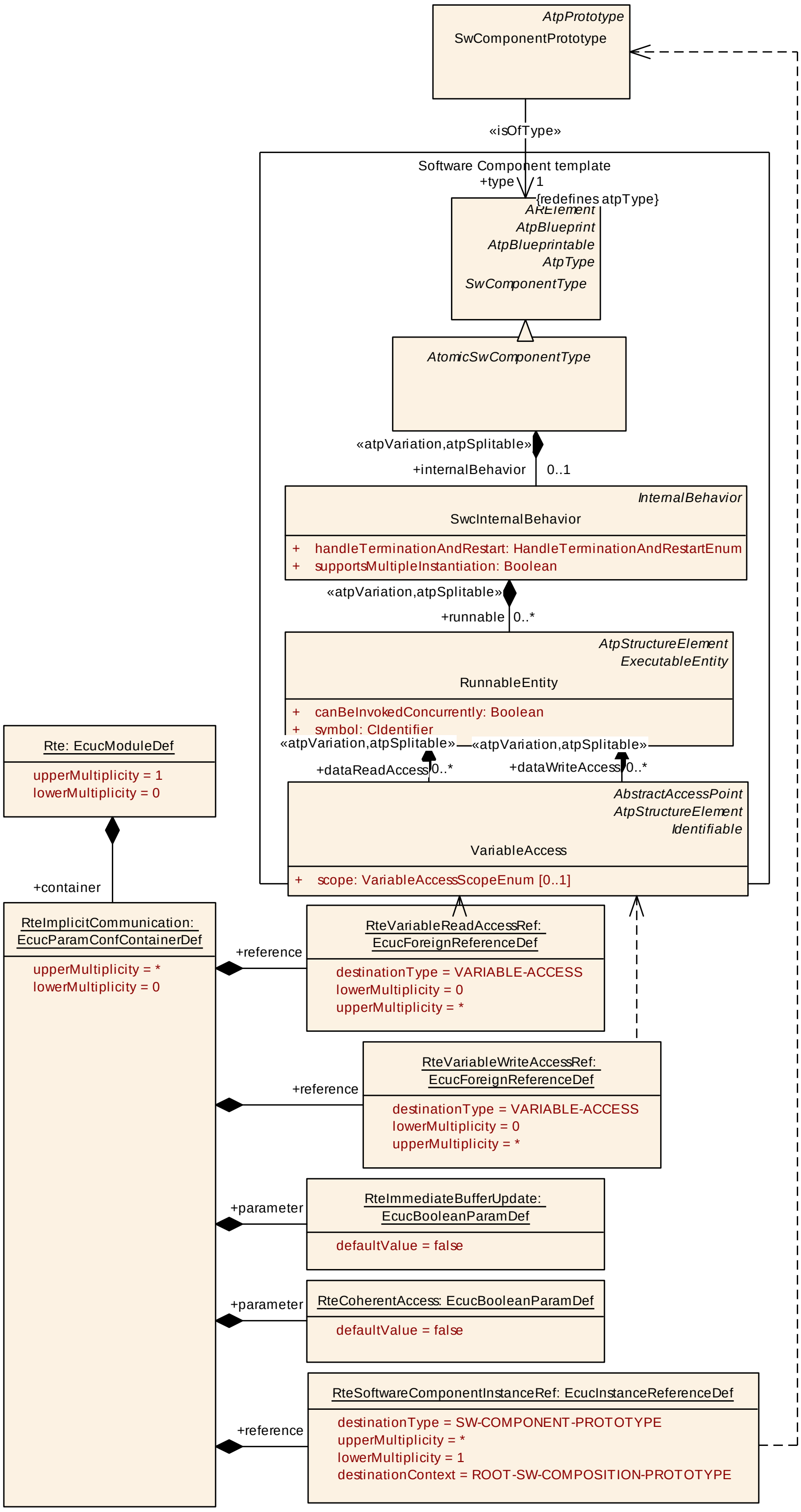

Figure 8.18: Configuration of the implicit communication

SWS Item	[ECUC_Rte_09034]
Container Name	RteImplicitCommunication
Description	Configuration of the Implicit Communication behavior to be generated.
Configuration Parameters	

Name	RteCoherentAccess [ECUC_Rte_09091]		
Parent Container	RteImplicitCommunication		
Description	If set to true the referenced VariableAccess'es of this RteImplicitCommunication container are in one CoherencyGroup. Data values for Coherent Implicit Read Access'es are read before the first reading RunnbaleEntity starts and are stable during the execution of all the reading RunnableEntitys; except Coherent Implicit Write Access'es belongs to the same Coherency Group. Data values written by Coherent Implicit Write Access'es are available for readers not belonging to the Coherency Group after the last writing RunnableEntity has terminated. Please note that a Coherent Implicit Data Access can be defined for VariableAccess'es to same and different data element. Nevertheless all Coherent Implicit Data Access'es of one Coherency Group have to be executed in the same task.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteImmediateBufferUpdate [ECUC_Rte_09033]		
Parent Container	RteImplicitCommunication		
Description	If set to true the RTE will perform preemption area specific buffer update immediately before (for VariableAccess in the role dataReadAccess) resp. after (for VariableAccess in the role dataWriteAccess) Runnable execution.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteSoftwareComponentInstanceRef [ECUC_Rte_09090]		
Parent Container	RteImplicitCommunication		
Description	Reference to a SwComponentPrototype. This denotes the instances of the VariableAccess belonging to the RteImplicitCommunication.		
Multiplicity	1..*		
Type	Instance reference to SW-COMPONENT-PROTOTYPE context: ROOT-SW-COMPOSITION-PROTOTYPE		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteVariableReadAccessRef [ECUC_Rte_09035]		
Parent Container	RteImplicitCommunication		
Description	Reference to the VariableAccess in the dataReadAccess role.		
Multiplicity	0..*		
Type	Foreign reference to VARIABLE-ACCESS		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteVariableWriteAccessRef [ECUC_Rte_09036]
Parent Container	RteImplicitCommunication
Description	Reference to the VariableAccess in the dataWriteAccess role.
Multiplicity	0..*
Type	Foreign reference to VARIABLE-ACCESS
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

Please note, that RteImplicitCommunication is defined as a container of RteEcucModuleDef to support the creation of the ECU Configuration Parameter Values related to RteImplicitCommunication independent from the other ECU Configuration Parameter Values. Typically the need for coherent implicit data accesses is known by the vendor of a set of software components. As long as shortNames of the RootSwCompositionPrototype and the referenced CompositionSwComponentType - describing the software of a flat ECU Extract - are known the ECU Configuration Parameter Values related to RteImplicitCommunication can be prescribed. In this case it is preferable to use relative references to the Vendor Specific Module Definition (VSMD), to RootSwCompositionPrototype and CompositionSwComponentType describing the software of a flat ECU Extract. With this relative references the ECU Configuration Parameter Values are independent from ARPackage structure only known by the ECU integrator. Nevertheless the shortName and location of of the EcucModuleConfigurationValues must be defined upfront.

8.8 Communication infrastructure

The configuration of the communication infrastructure (interaction of the RTE with the Com-Stack) is entirely predetermined by the ECU Extract provided as an input. The required input can be found in the AUTOSAR System Template [8] sections "Data Mapping" and "Communication".

In case the RTE does utilize the Com module for intra-ECU communication it is up to the vendor-specific configuration of the RTE to ensure configuration consistency.

8.9 Configuration of the BSW Scheduler

The configuration of the BSW Scheduler part of the RTE is shown in the overview in figure 8.19.

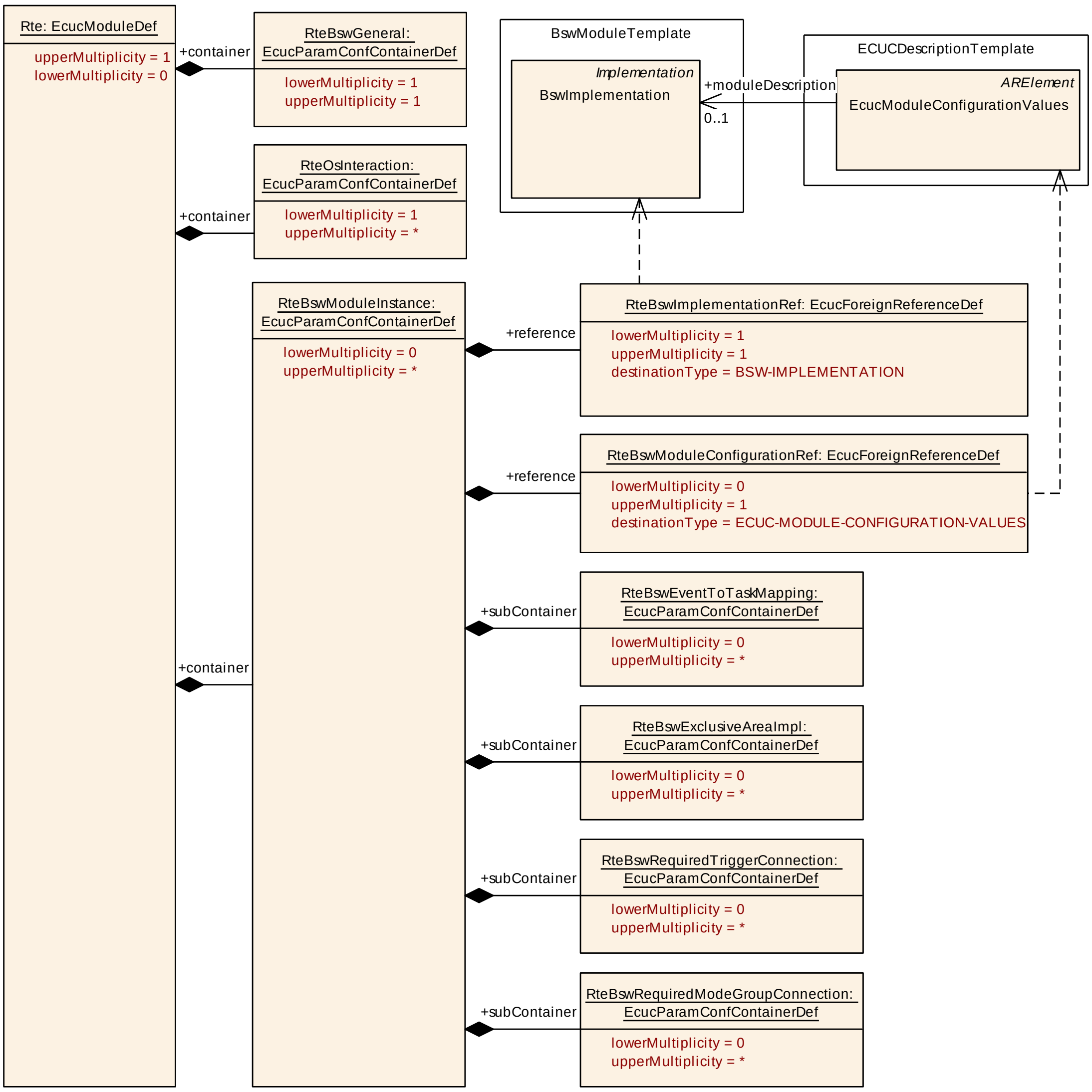

Figure 8.19: Configuration of BSW Scheduler overview

8.9.1 BSW Scheduler General configuration

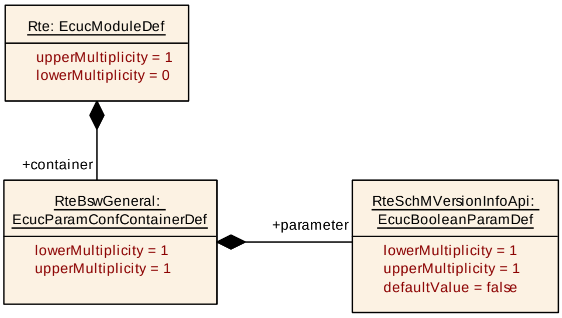

Figure 8.20: General configuration of BSW Scheduler

SWS Item	[ECUC_Rte_09061]

Container Name	RteBswGeneral
Description	General configuration parameters of the Bsw Scheduler section.
Configuration Parameters	

Name	RteSchMVersionInfoApi [ECUC_Rte_09062]		
Parent Container	RteBswGeneral		
Description	Enables the generation of the SchM_GetVersionInfo() API.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.9.2 BSW Module Instance configuration

SWS Item	[ECUC_Rte_09002]
Container Name	RteBswModuleInstance
Description	Represents one instance of a Bsw-Module configured on one ECU.
Configuration Parameters	

Name	RteBswImplementationRef [ECUC_Rte_09066]		
Parent Container	RteBswModuleInstance		
Description	Reference to the BswImplementation for which the Rte /SchM is configured.		
Multiplicity	1		
Type	Foreign reference to BSW-IMPLEMENTATION		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswModuleConfigurationRef [ECUC_Rte_09001]		
Parent Container	RteBswModuleInstance		
Description	Reference to the ECU Configuration Values provided for this BswImplementation.		
Multiplicity	0..1		
Type	Foreign reference to ECUC-MODULE-CONFIGURATION-VALUES		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	Pre-compile time	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	Pre-compile time	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
RteBswEventToTaskMapping	0..*	Maps a BswModuleEntity onto an OsTask based on the activating BswEvent. A BswModuleEntity can be activated by more than one BswEvent and thus be mapped to more than one OsTask. In the case of a BswSchedulableEntity executed via a direct function call this RteBswEventToTaskMapping is still specified but no RteBswMappedToTaskRef element is included. The RteBswPositionInTask parameter is necessary to provide an ordering of events invoked by the same RTE API.
RteBswExclusiveAreaImpl	0..*	Represents one ExclusiveArea of one BswImplementation. Used to specify the implementation means of this ExclusiveArea.
RteBswExternalTriggerConfig	0..*	Defines the configuration of Inter Basic Software Module Entity Triggering
RteBswInternalTriggerConfig	0..*	Defines the configuration of internal Basic Software Module Entity Triggering
RteBswModeMachineInstanceConfig	0..*	Defines the configuration of Basic Software Scheduler assigned (SWS_Rte_07534) mode machine instances.
RteBswRequiredClientServerConnection	0..*	Defines the connection between one requiredClientServerEntry and one providedClientServerEntry of a BswModuleDescription. This container shall be provided on the client side of the connection.
RteBswRequiredModeGroupConnection	0..*	Defines the connection between one requiredModeGroup of this BSW Module instance and one providedModeGroup instance.
RteBswRequiredSenderReceiverConnection	0..*	Defines the connection between one requiredData and one providedData of a BswModuleDescription. This container shall be provided on the receiver side of the connection.

RteBswRequiredTrigger Connection	0..*	Defines the connection between one requiredTrigger of this BSW Module instance and one releasedTrigger instance.

8.9.2.1 BSW ExclusiveArea configuration

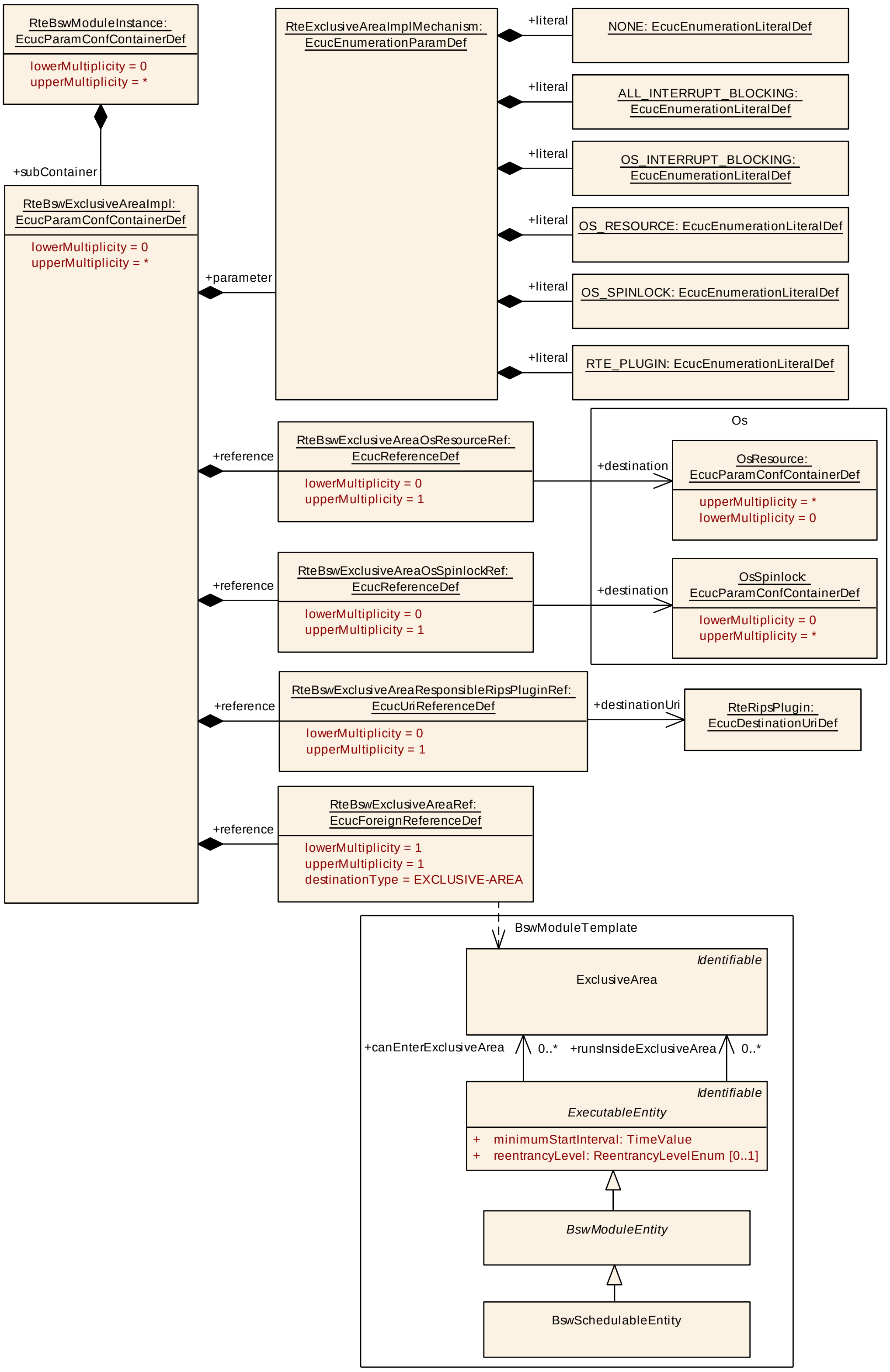

Figure 8.21: Configuration of BSW ExclusiveArea

SWS Item	[ECUC_Rte_09072]

Container Name	RteBswExclusiveAreaImpl
Description	Represents one ExclusiveArea of one BswImplementation. Used to specify the implementation means of this ExclusiveArea.
Configuration Parameters	

Name	RteExclusiveAreaImplMechanism [ECUC_Rte_09029]		
Parent Container	RteBswExclusiveAreaImpl		
Description	To be used implementation mechanism for the specified ExclusiveArea.		
Multiplicity	1		
Type	EcucEnumerationParamDef		
Range	ALL_INTERRUPT_BLOCKING		
	NONE		
	OS_INTERRUPT_BLOCKING		
	OS_RESOURCE		
	OS_SPINLOCK		
	RTE_PLUGIN	RTE Implementation Plug-in	
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswExclusiveAreaOsResourceRef [ECUC_Rte_09073]		
Parent Container	RteBswExclusiveAreaImpl		
Description	Optional reference to an OsResource in case RteExclusiveAreaImplMechanism is configured to OS_RESOURCE for this ExclusiveArea.		
Multiplicity	0..1		
Type	Reference to OsResource		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswExclusiveAreaOsSpinlockRef [ECUC_Rte_09112]		
Parent Container	RteBswExclusiveAreaImpl		
Description	Optional reference to an OsSpinlock in case RteExclusiveAreaImplMechanism is configured to OS_SPINLOCK for this ExclusiveArea.		
Multiplicity	0..1		
Type	Reference to OsSpinlock		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswExclusiveAreaRef [ECUC_Rte_09074]		
Parent Container	RteBswExclusiveAreaImpl		
Description	Reference to the ExclusiveArea for which the implementation mechanism shall be specified.		
Multiplicity	1		
Type	Foreign reference to EXCLUSIVE-AREA		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswExclusiveAreaResponsibleRipsPluginRef [ECUC_Rte_89011]
Parent Container	RteBswExclusiveAreaImpl
Description	Optional reference to the configuration container of the RTE Implementation Plug-in implementing the ExclusiveArea. It's required in case RteExclusiveAreaImplMechanism is configured to RTE_PLUGIN for this ExclusiveArea. **Tags:** atp.Status=draft
Multiplicity	0..1
Type	Reference to destinationUri [RteRipsUriDefSet/RteRipsPlugin]

Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

No Included Containers

8.9.2.2 BswEvent to task mapping

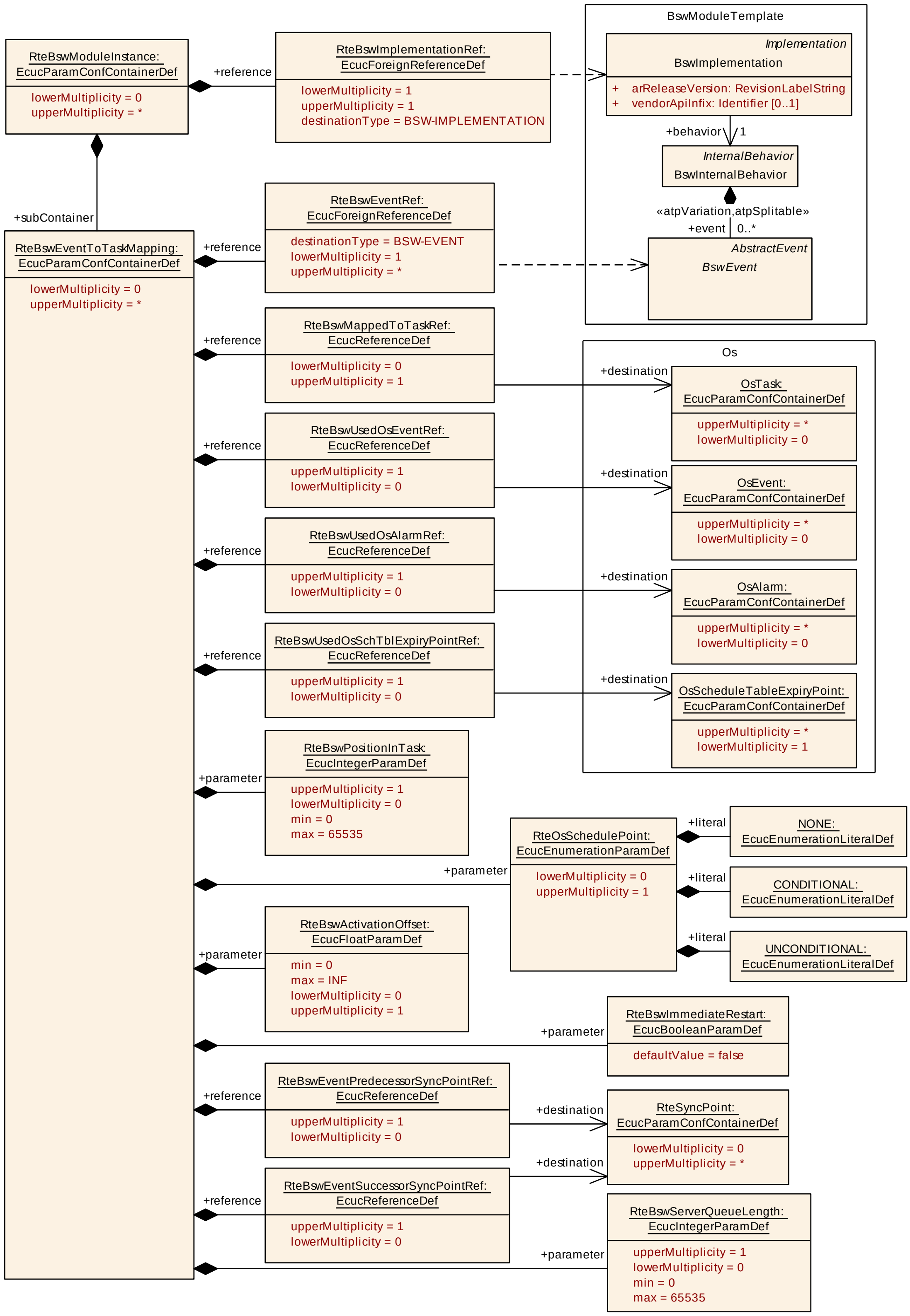

Figure 8.22: Configuration of BSW Event to Task Mapping

SWS Item	[ECUC_Rte_09065]
Container Name	RteBswEventToTaskMapping
Description	Maps a BswModuleEntity onto an OsTask based on the activating BswEvent. A BswModuleEntity can be activated by more than one BswEvent and thus be mapped to more than one OsTask. In the case of a BswSchedulableEntity executed via a direct function call this RteBswEventToTaskMapping is still specified but no RteBswMappedToTaskRef element is included. The RteBswPositionInTask parameter is necessary to provide an ordering of events invoked by the same RTE API.
Configuration Parameters	

Name	RteBswActivationOffset [ECUC_Rte_09063]		
Parent Container	RteBswEventToTaskMapping		
Description	Activation offset in seconds.		
Multiplicity	0..1		
Type	EcucFloatParamDef		
Range	[0 .. INF]		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswImmediateRestart [ECUC_Rte_09093]
Parent Container	RteBswEventToTaskMapping
Description	When RteBswImmediateRestart is set to true the BswSchedulableEntitiy shall be immediately re-started after termination if it was activated by this BswEvent while it was already started. This parameter shall not be set to true when the mapped BswEvent refers to a BswSchedulableEntitiy which minimumStartInterval attribute is > 0.
Multiplicity	1
Type	EcucBooleanParamDef
Default Value	false
Post-Build Variant Value	false

Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswPositionInTask [ECUC_Rte_09068]		
Parent Container	RteBswEventToTaskMapping		
Description	Each BswSchedulableEntity activation mapped to an OsTask has a specific position within the task execution. For periodic activation this is the order of execution. For event driver activation this is the order of evaluation which actual BswSchedulableEntity has to be executed. In case of direct function calls this parameter is necessary to provide an ordering of events when several ExecutableEntities are invoked by the same RTE API.		
Multiplicity	0..1		
Type	EcucIntegerParamDef		
Range	0 .. 65535		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswServerQueueLength [ECUC_Rte_09134]		
Parent Container	RteBswEventToTaskMapping		
Description	Specifies the length of the queue for the server call serialization.		
Multiplicity	0..1		
Type	EcucIntegerParamDef		
Range	0 .. 65535		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	

Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteOsSchedulePoint [ECUC_Rte_09022]		
Parent Container	RteBswEventToTaskMapping		
Description	Introduce a schedule point by explicitly calling Os Schedule service after the execution of the ExecutableEntity. The Rte generator is allowed to optimize several consecutive calls to Os schedule into one single call if the ExecutableEntity executions in between have been skipped. The absence of this parameter is interpreted as "NONE". It shall be considered an invalid configuration if the task is preemptable and the value of this parameter is not set to "NONE" or the parameter is absent.		
Multiplicity	0..1		
Type	EcucEnumerationParamDef		
Range	CONDITIONAL	A Schedule Point shall be introduced at the end of the execution of this ExecutableEntity. The Schedule Point can be skipped if several Schedule Points would be called without any ExecutableEntity execution in between.	
	NONE	No Schedule Point shall be introduced at the end of the execution of this ExecutableEntity.	
	UNCONDITIONAL	A Schedule Point shall always be introduced at the end of the execution of this ExecutableEntity.	
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswEventPredecessorSyncPointRef [ECUC_Rte_09130]		
Parent Container	RteBswEventToTaskMapping		
Description	The RteBswEventPredecessorSyncPointRef is necessary to provide a cross core synchronization in case of BswEvents triggered by the same event source but mapped to tasks belonging to different partitions on different cores. The synchronization point must be reached by all referencing BswEvents before the execution in all related tasks is continued. In case of RteBswEventPredecessorSyncPointRef the BswModuleEntity activated by the mapped BswEvent is executed after the synchronization point is passed.		
Multiplicity	0..1		
Type	Reference to RteSyncPoint		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswEventRef [ECUC_Rte_09064]		
Parent Container	RteBswEventToTaskMapping		
Description	Reference to the BswEvent.		
Multiplicity	1..*		
Type	Foreign reference to BSW-EVENT		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswEventSuccessorSyncPointRef [ECUC_Rte_09131]		
Parent Container	RteBswEventToTaskMapping		
Description	The RteBswEventSuccessorSyncPointRef is necessary to provide a cross core synchronization in case of BswEvents triggered by the same event source but mapped to tasks belonging to different partitions on different cores. The synchronization point must be reached by all referencing BswEvents before the execution in all related tasks is continued. In case of RteBswEventSuccessorSyncPointRef the BswModuleEntity activated by the mapped BswEvent is executed before the synchronization point is entered.		
Multiplicity	0..1		
Type	Reference to RteSyncPoint		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswMappedToTaskRef [ECUC_Rte_09067]		
Parent Container	RteBswEventToTaskMapping		
Description	Reference to the OsTask the BswSchedulableEntity activated by the RteBswEventRef is mapped to. If no reference to the OsTask is specified the BswSchedulableEntity activated by this BswEvent is executed in the context of the caller.		
Multiplicity	0..1		
Type	Reference to OsTask		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswUsedOsAlarmRef [ECUC_Rte_09069]		
Parent Container	RteBswEventToTaskMapping		
Description	If an OsAlarm is used to activate the OsTask this BswEvent is mapped to it shall be referenced here.		
Multiplicity	0..1		
Type	Reference to OsAlarm		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswUsedOsEventRef [ECUC_Rte_09070]		
Parent Container	RteBswEventToTaskMapping		
Description	If an OsEvent is used to activate the OsTask this BswEvent is mapped to it shall be referenced here.		
Multiplicity	0..1		
Type	Reference to OsEvent		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswUsedOsSchTblExpiryPointRef [ECUC_Rte_09071]
Parent Container	RteBswEventToTaskMapping
Description	If an OsScheduleTableExpiryPoint is used to activate the OsTask this BswEvent is mapped to it shall be referenced here.
Multiplicity	0..1
Type	Reference to OsScheduleTableExpiryPoint
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteRipsFillRoutineRef [ECUC_Rte_89005]		
Parent Container	RteBswEventToTaskMapping		
Description	Reference to a Buffer-Fill Routine implemented by an RTE Implementation Plug-In. This routine gets invoked directly before the ExecutableEntity is started. **Tags:** atp.Status=draft **Attributes:** requiresIndex=true		
Multiplicity	0..*		
Type	Reference to destinationUri [RteRipsUriDefSet/RteRipsPluginFillFlush Routine]		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

<table>
<tr><td>Name</td><td colspan="3">RteRipsFlushRoutineRef [ECUC_Rte_89006]</td></tr>
<tr><td>Parent Container</td><td colspan="3">RteBswEventToTaskMapping</td></tr>
<tr><td>Description</td><td colspan="3">Reference to a Buffer-Flush Routine implemented by an RTE Implementation Plug-In. This routine gets invoked directly after the ExecutableEntity has terminated.

Tags:
atp.Status=draft

Attributes:
requiresIndex=true</td></tr>
<tr><td>Multiplicity</td><td colspan="3">0..*</td></tr>
<tr><td>Type</td><td colspan="3">Reference to destinationUri [RteRipsUriDefSet/RteRipsPluginFillFlush Routine]</td></tr>
<tr><td>Post-Build Variant Multiplicity</td><td colspan="3">false</td></tr>
<tr><td>Post-Build Variant Value</td><td colspan="3">false</td></tr>
<tr><td rowspan="3">Multiplicity Configuration Class</td><td>Pre-compile time</td><td>X</td><td>All Variants</td></tr>
<tr><td>Link time</td><td>–</td><td></td></tr>
<tr><td>Post-build time</td><td>–</td><td></td></tr>
<tr><td rowspan="3">Value Configuration Class</td><td>Pre-compile time</td><td>X</td><td>All Variants</td></tr>
<tr><td>Link time</td><td>–</td><td></td></tr>
<tr><td>Post-build time</td><td>–</td><td></td></tr>
<tr><td>Scope / Dependency</td><td colspan="3">scope: local</td></tr>
</table>

No Included Containers

8.9.2.3 BSW Trigger configuration

8.9.2.3.1 BSW Trigger connection

The `RteBswRequiredTriggerConnection` container is defined in the context of the `RteBswModuleInstance` which is the required trigger context. So the reference to the `RteBswRequiredTriggerRef` is sufficient to define the required trigger. For the released trigger the tuple of `RteBswReleasedTriggerModInstRef` and `RteBswReleasedTriggerRef` is specified.

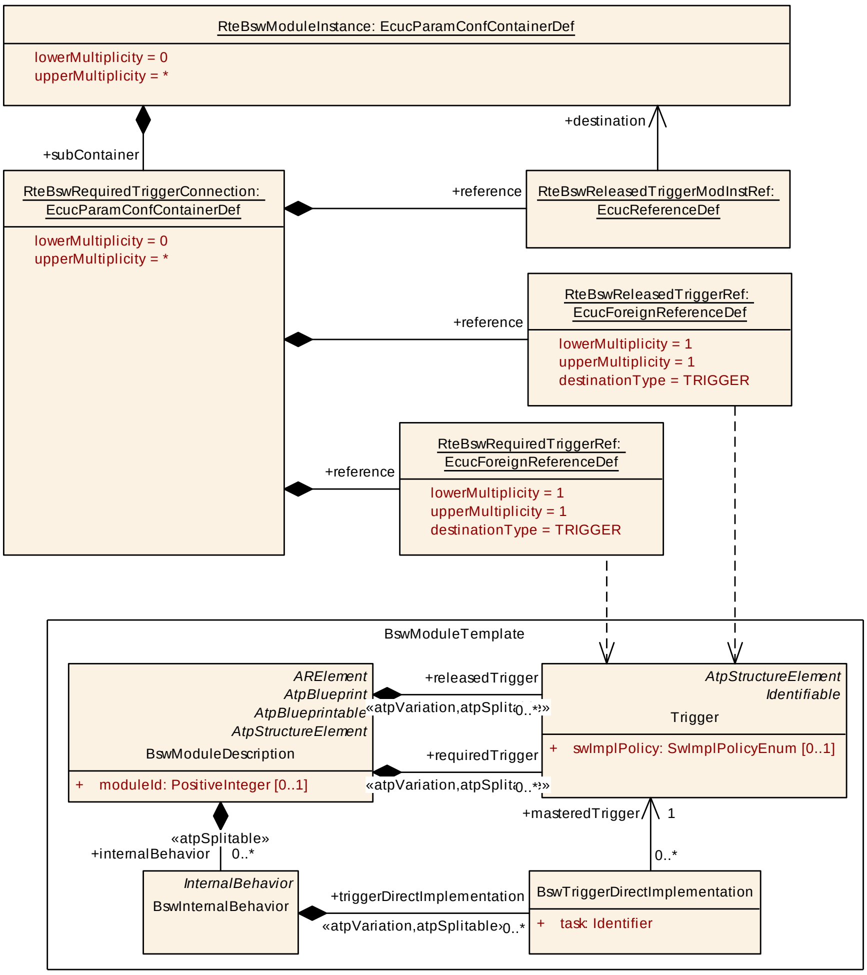

Figure 8.23: Configuration of BSW Trigger connection

SWS Item	[ECUC_Rte_09077]
Container Name	RteBswRequiredTriggerConnection
Description	Defines the connection between one requiredTrigger of this BSW Module instance and one releasedTrigger instance.
Configuration Parameters	

Name	RteBswReleasedTriggerModInstRef [ECUC_Rte_09075]
Parent Container	RteBswRequiredTriggerConnection
Description	Reference to the RteBswModuleInstance configuration container which identifies the instance of the BSW Module. Used with the RteBswReleasedTriggerRef to unambiguously identify the Trigger instance.
Multiplicity	1
Type	Reference to RteBswModuleInstance
Post-Build Variant Value	false

Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswReleasedTriggerRef [ECUC_Rte_09076]		
Parent Container	RteBswRequiredTriggerConnection		
Description	References the releasedTrigger to which this requiredTrigger shall be connected.		
Multiplicity	1		
Type	Foreign reference to TRIGGER		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswRequiredTriggerRef [ECUC_Rte_09078]		
Parent Container	RteBswRequiredTriggerConnection		
Description	References one requiredTrigger which shall be connected to the releasedTrigger.		
Multiplicity	1		
Type	Foreign reference to TRIGGER		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.9.2.3.2 BSW Trigger queuing

This configuration determine the size of the queue queuing the issued triggers.

The `RteBswExternalTriggerConfig` container and `RteBswInternalTriggerConfig` container is defined in the context of the `RteBswModuleInstance` which already predefines the context of the provided `Trigger` / `BswInternalTriggeringPoint`.

[SWS_Rte_CONSTR_09006] The references RteBswTriggerSourceRef has to be consistent with the RteBswImplementationRef ⌈ The references RteBswTriggerSourceRef has to be consistent with the RteBswImplementationRef. This means the referenced Trigger / BswInternalTriggeringPoint has to belong to the BswModuleDescription which is referenced by the related BswImplementation. ⌋*()*

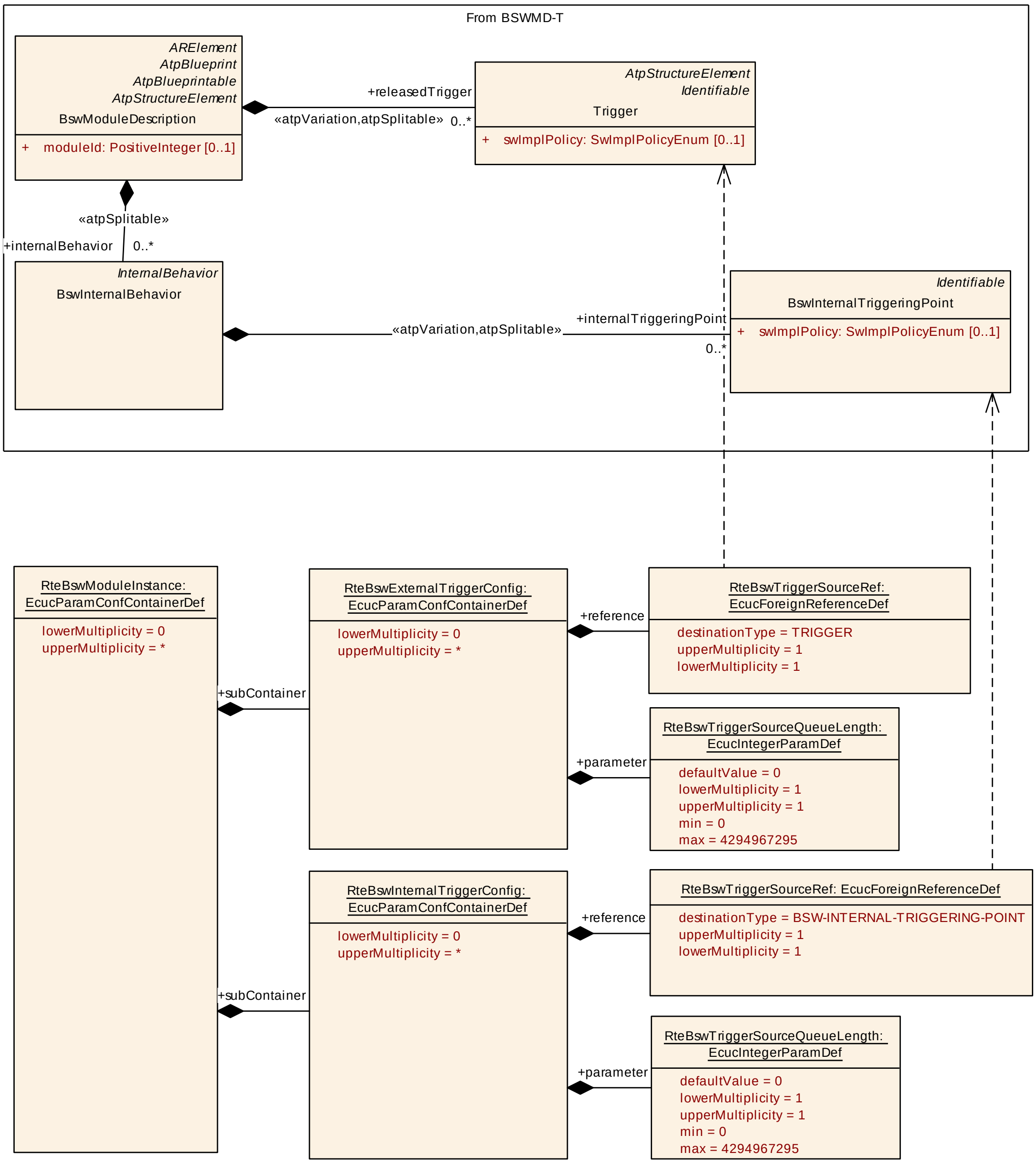

Figure 8.24: Configuration of BSW Trigger queuing

SWS Item	[ECUC_Rte_09099]
Container Name	RteBswExternalTriggerConfig
Description	Defines the configuration of Inter Basic Software Module Entity Triggering
Configuration Parameters	

Name	RteBswTriggerSourceQueueLength [ECUC_Rte_09101]		
Parent Container	RteBswExternalTriggerConfig		
Description	Length of trigger queue on the trigger source side. The queue is implemented by the RTE. A value greater or equal to 1 requests an queued behavior. Setting the value of RteTriggerSourceQueueLength to 0 requests an none queued implementation of the trigger communication. If there is no RteBswTriggerSourceQueueLength configured for a Trigger Emitter the default value of 0 applies as well.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 4294967295		
Default Value	0		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswTriggerSourceRef [ECUC_Rte_09100]		
Parent Container	RteBswExternalTriggerConfig		
Description	Reference to a Trigger instance in the role releasedTrigger of the related BSW Module instance. The referenced Trigger has to belong to the same BSW Module instance as the RteBswModuleInstance owning this parameter configures.		
Multiplicity	1		
Type	Foreign reference to TRIGGER		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

SWS Item	[ECUC_Rte_09102]
Container Name	RteBswInternalTriggerConfig
Description	Defines the configuration of internal Basic Software Module Entity Triggering
Configuration Parameters	

Name	RteBswTriggerSourceQueueLength [ECUC_Rte_09104]		
Parent Container	RteBswInternalTriggerConfig		
Description	Length of trigger queue on the trigger source side. The queue is implemented by the RTE. A value greater or equal to 1 requests an queued behavior. Setting the value of RteTriggerSourceQueueLength to 0 requests an none queued implementation of the trigger communication. If there is no RteBswTriggerSourceQueueLength configured for a Trigger Emitter the default value of 0 applies as well.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 4294967295		
Default Value	0		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswTriggerSourceRef [ECUC_Rte_09103]		
Parent Container	RteBswInternalTriggerConfig		
Description	Reference to a BswInternalTriggeringPoint of the related BSW Module instance. The referenced BswInternalTriggeringPoint has to belong to the same BSW Module instance as the RteBswModuleInstance owning this parameter configures.		
Multiplicity	1		
Type	Foreign reference to BSW-INTERNAL-TRIGGERING-POINT		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.9.2.4 BSW ModeDeclarationGroup configuration

The `RteBswRequiredModeGroupConnection` container is defined in the context of the `RteBswModuleInstance` which is the required mode group context. So the reference to the RteBswRequiredModeGroupRef is sufficient to define the required mode group. For the provided mode group the tuple of RteBswProvidedModeGrpModInstRef and RteBswProvidedModeGroupRef is specified.

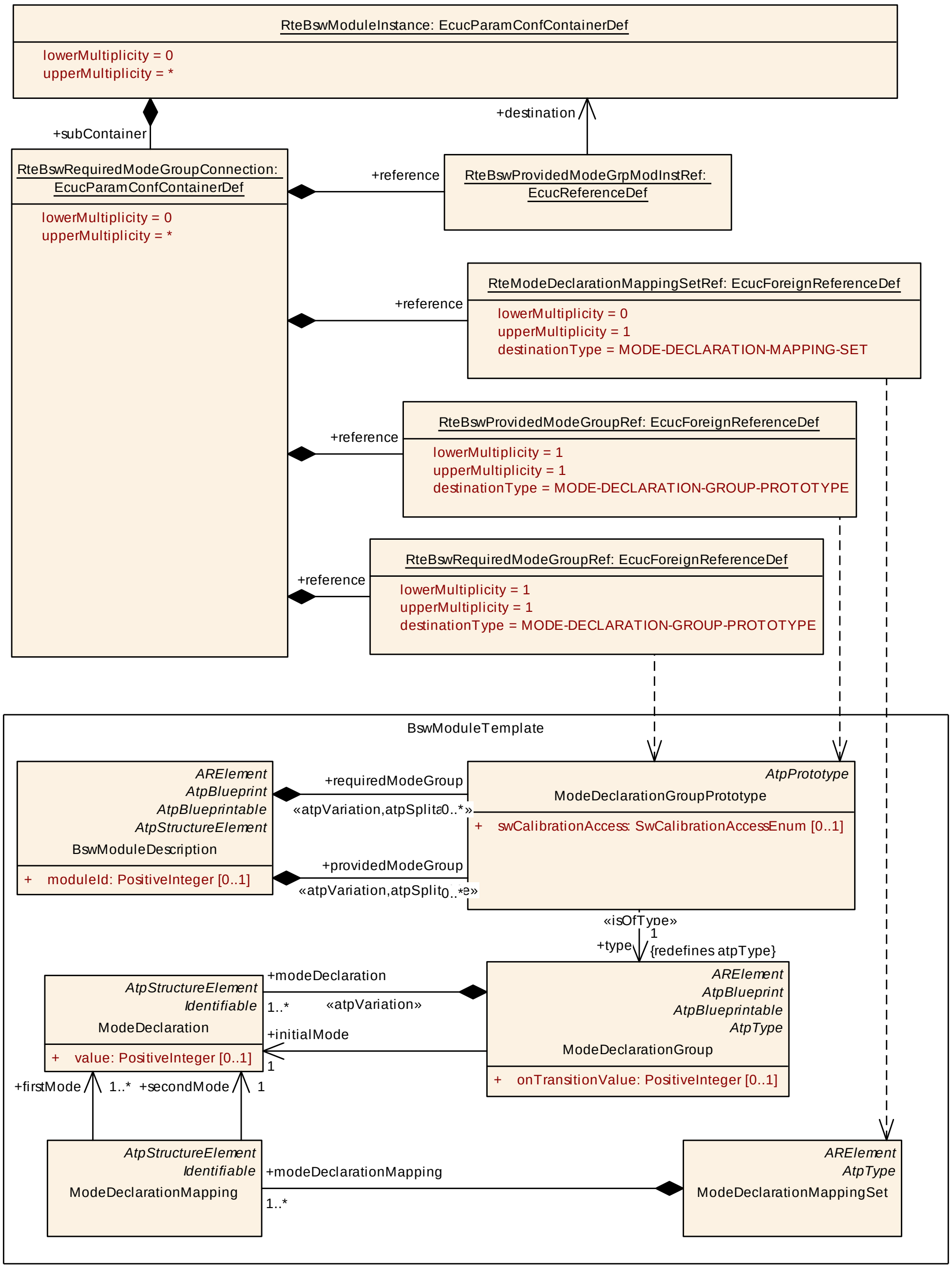

Figure 8.25: Configuration of BSW Scheduler overview

SWS Item	[ECUC_Rte_09081]
Container Name	RteBswRequiredModeGroupConnection
Description	Defines the connection between one requiredModeGroup of this BSW Module instance and one providedModeGroup instance.
Configuration Parameters	

Name	RteBswProvidedModeGroupRef [ECUC_Rte_09079]		
Parent Container	RteBswRequiredModeGroupConnection		
Description	References the providedModeGroupPrototype to which this requiredModeGroup shall be connected.		
Multiplicity	1		
Type	Foreign reference to MODE-DECLARATION-GROUP-PROTOTYPE		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswProvidedModeGrpModInstRef [ECUC_Rte_09080]		
Parent Container	RteBswRequiredModeGroupConnection		
Description	Reference to the RteBswModuleInstance configuration container which identifies the instance of the BSW Module. Used with the RteBswProvidedModeGroupRef to unambiguously identify the ModeDeclarationGroupPrototype instance.		
Multiplicity	1		
Type	Reference to RteBswModuleInstance		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswRequiredModeGroupRef [ECUC_Rte_09082]		
Parent Container	RteBswRequiredModeGroupConnection		
Description	References requiredModeGroupPrototype which shall be connected to the providedModeGroupPrototype.		
Multiplicity	1		
Type	Foreign reference to MODE-DECLARATION-GROUP-PROTOTYPE		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteModeDeclarationMappingSetRef [ECUC_Rte_09125]		
Parent Container	RteBswRequiredModeGroupConnection		
Description	This defines the effective ModeDeclarationMappingSet in the case that the provided ModeDeclarationGroupPrototype and the required ModeDeclarationGroupPrototype are not compatible.		
Multiplicity	0..1		
Type	Foreign reference to MODE-DECLARATION-MAPPING-SET		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.9.2.5 BSW Client Server configuration

The `RteBswRequiredClientServerConnection` container is defined in the context of the `RteBswModuleInstance`. So the reference to the `RteBswRequiredClientServerEntryRef` is sufficient to define the required `BswModuleClientServerEntry`. For the provided `BswModuleClientServerEntry` the `RteBswProvidedClientServerEntryRef` is specified.

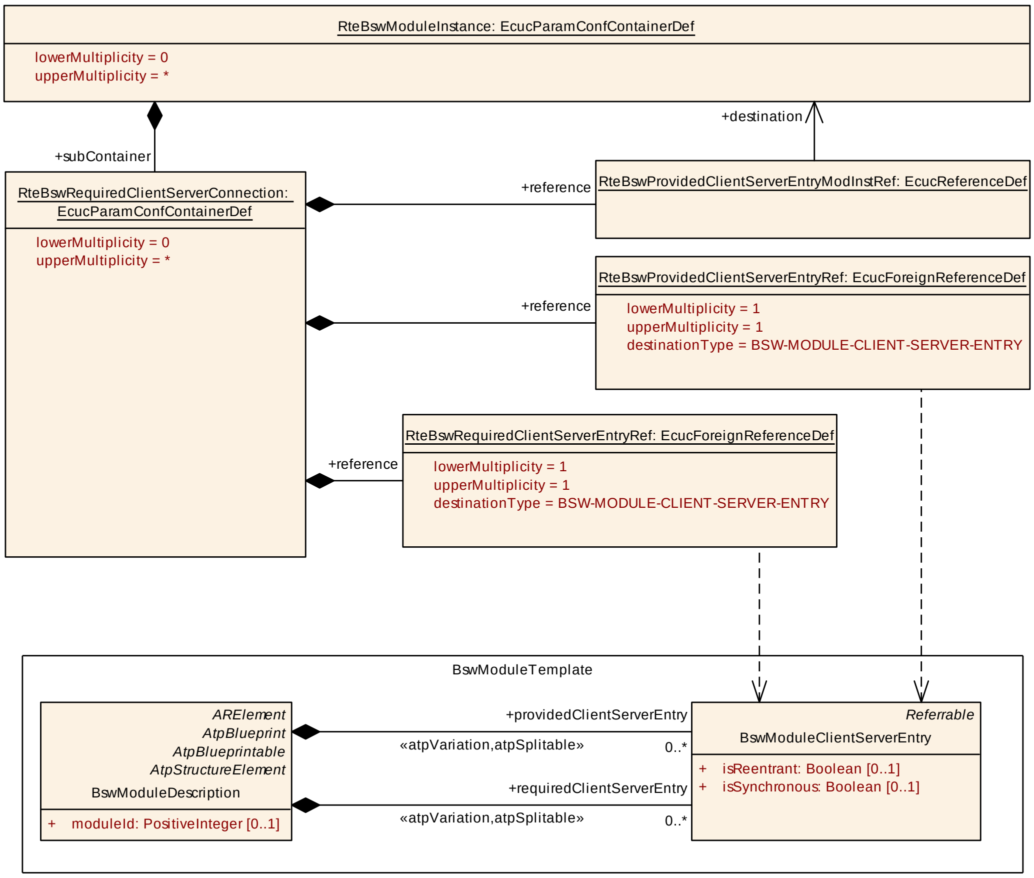

Figure 8.26: Configuration of BSW Client Server Communication

SWS Item	[ECUC_Rte_09117]
Container Name	RteBswRequiredClientServerConnection
Description	Defines the connection between one requiredClientServerEntry and one providedClientServerEntry of a BswModuleDescription. This container shall be provided on the client side of the connection.
Configuration Parameters	

Name	RteBswProvidedClientServerEntryModInstRef [ECUC_Rte_09124]		
Parent Container	RteBswRequiredClientServerConnection		
Description	Reference to the RteBswModuleInstance configuration container which identifies the instance of the BSW Module. Used with the RteBswProvidedClientServerEntryRef to unambiguously identify the BswModuleClientServerEntry instance.		
Multiplicity	1		
Type	Reference to RteBswModuleInstance		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswProvidedClientServerEntryRef [ECUC_Rte_09119]		
Parent Container	RteBswRequiredClientServerConnection		
Description	Reference the providedClientServerEntry for this connection.		
Multiplicity	1		
Type	Foreign reference to BSW-MODULE-CLIENT-SERVER-ENTRY		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswRequiredClientServerEntryRef [ECUC_Rte_09118]		
Parent Container	RteBswRequiredClientServerConnection		
Description	Reference the requiredClientServerEntry for this connection.		
Multiplicity	1		
Type	Foreign reference to BSW-MODULE-CLIENT-SERVER-ENTRY		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.9.2.6 BSW Sender Receiver configuration

The `RteBswRequiredSenderReceiverConnection` container is defined in the context of the `RteBswModuleInstance`. So the reference to the `RteBswRequiredVariableDataPrototypeRef` is sufficient to define the required `VariableDataPrototype`. For the provided `VariableDataPrototype` the `RteBswProvidedVariableDataPrototypeRef` is specified.

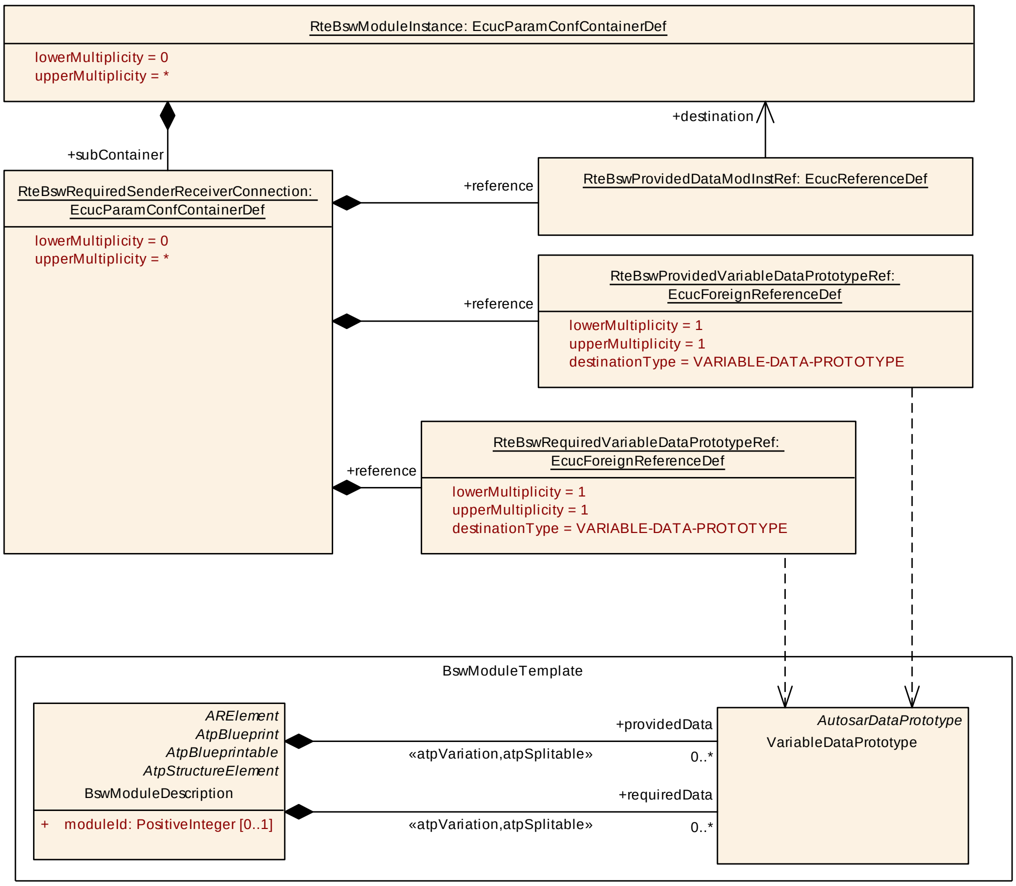

Figure 8.27: Configuration of BSW Sender Receiver Communication

SWS Item	[ECUC_Rte_09120]
Container Name	RteBswRequiredSenderReceiverConnection
Description	Defines the connection between one requiredData and one providedData of a BswModuleDescription. This container shall be provided on the receiver side of the connection.
Configuration Parameters	

Name	RteBswProvidedDataModInstRef [ECUC_Rte_09123]		
Parent Container	RteBswRequiredSenderReceiverConnection		
Description	Reference to the RteBswModuleInstance configuration container which identifies the instance of the BSW Module. Used with the RteBswProvidedVariableDataPrototypeRef to unambiguously identify the VariableDataPrototype instance.		
Multiplicity	1		
Type	Reference to RteBswModuleInstance		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswProvidedVariableDataPrototypeRef [ECUC_Rte_09122]		
Parent Container	RteBswRequiredSenderReceiverConnection		
Description	Reference the providedData for this connection.		
Multiplicity	1		
Type	Foreign reference to VARIABLE-DATA-PROTOTYPE		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswRequiredVariableDataPrototypeRef [ECUC_Rte_09121]		
Parent Container	RteBswRequiredSenderReceiverConnection		
Description	Reference the requiredData for this connection.		
Multiplicity	1		
Type	Foreign reference to VARIABLE-DATA-PROTOTYPE		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

8.9.2.7 BSW Mode Machine Instance configuration

This configuration provides the settings for the implementation of a *Basic Software Scheduler* assigned mode machine instance (see [SWS_Rte_07534].

The `RteBswModeMachineInstanceConfig` container is defined in the context of the `RteBswModuleInstance` which already predefines the context of the `ModeDeclarationGroupPrototype` in the `RteBswModeManagerRef` .

[SWS_Rte_CONSTR_09101] The reference `RteBswModeManagerRef` has to be consistent with the `RteBswImplementationRef` ⌈ The reference `RteBswModeManagerRef` has to be consistent with the `RteBswImplementationRef`. This means the referenced `ModeDeclarationGroupPrototype` has to be a `providedModeGroup` in the `BswModuleDescription` which is referenced by the related `BswImplementation`. ⌋*()*

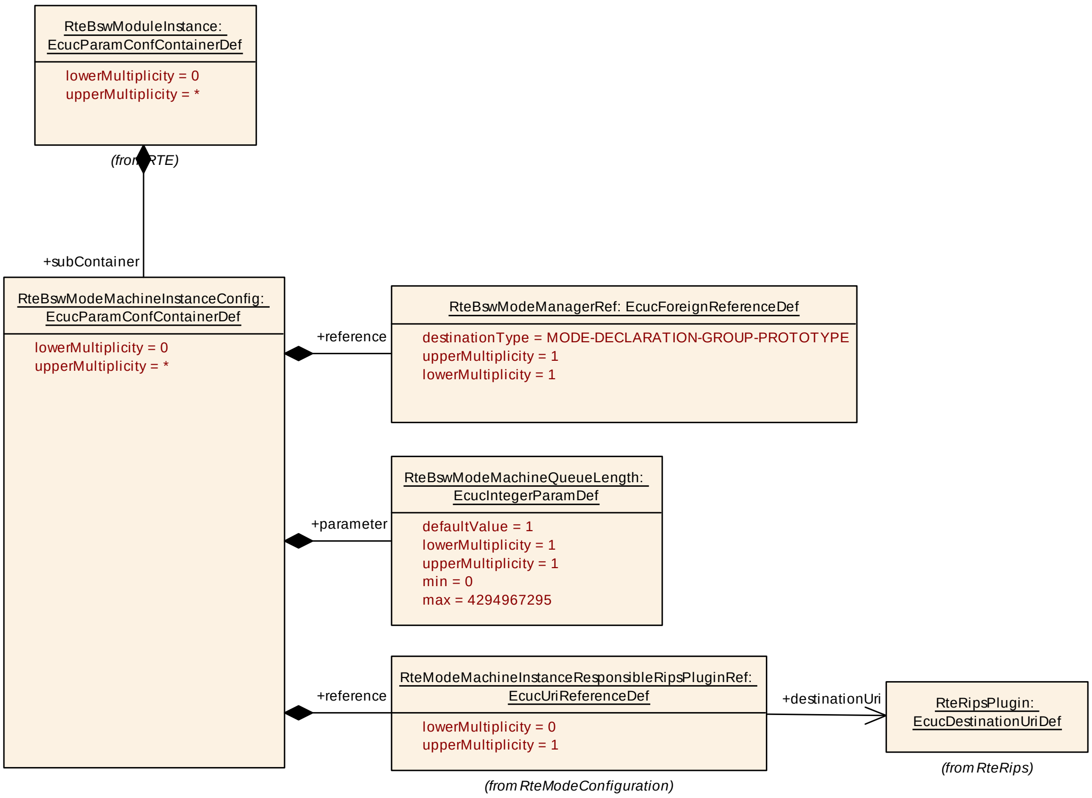

Figure 8.28: Configuration of a Basic Software Scheduler assigned mode machine instance

SWS Item	[ECUC_Rte_09148]
Container Name	RteBswModeMachineInstanceConfig
Description	Defines the configuration of Basic Software Scheduler assigned (SWS_Rte_07534) mode machine instances.
Configuration Parameters	

Name	RteBswModeMachineQueueLength [ECUC_Rte_09150]		
Parent Container	RteBswModeMachineInstanceConfig		
Description	Length of mode machine instance queue on the trigger source side. If there is no RteBswModeMachineQueueLength configured for a mode machine instance the value given in the BswModeSenderPolicy.queueLength applies.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 4294967295		
Default Value	1		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteBswModeManagerRef [ECUC_Rte_09149]		
Parent Container	RteBswModeMachineInstanceConfig		
Description	Reference to a ModeDeclarationGroupPrototype of the related BSW Module instance. The referenced ModeDeclarationGroupPrototype has to belong to the same BSW Module instance as the RteBswModuleInstance owning this parameter configures.		
Multiplicity	1		
Type	Foreign reference to MODE-DECLARATION-GROUP-PROTOTYPE		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteModeMachineInstanceResponsibleRipsPluginRef [ECUC_Rte_89013]		
Parent Container	RteBswModeMachineInstanceConfig		
Description	Optional reference to the configuration container of the RTE Implementation Plug-in implementing the protection of the mode machine instance. **Tags:** atp.Status=draft		
Multiplicity	0..1		
Type	Reference to destinationUri [RteRipsUriDefSet/RteRipsPlugin]		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

No Included Containers

8.10 Configuration of Synchronization Points

With synchronization points it possible to ensure the correct execution order in case of `RTEEvent`s activated by the identical event source (in particular the same `mode manager`) but mapped to `OsTask`s belonging to different partitions which in turn are belonging to different cores. With this configuration it is possible to ensure for instance the execution of all on-exit ExecutableEntitys before the on-transition ExecutableEntitys when required. Therefore the current applicability is constraint to RTEEvents triggered by mode communication.

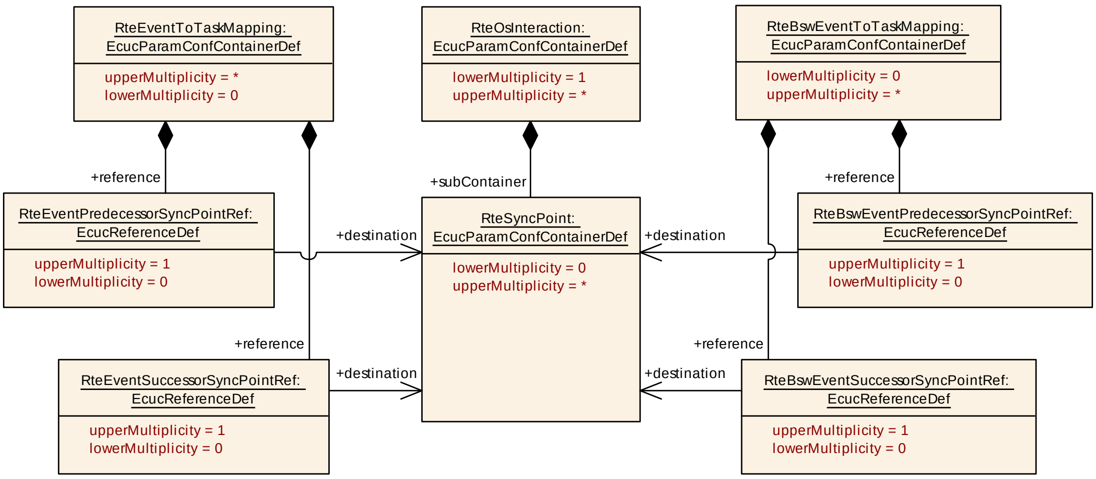

Figure 8.29: Configuration of Synchronization Points

SWS Item	[ECUC_Rte_09127]
Container Name	RteSyncPoint
Description	The RteSyncPoint is necessary to provide an cross core synchronization in case of RteEvents triggered by the same event source but mapped to tasks belonging to different partitions on different cores. The synchronization point must be reached by all referencing RteEvents before the execution in all related tasks is continued. In case of Rte(Bsw)EventSuccessorSyncPointRef the ExecutableEntity activated by the mapped event is executed before the synchronization point is entered. In case of Rte(Bsw)EventPredecessorSyncPointRef the ExecutableEntity activated by the mapped event is executed after the synchronization point is passed.
Configuration Parameters	

No Included Containers

RteEventPredecessorSyncPointRef and RteEventSuccessorSyncPointRef are only applicable for RteEventToTaskMappings where the mapped RTEEvent is either a SwcModeSwitchEvent or a ModeSwitchedAckEvent. RteBswEventPredecessorSyncPointRef and RteBswEventSuccessorSyncPointRef are only applicable for RteBswEventToTaskMappings where the mapped BswEvent is either a BswModeSwitchEvent or a BswModeSwitchedAckEvent.

8.11 Configuration of Initialization

In order to support different interactions with the start up code of the ECU the RTE supports different initialization strategies for variables implementing VariableDataPrototypes. Basically the initialization can be done either by start-up code or by the Rte_Start function. Further on it is possible to avoid any initialization for data which has to be reset safe or is explicitly initialized by other SW, e.g. the RAM Blocks might be initialized by NVRAM Manager.

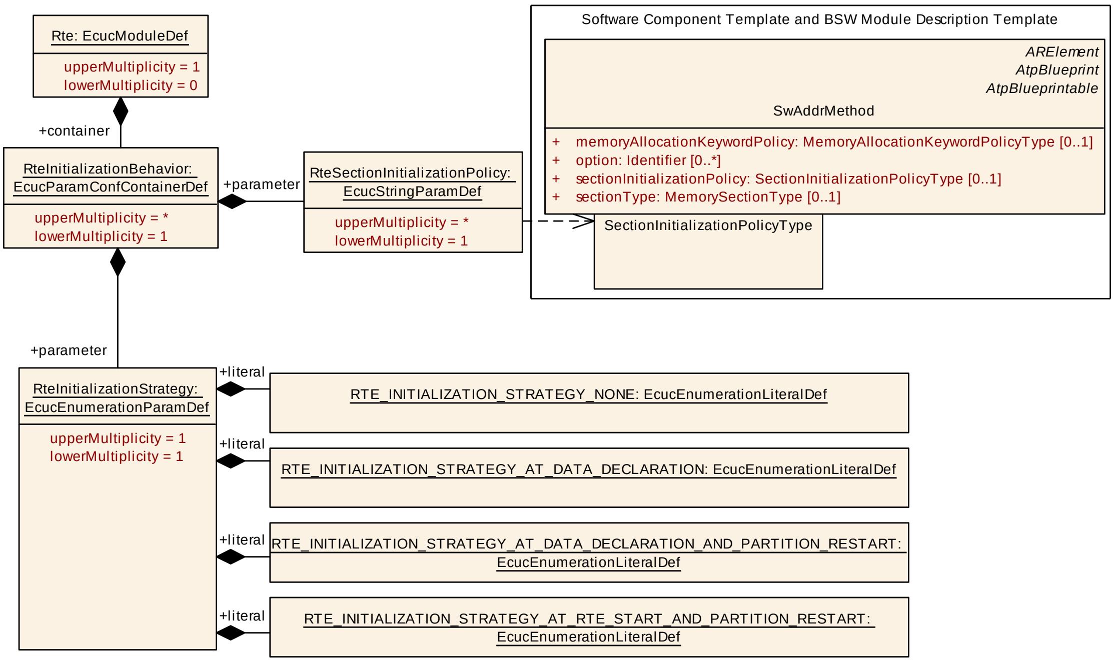

Figure 8.30: Configuration of initialization strategy

SWS Item	[ECUC_Rte_09087]
Container Name	RteInitializationBehavior
Description	Specifies the initialization strategy for variables allocated by RTE with the purpose to implement VariableDataPrototypes. The container defines a set of RteSectionInitializationPolicys and one RteInitializationStrategy which is applicable for this set.
Configuration Parameters	

Name	RteInitializationStrategy [ECUC_Rte_09089]	
Parent Container	RteInitializationBehavior	
Description	Definition of the initialization strategy applicable for the SectionInitializationPolicys selected by RteSectionInitializationPolicy.	
Multiplicity	1	
Type	EcucEnumerationParamDef	
Range	RTE_INITIALIZATION_STRATEGY_AT_DATA_DECLARATION	Variables shall be initialized at its declaration to the value defined by the related initValue attribute.

	RTE_INITIALIZATION_STRATEGY_AT_DATA_DECLARATION_AND_PARTITION_RESTART	Variables shall be initialized at its declaration to the value defined by the related initValue attribute and during execution of Rte_RestartPartition to the value defined by the related initValue attribute.	
	RTE_INITIALIZATION_STRATEGY_AT_RTE_START_AND_PARTITION_RESTART	Variables shall be initialized during execution of Rte_Start and Rte_RestartPartition to the value defined by the related initValue attribute.	
	RTE_INITIALIZATION_STRATEGY_NONE	Variables shall not be initialized at all.	
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteSectionInitializationPolicy [ECUC_Rte_09088]
Parent Container	RteInitializationBehavior
Description	This parameter describes the SectionInitializationPolicys for which a particular RTE initialization strategy applies. The SectionInitializationPolicy describes the intended initialization of MemorySections. The following values are standardized in AUTOSAR Methodology: • **NO-INIT**: No initialization and no clearing is performed. Such data elements must not be read before one has written a value into it. • **INIT**: To be used for data that are initialized by every reset to the specified value (initValue). • **POWER-ON-INIT**: To be used for data that are initialized by "Power On" to the specified value (initValue). Note: there might be several resets between power on resets. • **CLEARED**: To be used for data that are initialized by every reset to zero. • **POWER-ON-CLEARED**: To be used for data that are initialized by "Power On" to zero. Note: there might be several resets between power on resets.
Multiplicity	1..*
Type	EcucStringParamDef
Default Value	
Regular Expression	
Post-Build Variant Multiplicity	false

Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

[SWS_Rte_07075] ⌈ The RTE generator shall reject configurations where not all occurring sectionInitializationPolicy attribute values are configured to an RteInitializationStrategy. ⌋*(SRS_Rte_00018)*

The call of Rte_Start may trigger RunnableEntitys for initialization purpose. Those RunnableEntitys are either triggered by SwcModeSwitchEvents or InitEvents. To support the scheduling of such RunnableEntitys in the start up code of the ECU (e.g. by BswM or EcuM) its possible to map such RTEEvents to RteInitializationRunnableBatch containers which results in the existence of Rte_Init APIs.

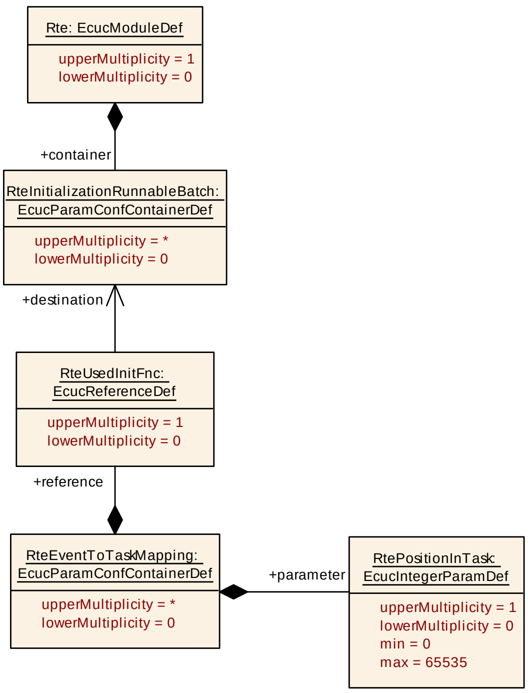

Figure 8.31: Configuration of Rte_Init functions

SWS Item	[ECUC_Rte_09115]
Container Name	RteInitializationRunnableBatch

Description	This container corresponds to an Rte_Init_<shortName of this container> function invoking the mapped RunnableEntities.
Configuration Parameters	

No Included Containers

Rte_Init API may only schedule RunnableEntitys for initialization purpose ore which are on-entry Runnable Entities.

[SWS_Rte_CONSTR_09063] Restricted kinds of RTEEvents which may mapped to RteInitializationRunnableBatch containers ⌈ Only SwcModeSwitchEvents with activation = onEntry and referring to the initialMode or InitEvents may be mapped to RteInitializationRunnableBatch containers with the means of a RteUsedInitFnc reference. ⌋*()*

[SWS_Rte_06769] ⌈ The RTE Generator shall reject configurations violating [SWS_Rte_CONSTR_09063]. ⌋*(SRS_Rte_00143, SRS_Rte_00240, SRS_Rte_00018)*

[SWS_Rte_CONSTR_09064] A single RteInitializationRunnableBatch container may not handle RTEEvents of different partitions ⌈ All RTEEvents mapped to a RteInitializationRunnableBatch container may only trigger RunnableEntitys belonging to the same partition. ⌋*()*

[SWS_Rte_06770] ⌈ The RTE Generator shall reject configurations violating [SWS_Rte_CONSTR_09064]. ⌋*(SRS_Rte_00143, SRS_Rte_00240, SRS_Rte_00018)*

8.12 Configuration of Task Chains

The configuration of RteOsTaskChain enables the definition of the task chain behavior. Please note [SWS_Rte_04558] and [SWS_Rte_04559].

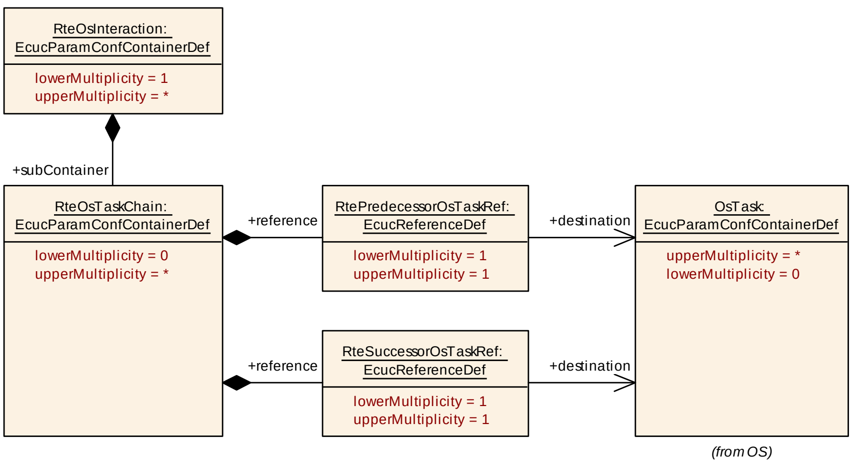

Figure 8.32: Configuration of task chains

SWS Item	[ECUC_Rte_09135]
Container Name	RteOsTaskChain
Description	This container holds the configuration of one task chain configuration.
Configuration Parameters	

Name	RtePredecessorOsTaskRef [ECUC_Rte_09136]		
Parent Container	RteOsTaskChain		
Description	OsTask which shall chain another OsTask when it terminates.		
Multiplicity	1		
Type	Reference to OsTask		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	RteSuccessorOsTaskRef [ECUC_Rte_09137]		
Parent Container	RteOsTaskChain		
Description	OsTask which shall be chained from the predecessor OsTask.		
Multiplicity	1		
Type	Reference to OsTask		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

No Included Containers

8.13 Configuration of distributed shared mode queues

The section lists the configuration for the general settings for `distributed shared mode queues`.

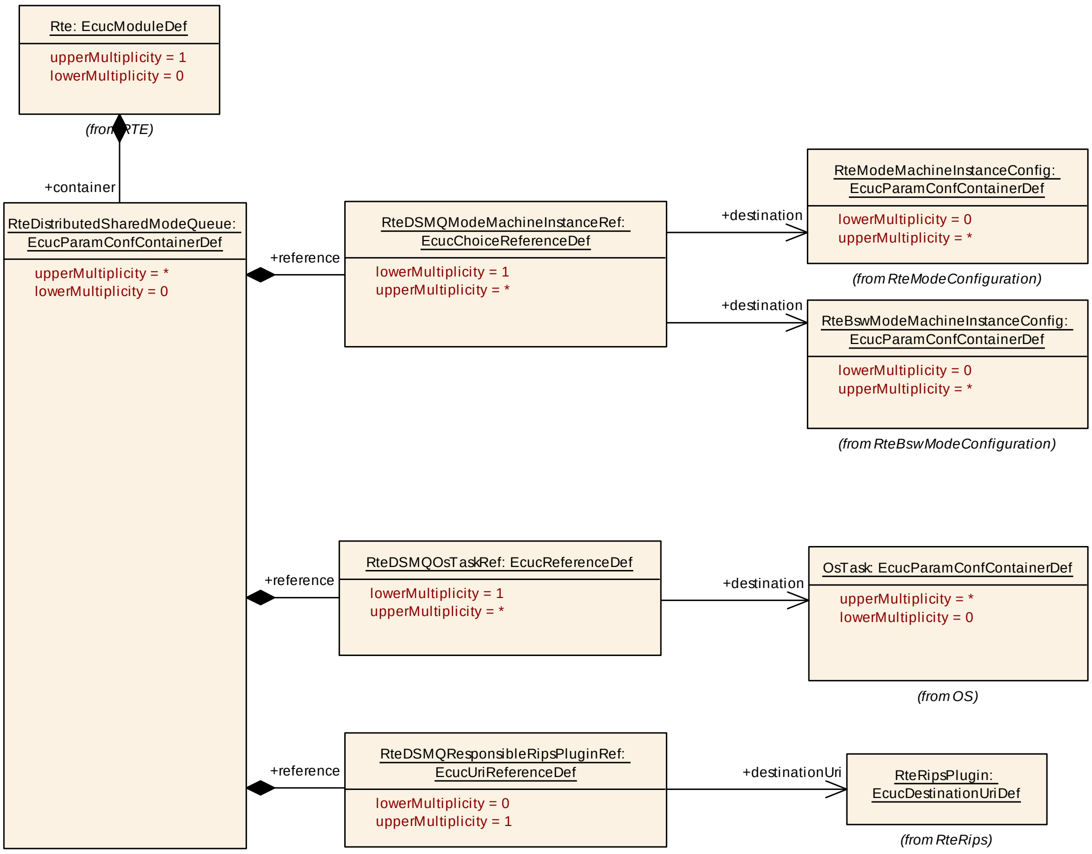

Figure 8.33: Configuration of RTE Implementation Plug-Ins

SWS Item	[ECUC_Rte_09145]
Container Name	RteDistributedSharedModeQueue
Description	This container holds the configuration of a distributed shared mode queue.
Configuration Parameters	

Name	RteDSMQModeMachineInstanceRef [ECUC_Rte_09146]		
Parent Container	RteDistributedSharedModeQueue		
Description	Reference to the mode machine instances which participate in this distributed shared mode queue.		
Multiplicity	1..*		
Type	Choice reference to [RteBswModeMachineInstanceConfig,RteModeMachineInstanceConfig]		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

Name	RteDSMQOsTaskRef [ECUC_Rte_09147]		
Parent Container	RteDistributedSharedModeQueue		
Description	Reference to the DSMQ transition OsTasks which are used to exclusively schedule on-entry ExecutableEntitys, on-transition ExecutableEntitys, on-exit ExecutableEntitys, and ModeSwitchAck ExecutableEntity activated by mode machine instances of this distributed shared mode queue.		
Multiplicity	1..*		
Type	Reference to OsTask		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

Name	RteDSMQResponsibleRipsPluginRef [ECUC_Rte_89014]		
Parent Container	RteDistributedSharedModeQueue		
Description	Optional reference to the configuration container of the RTE Implementation Plug-in implementing the protection of all mode machine instances assigned to this distributed shared mode queue. **Tags:** atp.Status=draft		
Multiplicity	0..1		
Type	Reference to destinationUri [RteRipsUriDefSet/RteRipsPlugin]		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

No Included Containers

8.14 Configuration of RTE Implementation Plug-Ins

8.14.1 General configuration definitions for `Uri References`

Please note, that for the structural decoupling of the RTE's configuration and the configuration of `RTE Implementation Plug-In`s `Uri Reference`s are used. See document [5], section *Uri Reference*. Thereby each `RTE Implementation Plug-In` define its own `EcucModuleDef`. AUTOSAR itself does not standardize those `EcucModuleDef`s. Instead the required references in the ECU configuration of the RTE are defined as `EcucUriReferenceDef`s and for the reference destination containers the `EcucDestinationUriDef`s are standardized in the `RteRipsUriDefSet`.

SWS Item	ECUC_Rte_89003
EcucDestinationUriDefSet Name	RteRipsUriDefSet
Description	Defines the set of DestinationUriDefs for the RTE Implementation Plug-in support.
Included EcucDestinationUriDefs	
Name	**Description**
RteRipsInvocationHandler	Defines the configuration container content of an invocation handler of an RTE Implementation Plug-In.
RteRipsPlugin	Defines the configuration container content of the RIPS Plug-in holding the Rte relevant settings.
RteRipsPluginFillFlush Routine	Defines the configuration container content of a Fill-Flush Routine implemented by a RTE Implementation Plug-In.

SWS Item	[ECUC_Rte_89009]
EcucDestinationUriDef Name	RteRipsInvocationHandler
Description	Defines the configuration container content of an invocation handler of an RTE Implementation Plug-In.
destinationUriNesting Contract	targetContainer
Configuration Parameters	

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
RteRipsInvocation HandlerFnc	0..*	This container describes an invocation handler function implemented by an RTE Implementation Plug-In to handle the invocation of server runnables and triggered runnables via a transformer. **Tags:** atp.Status=draft

SWS Item	[ECUC_Rte_89004]
EcucDestinationUriDef Name	RteRipsPlugin
Description	Defines the configuration container content of the RIPS Plug-in holding the Rte relevant settings.

destinationUriNesting Contract	targetContainer
Configuration Parameters	

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
RteRipsPluginProps	1	This container defines the identity of the Rte Implementation Plug-in and provides the RTE relevant parameters of the Rte Implementation Plug-in. The shortName of the container defines the name of the Rte Implementation Plug-in used for the API infixes. **Tags:** atp.Status=draft

SWS Item	[ECUC_Rte_89007]
EcucDestinationUriDef Name	RteRipsPluginFillFlushRoutine
Description	Defines the configuration container content of a Fill-Flush Routine implemented by a RTE Implementation Plug-In.
destinationUriNesting Contract	targetContainer
Configuration Parameters	

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
RteRipsPluginFillFlush RoutineFnc	0..*	This container describes a Fill-Flush Routine function implemented by a RTE Implementation Plug-In to handle the buffering for implicit communication. **Tags:** atp.Status=draft

The general configuration of the RTE Generator concerning the used `RTE Implementation Plug-Ins` are defined in the container `RteRips`.

8.14.2 General configuration of RTE Implementation Plug-Ins utilization

The section lists the configuration for the general settings to enable the `RTE Implementation Plug-In` support by RTE Generator.

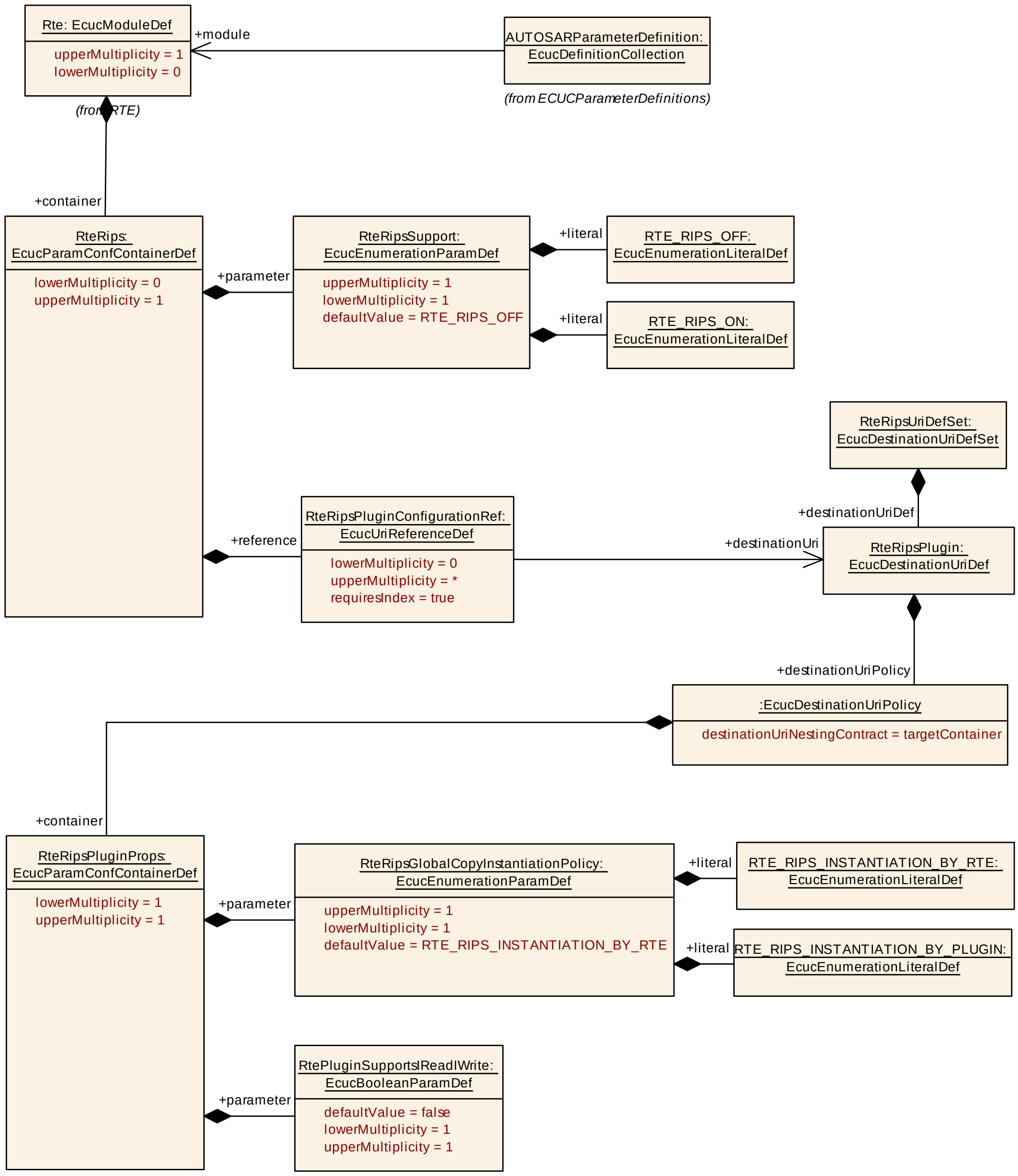

Figure 8.34: Configuration of RTE Implementation Plug-Ins

SWS Item	[ECUC_Rte_89000]		
Container Name	RteRips		
Description	This container provides the configuration of the Rte Implementation Plug-In support by RTE. If the container is NOT defined, the support for Rte Implementation Plug-Ins (RIPS) is globally disabled. **Tags:** atp.Status=draft		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Configuration Parameters			

Name	RteRipsSupport [ECUC_Rte_89001]		
Parent Container	RteRips		
Description	Globally enables or disables the support for Rte Implementation Plug-Ins (RIPS) **Tags:** atp.Status=draft		
Multiplicity	1		
Type	EcucEnumerationParamDef		
Range	RTE_RIPS_OFF	Support for Rte Implementation Plug-Ins (RIPS) is globally disabled.	
	RTE_RIPS_ON	Support for Rte Implementation Plug-Ins (RIPS) is globally enabled.	
Default Value	RTE_RIPS_OFF		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	RteRipsPluginConfigurationRef [ECUC_Rte_89002]		
Parent Container	RteRips		
Description	Reference to the configuration container of the RTE Implementation Plug-in holding the RTE relevant settings. All referenced RTE Implementation Plug-ins are considered for the RTE generation. **Tags:** atp.Status=draft **Attributes:** requiresIndex=true		
Multiplicity	0..*		
Type	Reference to destinationUri [RteRipsUriDefSet/RteRipsPlugin]		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

No Included Containers

The general implementation properties of the `RTE Implementation Plug-In` are defined in `RteRipsPluginProps`.

SWS Item	[ECUC_Rte_79000]

Container Name	RteRipsPluginProps
Description	This container defines the identity of the Rte Implementation Plug-in and provides the RTE relevant parameters of the Rte Implementation Plug-in. The shortName of the container defines the name of the Rte Implementation Plug-in used for the API infixes. **Tags:** atp.Status=draft
Configuration Parameters	

Name	RtePluginSupportsIReadIWrite [ECUC_Rte_79002]
Parent Container	RteRipsPluginProps
Description	Denotes if or if not the plug-in supports the Rte_Rips_IRead/IWrite macros for primitive data. **Tags:** atp.Status=draft
Multiplicity	1
Type	EcucBooleanParamDef
Default Value	false
Post-Build Variant Value	false
Scope / Dependency	scope: local

Name	RteRipsGlobalCopyInstantiationPolicy [ECUC_Rte_79001]	
Parent Container	RteRipsPluginProps	
Description	Globally enables or disables the support for Rte Implementation Plug-Ins (RIPS) **Tags:** atp.Status=draft	
Multiplicity	1	
Type	EcucEnumerationParamDef	
Range	RTE_RIPS_INSTANTIATION_BY_PLUGIN	The Rte Implementation Plug-In shall provide the global copy(s) for each Communication Graph.
	RTE_RIPS_INSTANTIATION_BY_RTE	The RTE shall provide an individual global copy for each Communication Graph.
Default Value	RTE_RIPS_INSTANTIATION_BY_RTE	
Post-Build Variant Value	false	
Scope / Dependency	scope: local	

No Included Containers

The container `RteRipsPluginProps` is mandatory to describe the properties and the name infix used for the `RTE Implementation Plug-In Services` and header files.

[SWS_Rte_70092] DRAFT ⌈ The RTE Implementation Plug-In shall describe its properties with an instance of an RteRipsPluginProps. ⌋*(SRS_Rte_00313)*

8.14.3 Configuration of Fill-Flush-Routines of RTE Implementation Plug-Ins

The section lists the configuration for the Fill-Flush-Routines needed in case a RTE Implemention Plug-In implements implicit communication. The details are described in section 7.3.4.7.1.

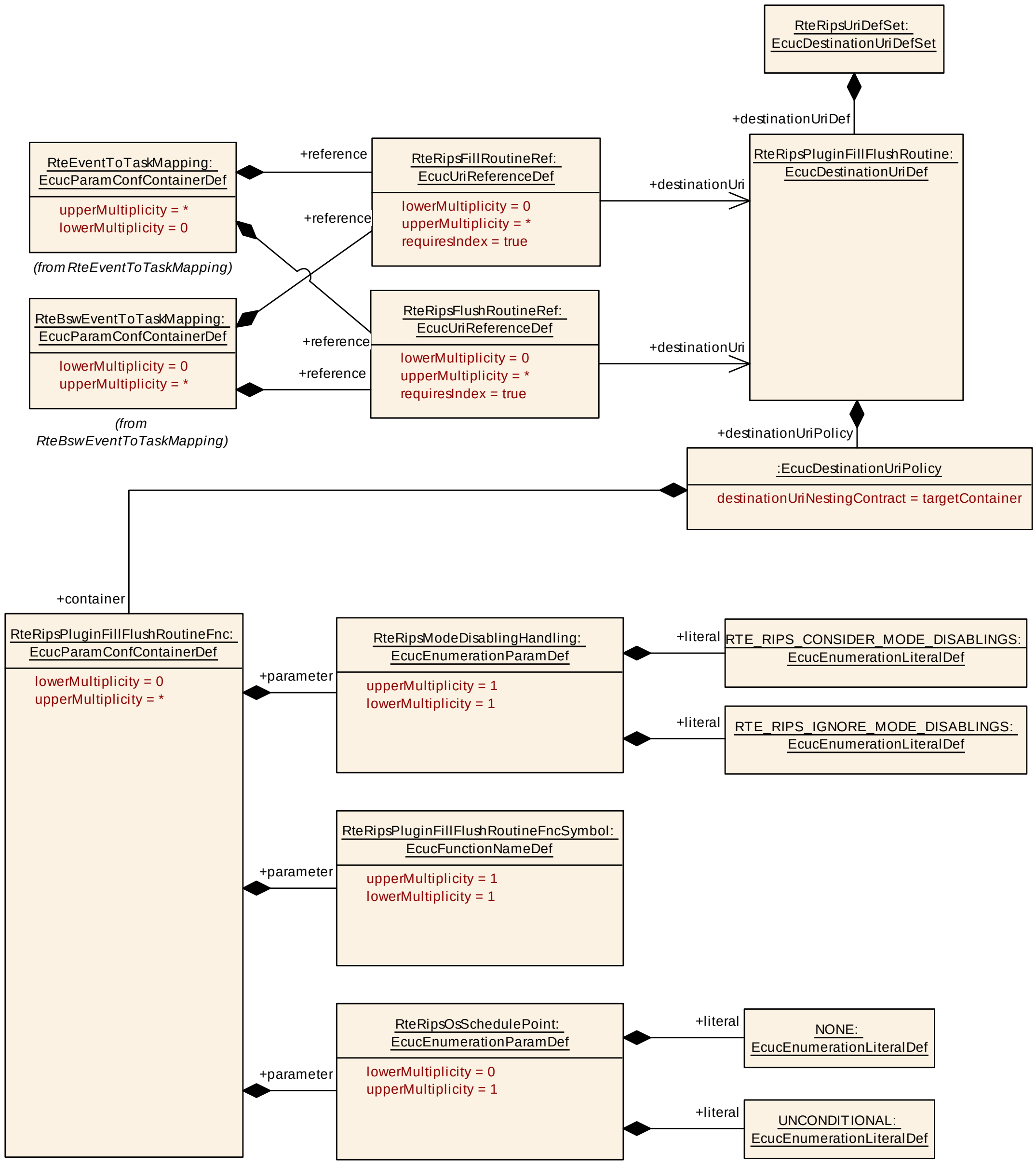

Figure 8.35: Configuration of Fill-Flush-Routines of RTE Implementation Plug-Ins

SWS Item	[ECUC_Rte_79003]
Container Name	RteRipsPluginFillFlushRoutineFnc

Description	This container describes a Fill-Flush Routine function implemented by a RTE Implementation Plug-In to handle the buffering for implicit communication. **Tags:** atp.Status=draft
Configuration Parameters	

Name	RteRipsModeDisablingHandling [ECUC_Rte_79004]	
Parent Container	RteRipsPluginFillFlushRoutineFnc	
Description	This parameter configures whether mode disabling dependencies are considered for the invocation of Rte_Rips_FillFlushRoutines. **Tags:** atp.Status=draft	
Multiplicity	1	
Type	EcucEnumerationParamDef	
Range	RTE_RIPS_CONSIDER_MODE_DISABLINGS	Support for Rte Implementation Plug-Ins (RIPS) is globally disabled.
	RTE_RIPS_IGNORE_MODE_DISABLINGS	Support for Rte Implementation Plug-Ins (RIPS) is globally enabled.
Post-Build Variant Value	false	
Scope / Dependency	scope: local	

Name	RteRipsOsSchedulePoint [ECUC_Rte_79006]	
Parent Container	RteRipsPluginFillFlushRoutineFnc	
Description	Introduce a schedule point by explicitly calling Os Schedule service after the execution of the Rte_Rips_FillFlushRoutine. **Tags:** atp.Status=draft	
Multiplicity	0..1	
Type	EcucEnumerationParamDef	
Range	NONE	No Schedule Point shall be introduced at the end of the execution of this Rte_Rips_FillFlushRoutine.
	UNCONDITIONAL	A Schedule Point shall always be introduced at the end of the execution of this Rte_Rips_FillFlushRoutine.
Post-Build Variant Multiplicity	false	
Post-Build Variant Value	false	
Scope / Dependency	scope: local	

Name	RteRipsPluginFillFlushRoutineFncSymbol [ECUC_Rte_79005]
Parent Container	RteRipsPluginFillFlushRoutineFnc
Description	C-Symbol of the Rte_Rips_FillFlushRoutine function. **Tags:** atp.Status=draft
Multiplicity	1
Type	EcucFunctionNameDef
Default Value	
Regular Expression	
Post-Build Variant Value	false
Scope / Dependency	scope: local

No Included Containers

8.14.4 Configuration of invocation handlers of RTE Implementation Plug-Ins

The section lists the configuration for the invocation handles needed in case a RTE Implementation Plug-In needs to invoke server runnables respectively the triggered runnables. The details are described in section 7.3.8.4.

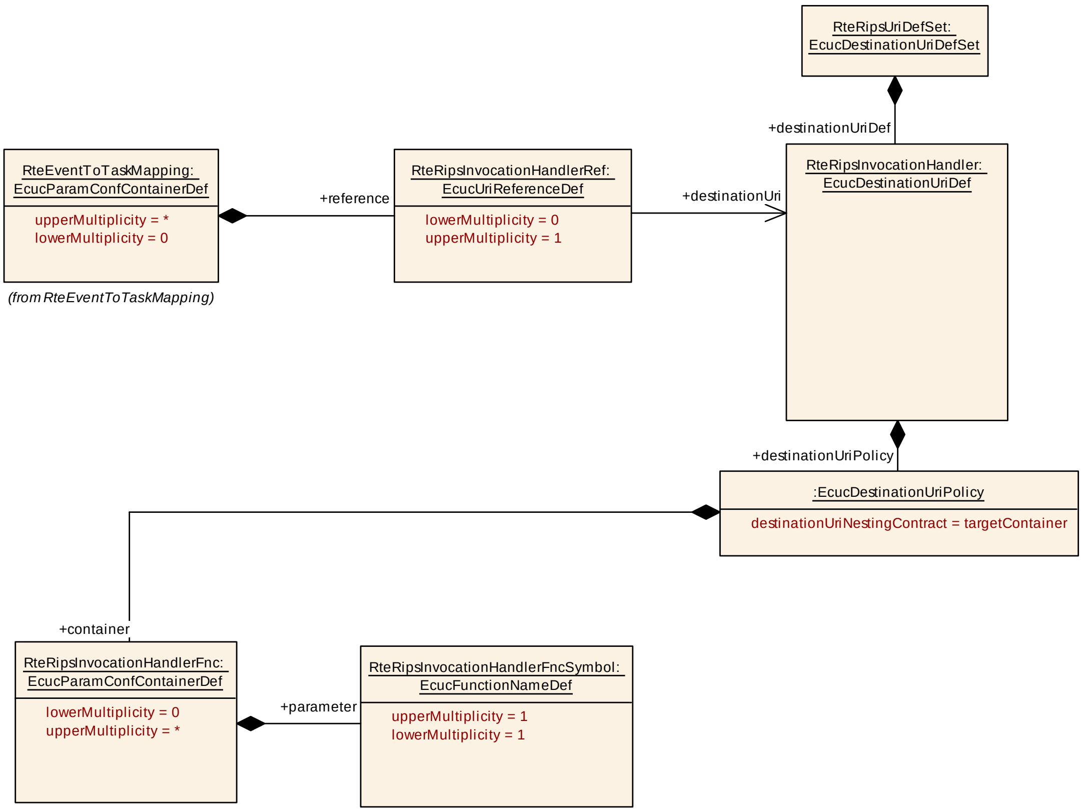

Figure 8.36: Configuration of invocation handler of RTE Implementation Plug-Ins

SWS Item	[ECUC_Rte_79007]
Container Name	RteRipsInvocationHandlerFnc
Description	This container describes an invocation handler function implemented by an RTE Implementation Plug-In to handle the invocation of server runnables and triggered runnables via a transformer. **Tags:** atp.Status=draft
Configuration Parameters	

Name	RteRipsInvocationHandlerFncSymbol [ECUC_Rte_79008]
Parent Container	RteRipsInvocationHandlerFnc
Description	C-Symbol of the Rte_Rips_FillFlushRoutine function. **Tags:** atp.Status=draft
Multiplicity	1
Type	EcucFunctionNameDef
Default Value	
Regular Expression	
Post-Build Variant Value	false
Scope / Dependency	scope: local

No Included Containers

A Metamodel Restrictions

This chapter lists all the restrictions to the AUTOSAR meta-model this version of the AUTOSAR RTE specification document relies on. The RTE generator shall reject configuration where any of the specified restrictions are violated.

A.1 Restrictions concerning WaitPoint

1. **[SWS_Rte_01358]** ⌈ The RTE shall raise an error if [constr_1091] is violated, so if RunnableEntity has WaitPoint connected to any of the following RTEEvents:

    - OperationInvokedEvent
    - SwcModeSwitchEvent
    - TimingEvent
    - BackgroundEvent
    - DataReceiveErrorEvent
    - ExternalTriggerOccurredEvent
    - InternalTriggerOccurredEvent
    - DataWriteCompletedEvent

    These events can only start a runnable. ⌋*(SRS_Rte_00092, SRS_Rte_00018)*
    Note: The only events that can unblock a WaitPoint are those listed in [constr_1091].

    Rationale: For OperationInvokedEvents, SwcModeSwitchEvents, TimingEvents, BackgroundEvents DataReceiveErrorEvent, ExternalTriggerOccurredEvent, InternalTriggerOccurredEvent, and DataWriteCompletedEvent it suffices to allow the activation of a RunnableEntity.

2. **[SWS_Rte_07402]** ⌈ The RTE generator shall reject a model where two (or more) different RunnableEntitys in the same internal behavior each have a WaitPoint referencing the same DataReceivedEvent, and the runnables are mapped to different tasks. ⌋*(SRS_Rte_00092, SRS_Rte_00018)*

    Rationale: In the same software components, the two runnables will attempt to read from the same queue, and only the one that accesses the queue first will actually receive the data.

A.2 Restrictions concerning RTEEvent

1. **[SWS_Rte_03526]** ⌈ The RTE generator shall reject configurations in which a RunnableEntity is triggered by multiple OperationInvokedEvents but violating the constraint [constr_2000] *Compatibility of ClientServerOperations triggering the same RunnableEntity* as defined in document [2] ⌋*(SRS_Rte_00072, SRS_Rte_00018)*

   Rationale: The signature of the RunnableEntity is dependent on its connected RTEEvent. Multiple OperationInvokedEvents are only supported if all referred ClientServerOperations would result in the same RunnableEntity prototype for the server runnable (see 5.7.5.6).

2. **[SWS_Rte_03010]** ⌈ One runnable entity shall only be resumed by one single RTEEvent on its WaitPoint. The RTE doesn't support the WaitPoint of one runnable entity connected to several RTEEvents. ⌋*(SRS_Rte_00092, SRS_Rte_00018)*

   Rationale: The WaitPoint of the runnable entity is caused by calling of the RTE API. One runnable entity can only call one RTE API at a time, and so it can only wait for one RTEEvent.

3. **[SWS_Rte_07007]** ⌈ The RTE generator shall reject configurations where different execution instances of a runnable entity, which use implicit data access, are mapped to different preemption areas. ⌋*(SRS_Rte_00018, SRS_Rte_00128, SRS_Rte_00129, SRS_Rte_00133, SRS_Rte_00142)*

   Rationale: Buffers used for implicit communication shall be consistent during the whole task execution. If it is guaranteed that one task does not preempt the other, direct accesses to the same copy buffer from different tasks are possible.

4. **[SWS_Rte_07403]** ⌈ The RTE generator shall reject a model where in the same SwcInternalBehavior two (or more) different DataReceivedEvents, that reference the same VariableDataPrototype with event semantics, trigger different runnable entities mapped to different tasks. ⌋*(SRS_Rte_00072, SRS_Rte_00018)*

   Rationale: In the same software components, the two runnables will attempt to read from the same queue, and only the one that accesses the queue first will actually receive the data.

A.3 Restrictions concerning queued implementation policy

1. **[SWS_Rte_03018]** ⌈ RTE does not support receiving with WaitPoint for VariableDataPrototypes with their swImplPolicy attribute is not set to queued. ⌋*(SRS_Rte_00109, SRS_Rte_00092, SRS_Rte_00018)*

Requirement [SWS_Rte_03018] rejects configurations where a DataReceivedEvent is referenced by a WaitPoint and references a VariableDataPrototype referenced by a NvDataInterface.

Rationale: unqueued implementation policy indicates that the receiver shall not wait for the VariableDataPrototype.

2. All the VariableAccesses in the dataSendPoint role referring to one VariableDataPrototype through one PPortPrototype are considered to have the same behavior by sending and acknowledgment reception. All DataSendCompletedEvents that reference VariableAccesses in the dataSendPoint role referring to the same VariableDataPrototype are considered equivalent.

   Rationale: The API Rte_Send/Rte_Write is dependent on the port name and the VariableDataPrototype name, not on the VariableAccesses. For each combination of one VariableDataPrototype and one port only one API will be generated and implemented for sending or acknowledgement reception.

A.4 Restrictions concerning ServerCallPoint

1. **[SWS_Rte_03014]** ⌈ All the ServerCallPoints referring to one ClientServerOperation through one RPortPrototype are considered to have the same behavior by calling service. The RTE generator shall reject configuration where this is violated. ⌋*(SRS_Rte_00051, SRS_Rte_00018)*

   Rationale: The API Rte_Call is dependent on the port name and the operation name, not on the ServerCallPoints. For each combination of one operation and one port only one API will be generated and implemented for calling a service. It is e.g. not possible to have different timeout values specified for different ServerCallPoints of the same ClientServerOperation. It is also not allowed to specify both, a synchronous and an asynchronous server call point for the same ClientServerOperation instance.

2. **[SWS_Rte_03605]** ⌈ If several require ports of a software component are categorized by the same client/server interface, all invocations of the same operation of this client/server interface have to be either synchronous, or all invocations of the same operation have to be asynchronous. This restriction applies under the following conditions:

   - the usage of the indirect API is specified for at least one of the respective port prototypes **and/or**
   - the software component supports multiple instantiation, **and** the RTE generation shall be performed in compatibility mode.

   ⌋*(SRS_Rte_00051, SRS_Rte_00018)*

Rationale: The signature of Rte_Call and the existence of Rte_Result depend on the kind of invocation.

3. **[SWS_Rte_07170]** ⌈ The RTE generator shall reject the configuration where [constr_2006] is violated. ⌋*(SRS_Rte_00051, SRS_Rte_00018)*

   Rationale: The support of several AsynchronousServerCallResultPoints per AsynchronousServerCallPoint would potentially support multiple AsynchronousServerCallReturnsEvents as well as multiple WaitPoints for the same AsynchronousServerCallPoint.

A.5 Restriction concerning multiple instantiation of software components

1. **[SWS_Rte_07101]** ⌈ The RTE generator shall reject configurations where [constr_2024] is violated, so in which a PortAPIOption with enableTakeAddress = *TRUE* is defined by a software-component supporting multiple instantiation. ⌋*(SRS_Rte_00018)*

   Rationale: The main focus of the feature is support for configuration of AUTOSAR Services which are limited to single instances.

A.6 Restrictions concerning runnable entity

1. **[SWS_Rte_03527]** ⌈ The RTE does NOT support multiple Runnable Entities that share the same entry point. ⌋*(SRS_Rte_00072, SRS_Rte_00018)*

   Rationale: The name of the runnable entity entry point is formed by a combination of SWC symbol prefix and symbol attribute of RunnableEntity. This means that two runnables in different SWCs can have the same symbol attribute as long as different SWC prefixes are used.

2. **[SWS_Rte_02733]** ⌈ The RTE Generator shall reject a configuration where a runnable has the attribute canBeInvokedConcurrently set to true and the attribute minimumStartInterval set to greater zero. ⌋*(SRS_Rte_00018)*

   Rationale: If a runnable should run concurrently (i.e., have several ExecutableEntity execution-instances), this implies that the minimum interval between the start of the runnables is zero. The configuration to be rejected is inconsistent.

A.7 Restrictions concerning runnables with dependencies on modes

1. Operations may not be disabled by a mode disabling dependency.

   [SWS_Rte_02706] ⌈ RTE shall reject the configurations violating [constr_1523]. ⌋ *(SRS_Rte_00143, SRS_Rte_00018)*

   [SWS_Rte_03869] ⌈ RTE shall reject the configurations violating [constr_4098]. ⌋ *(SRS_Rte_00143, SRS_Rte_00018)*

   Rationale: It is a preferable implementation, if the server responds with an explicit application error, when the server operation is not supported in a mode. To implement the disabling of operations would require a high amount of book keeping even for internal client server communication to prevent that the unique request response mapping gets lost.

2. Only a category 1 runnable may be triggered by

   - a `SwcModeSwitchEvent`
   - an `RTEEvent` with a mode disabling dependency

   [SWS_Rte_02500] ⌈ The RTE generator shall reject configurations with category 2 runnables connected to `SwcModeSwitchEvent`s and `RTEEvent`s / `BswEvent`s with `mode disabling dependencys` if the mode machine instance is synchronous. The rejection may be reduced to a warning when the RTE generator is explicitly set to a non strict mode. ⌋ *(SRS_Rte_00143, SRS_Rte_00213, SRS_Rte_00018)*

   Rationale: The above runnables are executed or terminated on the transitions between different modes. To execute the mode switch withing finite time, also these runnables have to be executed within finite execution time.

3. All `on-entry ExecutableEntitys`, `on-transition ExecutableEntitys`, and `on-exit ExecutableEntitys` of the same `core local mode user group` should be mapped to the same task in case of synchronous mode switching procedure.

   [SWS_Rte_02662] ⌈ The RTE generator shall reject configurations with on-entry, on-transition, or on-exit ExecutableEntity's of the same `core local mode user group` that are mapped to different tasks in case of synchronous mode switching procedure. ⌋ *(SRS_Rte_00143, SRS_Rte_00213, SRS_Rte_00018)*

   In case of asynchronous mode switching procedure, a mapping of all affected runnables to no task is also possible.

   Rationale: This restriction simplifies the implementation of the semantics of a synchronous mode switch.

4. To guarantee that all mode disabling dependent ExecutableEntitys of a core local mode user group have terminated before the start of the on-exit ExecutableEntitys of the transition, the mode disabling dependent ExecutableEntitys should run with higher or equal priority.

   [SWS_Rte_02663] ⌈ The RTE generator shall reject configurations with mode disabling dependent ExecutableEntitys that are mapped to a task with lower priority than the task that contains the on-entry ExecutableEntitys and on-exit ExecutableEntitys of that core local mode user group supporting a synchronous mode switching procedure. ⌋ *(SRS_Rte_00143, SRS_Rte_00213, SRS_Rte_00018)*

5. **[SWS_Rte_02664]** ⌈ The RTE generator shall reject configurations of a task with

   - on-exit ExecutableEntitys mapped after on-entry ExecutableEntitys or
   - on-transition ExecutableEntitys mapped after on-entry ExecutableEntitys or
   - on-exit ExecutableEntitys mapped after on-transition ExecutableEntitys

   of the same mode machine instance supporting a synchronous mode switching procedure. ⌋ *(SRS_Rte_00143, SRS_Rte_00213, SRS_Rte_00018)*

   Rationale: This restriction simplifies the implementation of the semantics of a synchronous mode switch.

6. **[SWS_Rte_06839]** ⌈ The RTE generator shall reject configurations of a DSMQ transition OsTask with

   - on-exit ExecutableEntitys mapped after on-entry ExecutableEntitys or
   - on-exit ExecutableEntitys mapped after on-transition ExecutableEntitys or
   - on-exit ExecutableEntitys mapped after ModeSwitchAck ExecutableEntitys or
   - on-transition ExecutableEntitys mapped after on-entry ExecutableEntitys or
   - on-transition ExecutableEntitys mapped after ModeSwitchAck ExecutableEntitys or
   - on-entry ExecutableEntitys mapped after ModeSwitchAck ExecutableEntitys

   of mode machine instances belonging to a distributed shared mode group. ⌋ *(SRS_Rte_00310, SRS_Rte_00143, SRS_Rte_00213, SRS_Rte_00018)*

Rationale: This restriction simplifies the implementation of the semantics of a synchronous mode switch in combination with a distributed shared mode group.

7. **[SWS_Rte_07157]** ⌈ The RTE generator shall reject configurations with

   - on-exit ExecutableEntitys mapped after on-entry ExecutableEntitys or
   - on-transition ExecutableEntitys mapped after on-entry ExecutableEntitys or
   - on-exit ExecutableEntitys mapped after on-transition ExecutableEntitys

   of the same software component or Basic Software Module for a mode machine instance supporting an asynchronous mode switching procedure. ⌋ *(SRS_Rte_00143, SRS_Rte_00213, SRS_Rte_00018)*

   Rationale: This restriction simplifies the implementation of the semantics of an asynchronous mode switch.

8. If a mode is used to trigger a runnable for entering or leaving the mode, but this runnable has a mode disabling dependency on the same mode, the mode disabling dependency inhibits the activation of the runnable on the transition (see section 4.4.4).

   To prevent such a misleading configuration, it is strongly recommended not to configure a mode disabling dependency for an on-entry ExecutableEntity or on-exit ExecutableEntity, using the same mode.

9. In case that the mode machine instance is initialized by Rte_Init API the related on-entry Runnable Entities for the initialMode have to be executed in the context of the Rte_Init API. In order to enable the complete transition to the initialMode it is required that all on-entry Runnable Entities are mapped to RteInitializationRunnableBatch containers otherwise a part of the on-entry Runnable Entities wouldn't be scheduled during the transition to the initialMode.

   [SWS_Rte_CONSTR_09062] Entire mapping of on-entry Runnable Entities for initialMode to RteInitializationRunnableBatch containers ⌈ Either all or none of the on-entry Runnable Entities of a particular mode machine instance for the initialMode shall be mapped to RteInitializationRunnableBatch containers. ⌋ *()*

   [SWS_Rte_06768] ⌈ The RTE Generator shall reject configurations violating [SWS_Rte_CONSTR_09062]. ⌋ *(SRS_Rte_00143, SRS_Rte_00240, SRS_Rte_00018)*

   Please note as well [SWS_Rte_CONSTR_09063] which limits the applicability of the mapping to RteInitializationRunnableBatch containers.

A.8 Restriction concerning SwcInternalBehavior

1. **[SWS_Rte_07686]** ⌈ The RTE Generator shall reject configurations where an ApplicationSwComponentType, ServiceSwComponentType, ComplexDeviceDriverSwComponentType, EcuAbstractionSwComponentType, SensorActuatorSwComponentType or ServiceProxySwComponentType does not contain a SwcInternalBehavior. ⌋*(SRS_Rte_00018)*

A.9 Restrictions concerning Initial Value

1. **[SWS_Rte_07642]** ⌈ When the *external configuration switch* strictInitialValuesCheck is enabled, the RTE Generator shall reject configurations where a SwAddrMethod has a sectionInitializationPolicy set to init but no initValues are specified on the sender or receiver side. ⌋*(SRS_Rte_00068, SRS_Rte_00108, SRS_Rte_00018)*

   Rationale: The initValue is used to guarantee that the RTE won't deliver undefined values.

2. **[SWS_Rte_08311]** ⌈ When the *external configuration switch* strictInitialValuesCheck is enabled, the RTE Generator shall reject configurations where a SwAddrMethod has a sectionInitializationPolicy set to init but no initValue is specified on the inter runnable variable. ⌋*(SRS_Rte_00068, SRS_Rte_00108, SRS_Rte_00018)*

   Rationale: The initValue is used to guarantee that the RTE won't deliver undefined values.

3. **[SWS_Rte_07681]** ⌈ If strict checking of initial values is enabled (see [SWS_Rte_07680]), the RTE Generator shall reject configurations where a ParameterDataPrototype has no initValues. ⌋*(SRS_Rte_00108, SRS_Rte_00018)*

   Rationale: This allows to provide the values with a calibration without any involvements from the RTE Generator, and still permits to enable a stricter check on projects where it is required.

A.10 Restriction concerning PerInstanceMemory

1. **[SWS_Rte_07045]** ⌈ The RTE generator shall reject configurations where the type attribute of a 'C' typed PerInstanceMemory is equal to the name of a ImplementationDataType contained in the input configuration. ⌋*(SRS_Rte_00013, SRS_Rte_00077)*

   Rationale: This would lead to equally named C type definitions.

A.11 Restrictions concerning unconnected r-port

1. **[SWS_Rte_03019]** ⌈ If strict checking has been enabled (see [SWS_Rte_05099]) there shall not be unconnected r-port. The RTE generator shall in this case reject the configuration with unconnected r-port. ⌋*(SRS_Rte_00139, SRS_Rte_00018)*

   Rationale: Unconnected r-port is considered as wrong configuration of the system.

2. **[SWS_Rte_02750]** ⌈ The RTE Generator shall reject configurations where an r-port typed with a `ParameterInterface` is not connected and an `initValue` of a `ParameterRequireComSpec` is not provided for each `ParameterDataPrototype`s of this `ParameterInterface`. ⌋*(SRS_Rte_00139, SRS_Rte_00159, SRS_Rte_00018)*

A.12 Restrictions regarding communication of mode switch notifications

1. **[SWS_Rte_02670]** ⌈RTE shall not support connections with multiple senders (n:1 communication) of `mode switch notifications` connected to the same receiver. The RTE generator shall reject configurations with multiple senders of `mode switch notifications` connected to the same receiver. ⌋*(SRS_Rte_00131, SRS_Rte_00018)*

   Rationale: No use case is known to justify the required complexity.

2. **[SWS_Rte_08788]** ⌈ RTE shall reject configurations

   - where one `ModeDeclarationGroupPrototype` of a provide port is connected to `ModeDeclarationGroupPrototype`s of require ports from more than one partition

   and

   - where at least one of the mode user partitions can be restarted

   and

   - where the `modeUserErrorBehavior` of `ModeDeclarationGroup` is not set to `lastMode`

   ⌋*(SRS_Rte_00131, SRS_Rte_00018)*

3. For each `ModeDeclarationGroup`, used in the SW-C's ports, RTE needs a unique mapping to an `ImplementationDataType`.

   [SWS_Rte_02738] ⌈ RTE shall reject a configuration, in which there is not exactly one `ModeRequestTypeMap` referencing the `ModeDeclarationGroup` used in a `ModeDeclarationGroupPrototype` of the SW-C's ports. ⌋*(SRS_Rte_00144, SRS_Rte_00018)*

A.13 Restrictions regarding Measurement and Calibration

1. **[SWS_Rte_03951]** ⌈ RTE does not support measurement of queued communication. ⌋*(SRS_Rte_00153, SRS_Rte_00018)*

   Rationale: Measurement of queued communication is not supported yet. Reasons are:

   - A queue can be empty. What's to measure then? Data interpretation is ambiguous.
   - Which of the queue entries the measurement data has to be taken from (first pending entry, last entry, an intermediate one, mean value, min. or max. value)? Needs might differ out of user view? Data interpretation is ambiguous.
   - Compared e.g. to sender-receiver last-is-best approach only inefficient solutions are possible because implementation of queues entails storage of information dynamically at different memory locations. So always additional copies are required.

2. **[SWS_Rte_03970]** ⌈ The RTE generator shall reject configurations violating [constr_1092] so containing require ports attached to `ParameterSwComponentType`s. ⌋*(SRS_Rte_00154, SRS_Rte_00156, SRS_Rte_00018)*

   Rationale: Require ports on `ParameterSwComponentType`s don't make sense. `ParameterSwComponentType`s only have to provide calibration parameters to other `SwComponentType`s.

A.14 Restriction concerning ExclusiveAreaImplMechanism

1. **Usage of `WaitPoint`s is restricted depending on *ExclusiveAreaImplMechanism***
   If an exclusive area's configuration value for *ExclusiveAreaImplMechanism* is *InterruptBlocking* or *OsResource*, no runnable entity shall contain any `WaitPoint` inside this exclusive area.

   Please note that a wait point can either be a modelling `WaitPoint` e. g. a `WaitPoint` in the SW-C description caused by the usage of a blocking API (e. g. `Rte_Receive`) or an implementation wait point caused by a special implementation to fulfill the requirements of the ECU configuration, e. g. the runnable-to-task mapping.

   Rationale: The operating system has the limitation that a `WaitEvent` call is not allowed with disabled interrupts. Therefore the implementation mechanism *InterruptBlocking* cannot be used if the exclusive area contains a `WaitPoint`.

   Further the operating system has the limitation that an OS `WaitPoint` cannot be entered with occupied OS Resources. This implies that the implementation mechanism *OsResource* cannot be used if the exclusive area contains a WaitPoint.

A.15 Restrictions concerning AtomicSwComponentTypes

1. **[SWS_Rte_07190]** ⌈ The RTE generator shall reject configurations where multiple SwComponentTypes have the same component type symbol regardless of the ARPackage hierarchy. ⌋*(SRS_Rte_00018)*

   Rational: This is required to generated unique names for the *Application Header Files* and component data structures.

2. **[SWS_Rte_07191]** ⌈ The RTE generator shall reject configurations where a SwComponentType has PortPrototypes typed by different PortInterfaces with equal short name but conflicting ApplicationErrors. ApplicationErrors are conflicting if ApplicationErrors with same name do have different errorCodes. ⌋*(SRS_Rte_00018)*

   Rational: This is required to generated unique symbolic names for ApplicationErrors. (see also [SWS_Rte_02576])

A.16 Restriction concerning the enableUpdate attribute of NonqueuedReceiverComSpecs

1. **[SWS_Rte_07654]** ⌈ The RTE Generator shall reject configurations violating [constr_1103] so where a VariableDataPrototype is referenced by a NonqueuedReceiverComSpec with the enableUpdate attribute enabled, when this VariableDataPrototype is referenced by a VariableAccess in the dataReadAccess role. ⌋*(SRS_Rte_00179, SRS_Rte_00018)*

   Rational: the update flag is restricted to explicit communication currently.

A.17 Restrictions concerning the large and dynamic data type

1. **[SWS_Rte_07810]** ⌈ The RTE shall reject the configuration if a dataElement that contain an ImplementationDataType with subElements with arraySizeSemantics equal to variableSize resolves to another type than uint8[n]. ⌋*(SRS_Rte_00018)*

   Rationale: COM limits the dynamic signals to the ComSignalType UINT_8DYN (see the requirement COM569). COM doesn't support dynamic signals included into signal groups. See more explanations in chapter 4.3.1.14.

2. **[SWS_Rte_08423]** ⌈ The RTE shall reject the configuration if an ImplementationDataType does not have a dynamicArraySizeProfile defined and contains a subElement with the category ARRAY that in turn contains a subElement with arraySizeSemantics set to variableSize. ⌋ *(SRS_Rte_00018)*

3. **[SWS_Rte_07811]** ⌈ The RTE shall reject configurations where a dataElement mapped to a Com I-PDU with ComIPduType equal to TP and swImplPolicy is different from queued and supportedFeatures of the PortAPIOption is not set to supportsBufferLocking. ⌋ *(SRS_Rte_00018)*

   Rationale: Otherwise COM might return COM_BUSY. See more explanations in chapter 4.3.1.15.

4. **[SWS_Rte_08603]** ⌈ The RTE shall reject configurations where a dataElemnt mapped to a LdCom I-PDU with LdComApiType equals to LdCom_TP and swImplPolicy is different from queued and supportedFeatures of the PortAPIOption is not set to supportsBufferLocking. ⌋ *(SRS_Rte_00018)*

5. **[SWS_Rte_08604]** ⌈ The RTE shall reject configurations where a ClientServerOperation mapped to a Com I-PDU with ComIPduType equal to TP and supportedFeatures of the PortAPIOption is not set to supportsBufferLocking. ⌋ *(SRS_Rte_00018)*

6. **[SWS_Rte_08605]** ⌈ The RTE shall reject configurations where a ClientServerOperation mapped to a LdCom I-PDU with LdComApiType equals to LdCom_TP and supportedFeatures of the PortAPIOption is not set to supportsBufferLocking. ⌋ *(SRS_Rte_00018)*

7. **[SWS_Rte_07812]** ⌈ The RTE shall reject the configuration if a dataElement with an ImplementationDataType with subElements with arraySizeSemantics equal to variableSize has a swImplPolicy different from queued. ⌋ *(SRS_Rte_00018)*

   Rationale: Otherwise COM might return COM_BUSY. See more explanations in chapter 4.3.1.15.

A.18 Restriction concerning REFERENCE types

1. **[SWS_Rte_07670]** ⌈ The RTE shall reject a configuration violating [constr_1295]. ⌋ *(SRS_Rte_00018)*

   Rationale: Only for AUTOSAR services, complex device drivers or ECU abstraction, the use of references is allowed to prevent the misuse of references for communication via the referenced memory (intra-partition scope). For example, such a misuse could occur with application software components communicating together and mapped to different partitions or ECUs.

A.19 Restriction concerning ModeDeclarationGroup categories and value attributes

1. **[SWS_Rte_06801]** ⌈ The RTE generator shall reject a configuration if constraint [constr_1298] is violated. ⌋*(SRS_Rte_00018)*

   [SWS_Rte_06802] ⌈ The RTE generator shall reject a configuration if constraint [constr_1299] is violated. ⌋*(SRS_Rte_00018)*

   [SWS_Rte_06803] ⌈ The RTE generator shall reject a configuration if constraint [constr_1181] is violated. ⌋*(SRS_Rte_00018)*

   Rationale: In case of category `EXPLICIT_ORDER` the `onTransitionValue` and `value` attributes are required to generate the according definitions (see 5.5.4 and 6.4.2). Thereby unique numbers are required. In case of `ALPHABETIC_ORDER` the definition of those values are meaningless and causing the risk of inconsistency to the numbering according the alphabetical sorting.

A.20 Restrictions concerning C/S Interfaces

1. **[SWS_Rte_07845]** ⌈ The Rte Generator shall reject configurations where a `ClientServerOperation` in a `PPortPrototype` is defined but no `RunnableEntity` is triggered by an `OperationInvokedEvent` that references the `ClientServerOperation`. ⌋*(SRS_Rte_00029, SRS_Rte_00018)*

   Rationale: Otherwise the implementation by a server runnable of the operation in the C/S interface does not exist.

B External Requirements

A summary on model constraints is provided in document [33].

C MISRA C Compliance

In general, all RTE code, whether generated or not, shall conform to the MISRA C standard [SWS_Rte_01168] [27]. This chapter lists all the MISRA C rules that may be violated by the generated RTE.

The MISRA C standard was defined with having mainly hand-written code in mind. Part of the MISRA C rules only apply to hand-written code, they do not make much sense in the context of automatic code generation. Additionally, there are some rules that are violated because of technical reasons, mainly to reduce RTE overhead.

The rules listed in this chapter are expected to be violated by RTE code. Violations to the rules listed here do not need to be documented as non-compliant to MISRA C in the generated code itself.

MISRA rule	2.3
Description	A project should not contain unused type declarations.
Violations	This is in support of [SWS_Rte_02648].

Table C.1: MISRA rule 2.3

MISRA rules	5.1 to 5.1, Dir1.1
Description	Identifiers (internal and external) shall not rely on significance of more than 31 characters. Furthermore the compiler/linker shall be checked to ensure that 31 character significance and case sensitivity are supported for external identifiers.
Violations	The defined RTE naming convention may result in identifiers with more than 31 characters. The compliance to this rule is under user's control.

Table C.2: MISRA rules 5.1 to 5.1, Dir1.1

MISRA rule	8.5
Description	An external object or function shall be declared once and in one and only one file.
Violations	This is in support of application header file generation.

Table C.3: MISRA rule 8.5

MISRA rule	8.8
Description	The static storage class specifier shall be used in all declarations of objects and functions that have internal linkage.
Violations	E.g. for the purpose of monitoring during calibration or debugging it may be necessary to use non-static declarations at file scope.

Table C.4: MISRA rule 8.8

MISRA rule	12.3
Description	The comma operator should not be used.
Violations	Function-like macros may have to use the comma operator. Function-like macros are required for efficiency reasons [SRS_BSW_00330].

Table C.5: MISRA rule 12.3

MISRA rule	11.2
Description	Conversions shall not be performed between a pointer to an incomplete type and any other type.
Violations	Casting to/from pointer type may be needed for the interface with COM. Casting from a pointer to a data element with status to a pointer to a data element without status.

Table C.6: MISRA rule 11.2

MISRA rule	11.3
Description	A cast shall not be performed between a pointer to object type and a pointer to a different object type.
Violations	Casting to/from pointer type may be needed for the interface with COM. Casting from a pointer to a data element with status to a pointer to a data element without status.

Table C.7: MISRA rule 11.3

MISRA rule	8.7
Description	Functions and objects should not be defined with external linkage if they are referenced in only one translation unit.
Violations	Support the use cases where SW-Cs are delivered as OBJ code and the ports might not be connected during generation time.

Table C.8: MISRA rule 8.7

MISRA rule	11.5
Description	A conversion should not be performed from pointer to void into pointer to object.
Violations	Casting to/from pointer type may be needed for the interface with COM. Casting from a pointer to a data element with status to a pointer to a data element without status.

Table C.9: MISRA rule 11.5

D Referenced Meta Classes

Class	**ARPackage**			
Package	M2::AUTOSARTemplates::GenericStructure::GeneralTemplateClasses::ARPackage			
Note	AUTOSAR package, allowing to create top level packages to structure the contained ARElements. ARPackages are open sets. This means that in a file based description system multiple files can be used to partially describe the contents of a package. This is an extended version of MSR's SW-SYSTEM.			
Base	*ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
arPackage	ARPackage	*	aggr	This represents a sub package within an ARPackage, thus allowing for an unlimited package hierarchy. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=blueprintDerivationTime xml.sequenceOffset=30
element	PackageableElement	*	aggr	Elements that are part of this package **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=systemDesignTime xml.sequenceOffset=20
referenceBase	ReferenceBase	*	aggr	This denotes the reference bases for the package. This is the basis for all relative references within the package. The base needs to be selected according to the base attribute within the references. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=shortLabel xml.sequenceOffset=10

Table D.1: ARPackage

Class	***AbstractAccessPoint*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::AccessCount			
Note	Abstract class indicating an access point from an ExecutableEntity.			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	AsynchronousServerCallResultPoint, ExternalTriggeringPointIdent, InternalTriggeringPoint, ModeAccessPointIdent, ModeSwitchPoint, ParameterAccess, *ServerCallPoint*, VariableAccess			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
–	–	–	–	–

Table D.2: AbstractAccessPoint

Class	***AbstractProvidedPortPrototype*** (abstract)
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components
Note	This abstract class provides the ability to become a provided PortPrototype.
Base	*ARObject*, *AtpBlueprintable*, *AtpFeature*, *AtpPrototype*, *Identifiable*, *MultilanguageReferrable*, *PortPrototype*, *Referrable*
Subclasses	PPortPrototype, PRPortPrototype

▽

△

Class	***AbstractProvidedPortPrototype*** (abstract)			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
providedComSpec	PPortComSpec	*	aggr	Provided communication attributes per interface element (data element or operation).

Table D.3: AbstractProvidedPortPrototype

Class	***AbstractRequiredPortPrototype*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	This abstract class provides the ability to become a required PortPrototype.			
Base	*ARObject*, *AtpBlueprintable*, *AtpFeature*, *AtpPrototype*, *Identifiable*, *MultilanguageReferrable*, *PortPrototype*, *Referrable*			
Subclasses	PRPortPrototype, RPortPrototype			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
requiredComSpec	RPortComSpec	*	aggr	Required communication attributes, one for each interface element.

Table D.4: AbstractRequiredPortPrototype

Class	**AnyInstanceRef**			
Package	M2::AUTOSARTemplates::GenericStructure::GeneralTemplateClasses::AnyInstanceRef			
Note	Describes a reference to any instance in an AUTOSAR model. This is the most generic form of an instance ref. Refer to the superclass notes for more details.			
Base	*ARObject*, *AtpInstanceRef*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
base	AtpClassifier	1	ref	This is the base from which navigation path begins. **Stereotypes:** atpDerived
contextElement	AtpFeature	*	ref	This is one step in the navigation path specified by the instance ref.
target	AtpFeature	1	ref	This is the target of the instance ref.

Table D.5: AnyInstanceRef

Enumeration	**ApiPrincipleEnum**
Package	M2::AUTOSARTemplates::CommonStructure::InternalBehavior
Note	This enumeration represents the ability to control the granularity of API generation.
Literal	***Description***
common	The Rte or SchM API is provided for the whole software component / BSW Module **Tags:** atp.EnumerationValue=0
perExecutable	The Rte or SchM API is provided for a specific ExecutableEntity of a software component / BSW Module **Tags:** atp.EnumerationValue=1

Table D.6: ApiPrincipleEnum

Class	**ApplicationArrayDataType**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::Datatypes			
Note	An application data type which is an array, each element is of the same application data type. **Tags:** atp.recommendedPackage=ApplicationDataTypes			
Base	*ARElement, ARObject, ApplicationCompositeDataType, ApplicationDataType, AtpBlueprint, AtpBlueprintable, AtpClassifier, AtpType, AutosarDataType, CollectableElement, Identifiable, MultilanguageReferrable, PackageableElement, Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
dynamicArraySizeProfile	String	0..1	attr	Specifies the profile which the array will follow if it is a variable size array.
element	ApplicationArrayElement	1	aggr	This association implements the concept of an array element. That is, in some cases it is necessary to be able to identify single array elements, e.g. as input values for an interpolation routine.

Table D.7: ApplicationArrayDataType

Class	**ApplicationArrayElement**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::DataPrototypes			
Note	Describes the properties of the elements of an application array data type.			
Base	*ARObject, ApplicationCompositeElementDataPrototype, AtpFeature, AtpPrototype, DataPrototype, Identifiable, MultilanguageReferrable, Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
arraySizeHandling	ArraySizeHandlingEnum	0..1	attr	The way how the size of the array is handled.
arraySizeSemantics	ArraySizeSemanticsEnum	0..1	attr	This attribute controls how the information about the array size shall be interpreted.
indexDataType	ApplicationPrimitiveDataType	0..1	ref	This reference can be taken to assign a CompuMethod of category TEXTTABLE to the array. The texttable entries associate a textual value to an index number such that the element with that index number is represented by a symbolic name.
maxNumberOfElements	PositiveInteger	0..1	attr	The maximum number of elements that the array can contain. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.8: ApplicationArrayElement

Class	***ApplicationCompositeDataType*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::Datatypes			
Note	Abstract base class for all application data types composed of other data types.			
Base	*ARElement, ARObject, ApplicationDataType, AtpBlueprint, AtpBlueprintable, AtpClassifier, AtpType, AutosarDataType, CollectableElement, Identifiable, MultilanguageReferrable, PackageableElement, Referrable*			
Subclasses	ApplicationArrayDataType, ApplicationRecordDataType			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
–	–	–	–	–

Table D.9: ApplicationCompositeDataType

Class	***ApplicationCompositeElementDataPrototype*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::DataPrototypes			
Note	This class represents a data prototype which is aggregated within a composite application data type (record or array). It is introduced to provide a better distinction between target and context in instance Refs.			
Base	*ARObject*, *AtpFeature*, *AtpPrototype*, *DataPrototype*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	ApplicationArrayElement, ApplicationRecordElement			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
type	ApplicationDataType	1	tref	This represents the corresponding data type. **Stereotypes:** isOfType

Table D.10: ApplicationCompositeElementDataPrototype

Class	***ApplicationDataType*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::Datatypes			
Note	ApplicationDataType defines a data type from the application point of view. Especially it should be used whenever something "physical" is at stake. An ApplicationDataType represents a set of values as seen in the application model, such as measurement units. It does not consider implementation details such as bit-size, endianess, etc. It should be possible to model the application level aspects of a VFB system by using ApplicationData Types only.			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *AutosarDataType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Subclasses	*ApplicationCompositeDataType*, ApplicationPrimitiveDataType			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
–	–	–	–	–

Table D.11: ApplicationDataType

Class	**ApplicationError**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	This is a user-defined error that is associated with an element of an AUTOSAR interface. It is specific for the particular functionality or service provided by the AUTOSAR software component.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
errorCode	Integer	1	attr	The RTE generator is forced to assign this value to the corresponding error symbol. Note that for error codes certain ranges are predefined (see RTE specification).

Table D.12: ApplicationError

Class	**ApplicationPrimitiveDataType**
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::Datatypes
Note	A primitive data type defines a set of allowed values. **Tags:** atp.recommendedPackage=ApplicationDataTypes
Base	*ARElement*, *ARObject*, *ApplicationDataType*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *AutosarDataType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*

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Class	**ApplicationPrimitiveDataType**			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
–	–	–	–	–

Table D.13: ApplicationPrimitiveDataType

Class	**ApplicationRecordDataType**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::Datatypes			
Note	An application data type which can be decomposed into prototypes of other application data types. **Tags:** atp.recommendedPackage=ApplicationDataTypes			
Base	*ARElement*, *ARObject*, *ApplicationCompositeDataType*, *ApplicationDataType*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *AutosarDataType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
element (ordered)	ApplicationRecordElement	1..*	aggr	Specifies an element of a record. The aggregation of ApplicationRecordElement is subject to variability with the purpose to support the conditional existence of elements inside a ApplicationrecordDataType. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.14: ApplicationRecordDataType

Class	**ApplicationRecordElement**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::DataPrototypes			
Note	Describes the properties of one particular element of an application record data type.			
Base	*ARObject*, *ApplicationCompositeElementDataPrototype*, *AtpFeature*, *AtpPrototype*, *DataPrototype*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
isOptional	Boolean	0..1	attr	This attribute represents the ability to declare the enclosing ApplicationRecordElement as optional. This means the that, at runtime, the ApplicationRecordElement may or may not have a valid value and shall therefore be ignored. The underlying runtime software provides means to set the ApplicationRecordElement as not valid at the sending end of a communication and determine its validity at the receiving end. **Tags:** atp.Status=draft

Table D.15: ApplicationRecordElement

Class	**ApplicationRuleBasedValueSpecification**
Package	M2::AUTOSARTemplates::CommonStructure::Constants
Note	This meta-class represents rule based values for DataPrototypes typed by ApplicationDataTypes (ApplicationArrayDataType or a compound ApplicationPrimitiveDataType which also boils down to an array-nature).

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Class	**ApplicationRuleBasedValueSpecification**			
Base	*ARObject*, *AbstractRuleBasedValueSpecification*, *ValueSpecification*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
category	Identifier	1	attr	This represents the category of the RuleBasedValue Specification **Tags:** xml.sequenceOffset=-20
swAxis Cont (ordered)	RuleBasedAxisCont	*	aggr	This represents the axis values of a Compound Primitive Data Type (curve or map). The first swAxisCont describes the x-axis, the second sw AxisCont describes the y-axis, the third swAxisCont describes the z-axis. In addition to this, the axis can be denoted in swAxisIndex.
swValueCont	RuleBasedValueCont	0..1	aggr	This represents the values of an array or Compound Primitive Data Type.

Table D.16: ApplicationRuleBasedValueSpecification

Class	**ApplicationSwComponentType**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	The ApplicationSwComponentType is used to represent the application software. **Tags:** atp.recommendedPackage=SwComponentTypes			
Base	*ARElement*, *ARObject*, *AtomicSwComponentType*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *Atp Type*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*, *Sw ComponentType*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
–	–	–	–	–

Table D.17: ApplicationSwComponentType

Class	**ApplicationValueSpecification**			
Package	M2::AUTOSARTemplates::CommonStructure::Constants			
Note	This meta-class represents values for DataPrototypes typed by ApplicationDataTypes (this includes in particular compound primitives). For further details refer to ASAM CDF 2.0. This meta-class corresponds to some extent with SW-INSTANCE in ASAM CDF 2.0.			
Base	*ARObject*, *ValueSpecification*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
category	Identifier	1	attr	Specifies to which category of ApplicationDataType this ApplicationValueSpecification can be applied (e.g. as an initial value), thus imposing constraints on the structure and semantics of the contained values, see [constr_1006] and [constr_2051].
swAxis Cont (ordered)	SwAxisCont	*	aggr	This represents the axis values of a Compound Primitive Data Type (curve or map). The first swAxisCont describes the x-axis, the second sw AxisCont describes the y-axis, the third swAxisCont describes the z-axis. In addition to this, the axis can be denoted in swAxisIndex.
swValueCont	SwValueCont	0..1	aggr	This represents the values of a Compound Primitive Data Type.

Table D.18: ApplicationValueSpecification

Class	**ArgumentDataPrototype**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	An argument of an operation, much like a data element, but also carries direction information and is owned by a particular ClientServerOperation.			
Base	*ARObject, AtpFeature, AtpPrototype, AutosarDataPrototype, DataPrototype, Identifiable, Multilanguage Referrable, Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
direction	ArgumentDirectionEnum	1	attr	This attribute specifies the direction of the argument prototype.
serverArgumentImplPolicy	ServerArgumentImplPolicyEnum	0..1	attr	This defines how the argument type of the servers RunnableEntity is implemented. If the attribute is not defined this has the same semantics as if the attribute is set to the value useArgumentType for primitive arguments and structures.

Table D.19: ArgumentDataPrototype

Enumeration	**ArgumentDirectionEnum**
Package	M2::AUTOSARTemplates::GenericStructure::GeneralTemplateClasses::PrimitiveTypes
Note	Use cases: • Arguments in ClientServerOperation can have different directions that need to be formally indicated because they have an impact on how the function signature looks like eventually. • Arguments in BswModuleEntry already determine a function signature, but the direction is used to specify the semantics, especially of pointer arguments.
Literal	***Description***
in	The argument value is passed to the callee. **Tags:** atp.EnumerationValue=0
inout	The argument value is passed to the callee but also passed back from the callee to the caller. **Tags:** atp.EnumerationValue=1
out	The argument value is passed from the callee to the caller. **Tags:** atp.EnumerationValue=2

Table D.20: ArgumentDirectionEnum

Enumeration	**ArraySizeSemanticsEnum**
Package	M2::AUTOSARTemplates::CommonStructure::ImplementationDataTypes
Note	This type controls how the information about the number of elements in an ApplicationArrayDataType is to be interpreted.
Literal	***Description***
fixedSize	This means that the ApplicationArrayDataType will always have a fixed number of elements. **Tags:** atp.EnumerationValue=0
variableSize	This implies that the actual number of elements in the ApplicationArrayDataType might vary at run-time. The value of arraySize represents the maximum number of elements in the array. **Tags:** atp.EnumerationValue=1

Table D.21: ArraySizeSemanticsEnum

Class	**ArrayValueSpecification**			
Package	M2::AUTOSARTemplates::CommonStructure::Constants			
Note	Specifies the values for an array.			
Base	*ARObject*, *CompositeValueSpecification*, *ValueSpecification*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
element (ordered)	ValueSpecification	*	aggr	The value for a single array element. All Value Specifications aggregated by ArrayValueSpecification shall have the same structure. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.22: ArrayValueSpecification

Class	**AssemblySwConnector**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Composition			
Note	AssemblySwConnectors are exclusively used to connect SwComponentPrototypes in the context of a CompositionSwComponentType.			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*, *SwConnector*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
provider	AbstractProvidedPort Prototype	0..1	iref	Instance of providing port.
requester	AbstractRequiredPort Prototype	0..1	iref	Instance of requiring port.

Table D.23: AssemblySwConnector

Class	**AsynchronousServerCallPoint**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::ServerCall			
Note	An AsynchronousServerCallPoint is used for asynchronous invocation of a ClientServerOperation. IMPORTANT: a ServerCallPoint cannot be used concurrently. Once the client RunnableEntity has made the invocation, the ServerCallPoint cannot be used until the call returns (or an error occurs!) at which point the ServerCallPoint becomes available again.			
Base	*ARObject*, *AbstractAccessPoint*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*, *ServerCallPoint*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
–	–	–	–	–

Table D.24: AsynchronousServerCallPoint

Class	**AsynchronousServerCallResultPoint**
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::ServerCall
Note	If a RunnableEntity owns a AsynchronousServerCallResultPoint it is entitled to get the result of the referenced AsynchronousServerCallPoint. If it is associated with AsynchronousServerCallReturnsEvent, this RTEEvent notifies the completion of the required ClientServerOperation or a timeout. The occurrence of this event can either unblock a Wait Point or can lead to the invocation of a RunnableEntity.
Base	*ARObject*, *AbstractAccessPoint*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*

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Class	**AsynchronousServerCallResultPoint**			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
asynchronous ServerCallPoint	AsynchronousServer CallPoint	1	ref	The referenced Asynchronous Server Call Point defines the asynchronous server call from which the results are returned.

Table D.25: AsynchronousServerCallResultPoint

Class	**AsynchronousServerCallReturnsEvent**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	This event is raised when an asynchronous server call is finished.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
eventSource	AsynchronousServer CallResultPoint	1	ref	The referenced AsynchronousServerCallResultPoint which is raises the RTEEvent in case of returning asynchronous server call.

Table D.26: AsynchronousServerCallReturnsEvent

Class	***AtomicSwComponentType*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	An atomic software component is atomic in the sense that it cannot be further decomposed and distributed across multiple ECUs.			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*, *SwComponentType*			
Subclasses	ApplicationSwComponentType, ComplexDeviceDriverSwComponentType, EcuAbstractionSwComponent Type, NvBlockSwComponentType, SensorActuatorSwComponentType, ServiceProxySwComponent Type, ServiceSwComponentType			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
internalBehavior	SwcInternalBehavior	0..1	aggr	The SwcInternalBehaviors owned by an AtomicSw ComponentType can be located in a different physical file. Therefore the aggregation is «atpSplitable». **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=internalBehavior, variationPoint.short Label vh.latestBindingTime=preCompileTime
symbolProps	SymbolProps	0..1	aggr	This represents the SymbolProps for the AtomicSw ComponentType. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=shortName

Table D.27: AtomicSwComponentType

Class	«atpMixedString» ***AttributeValueVariationPoint*** (abstract)
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling::AttributeValueVariationPoints
Note	This class represents the ability to derive the value of the Attribute from a system constant (by Sw SystemconstDependentFormula). It also provides a bindingTime.
Base	*ARObject*, *FormulaExpression*, *SwSystemconstDependentFormula*

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Class	«atpMixedString» ***AttributeValueVariationPoint*** (abstract)			
Subclasses	*AbstractEnumerationValueVariationPoint*, *AbstractNumericalVariationPoint*, BooleanValueVariationPoint, FloatValueVariationPoint, IntegerValueVariationPoint, PositiveIntegerValueVariationPoint, Unlimited IntegerValueVariationPoint			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
bindingTime	BindingTimeEnum	0..1	attr	This is the binding time in which the attribute value needs to be bound. If this attribute is missing, the attribute is not a variation point. In particular this means that It needs to be a single value according to the type specified in the pure model. It is an error if it is still a formula. **Tags:** xml.attribute=true
blueprintValue	String	0..1	attr	This represents a description that documents how the value shall be defined when deriving objects from the blueprint. **Tags:** xml.attribute=true
sd	String	0..1	attr	This special data is provided to allow synchronization of Attribute value variation points with variant management systems. The usage is subject of agreement between the involved parties. **Tags:** xml.attribute=true
shortLabel	PrimitiveIdentifier	0..1	attr	This allows to identify the variation point. It is also intended to allow RTE support for CompileTime Variation points. **Tags:** xml.attribute=true

Table D.28: AttributeValueVariationPoint

Class	***AutosarDataPrototype*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::DataPrototypes			
Note	Base class for prototypical roles of an AutosarDataType.			
Base	*ARObject*, *AtpFeature*, *AtpPrototype*, *DataPrototype*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	ArgumentDataPrototype, ParameterDataPrototype, VariableDataPrototype			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
type	AutosarDataType	1	tref	This represents the corresponding data type. **Stereotypes:** isOfType

Table D.29: AutosarDataPrototype

Class	***AutosarDataType*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::Datatypes			
Note	Abstract base class for user defined AUTOSAR data types for ECU software.			
Base	*ARElement*, *ARObject*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *Multilanguage Referrable*, *PackageableElement*, *Referrable*			
Subclasses	*AbstractImplementationDataType*, *ApplicationDataType*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
swDataDef Props	SwDataDefProps	0..1	aggr	The properties of this AutosarDataType.

Table D.30: AutosarDataType

Class	**BackgroundEvent**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	This event is used to trigger RunnableEntities that are supposed to be executed in the background.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
–	–	–	–	–

Table D.31: BackgroundEvent

Class	***BaseType*** (abstract)			
Package	M2::MSR::AsamHdo::BaseTypes			
Note	This abstract meta-class represents the ability to specify a platform dependant base type.			
Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *Packageable Element*, *Referrable*			
Subclasses	SwBaseType			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
baseType Definition	BaseTypeDefinition	1	aggr	This is the actual definition of the base type. **Tags:** xml.roleElement=false xml.roleWrapperElement=false xml.sequenceOffset=20 xml.typeElement=false xml.typeWrapperElement=false

Table D.32: BaseType

Class	**BaseTypeDirectDefinition**			
Package	M2::MSR::AsamHdo::BaseTypes			
Note	This BaseType is defined directly (as opposite to a derived BaseType)			
Base	*ARObject*, *BaseTypeDefinition*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
baseType Encoding	BaseTypeEncoding String	1	attr	This specifies, how an object of the current BaseType is encoded, e.g. in an ECU within a message sequence. **Tags:** xml.sequenceOffset=90
baseTypeSize	PositiveInteger	0..1	attr	Describes the length of the data type specified in the container in bits. **Tags:** xml.sequenceOffset=70
byteOrder	ByteOrderEnum	0..1	attr	This attribute specifies the byte order of the base type. **Tags:** xml.sequenceOffset=110
memAlignment	PositiveInteger	0..1	attr	This attribute describes the alignment of the memory object in bits. E.g. "8" specifies, that the object in question is aligned to a byte while "32" specifies that it is aligned four byte. If the value is set to "0" the meaning shall be interpreted as "unspecified". **Tags:** xml.sequenceOffset=100

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Class	BaseTypeDirectDefinition			

native Declaration	NativeDeclarationString	0..1	attr	This attribute describes the declaration of such a base type in the native programming language, primarily in the Programming language C. This can then be used by a code generator to include the necessary declarations into a header file. For example
				BaseType with
				`shortName: "MyUnsignedInt"`
				`nativeDeclaration: "unsigned short"`
				Results in
				`typedef unsigned short MyUnsignedInt;`
				If the attribute is not defined the referring Implementation DataTypes will not be generated as a typedef by RTE.
				If a nativeDeclaration type is given it shall fulfill the characteristic given by basetypeEncoding and baseType Size.
				This is required to ensure the consistent handling and interpretation by software components, RTE, COM and MCM systems.
				Tags: xml.sequenceOffset=120

Table D.33: BaseTypeDirectDefinition

Enumeration	**BindingTimeEnum**
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling
Note	This enumerator specifies the applicable binding times for the pre build variation points.
Literal	***Description***
codeGeneration Time	• Coding by hand, based on requirements document. • Tool based code generation, e.g. from a model. • The model may contain variants. • Only code for the selected variant(s) is actually generated. **Tags:** atp.EnumerationValue=0
linkTime	Configure what is included in object code, and what is omitted Based on which variant(s) are selected E.g. for modules that are delivered as object code (as opposed to those that are delivered as source code) **Tags:** atp.EnumerationValue=1
preCompileTime	This is typically the C-Preprocessor. Exclude parts of the code from the compilation process, e.g., because they are not required for the selected variant, because they are incompatible with the selected variant, because they require resources that are not present in the selected variant. Object code is only generated for the selected variant(s). The code that is excluded at this stage code will not be available at later stages. **Tags:** atp.EnumerationValue=2

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Enumeration	**BindingTimeEnum**
systemDesignTime	• Designing the VFB. • Software Component types (PortInterfaces). • SWC Prototypes and the Connections between SWCprototypes. • Designing the Topology • ECUs and interconnecting Networks • Designing the Communication Matrix and Data Mapping **Tags:** atp.EnumerationValue=3

Table D.34: BindingTimeEnum

Class	«atpMixedString» **BooleanValueVariationPoint**			
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling::AttributeValueVariationPoints			
Note	This class represents an attribute value variation point for Boolean attributes. Note that this class might be used in the extended meta-model on			
Base	*ARObject*, *AttributeValueVariationPoint*, *FormulaExpression*, *SwSystemconstDependentFormula*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
–	–	–	–	–

Table D.35: BooleanValueVariationPoint

Class	***BswApiOptions*** (abstract)			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	This meta-class represents the ability to define options for the definition of the signature of function prototypes.			
Base	*ARObject*			
Subclasses	BswClientPolicy, *BswDataReceptionPolicy*, BswDataSendPolicy, BswExclusiveAreaPolicy, BswInternalTriggeringPointPolicy, BswParameterPolicy, BswPerInstanceMemoryPolicy, BswReleasedTriggerPolicy			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
enableTakeAddress	Boolean	0..1	attr	If set to true, the BSW Module is able to use the API reference for deriving a pointer to an object

Table D.36: BswApiOptions

Class	**BswAsynchronousServerCallPoint**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	Represents an asynchronous procedure call point via the BSW Scheduler.			
Base	*ARObject*, *BswModuleCallPoint*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
calledEntry	BswModuleClientServerEntry	1	ref	The entry to be called.

Table D.37: BswAsynchronousServerCallPoint

Class	BswAsynchronousServerCallResultPoint			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	The callback point for an BswAsynchronousServerCallPoint i.e. the point at which the result can be retrieved from the BSW Scheduler.			
Base	*ARObject*, *BswModuleCallPoint*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
asynchronous ServerCallPoint	BswAsynchronous ServerCallPoint	1	ref	The call point invoking the call to which the result belongs.

Table D.38: BswAsynchronousServerCallResultPoint

Class	BswBackgroundEvent			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	A recurring BswEvent which is used to perform background activities. It is similar to a BswTimingEvent but has no fixed time period and is activated only with low priority.			
Base	*ARObject*, *AbstractEvent*, *BswEvent*, *BswScheduleEvent*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
–	–	–	–	–

Table D.39: BswBackgroundEvent

Class	BswCalledEntity			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	BSW module entity which is designed to be called from another BSW module or cluster.			
Base	*ARObject*, *BswModuleEntity*, *ExecutableEntity*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
–	–	–	–	–

Table D.40: BswCalledEntity

Class	BswDataReceivedEvent			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	This event is thrown on reception of the referenced data via Sender-Receiver-Communication over the BSW Scheduler.			
Base	*ARObject*, *AbstractEvent*, *BswEvent*, *BswScheduleEvent*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
data	VariableDataPrototype	1	ref	The received data.

Table D.41: BswDataReceivedEvent

Class	***BswDataReceptionPolicy*** (abstract)
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior
Note	Specifies the reception policy for the referred data in sender-receiver communication over the BSW Scheduler. To be used for inter-partition and/or inter-core communication.
Base	*ARObject*, *BswApiOptions*

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Class	***BswDataReceptionPolicy*** (abstract)			
Subclasses	BswQueuedDataReceptionPolicy			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
receivedData	VariableDataPrototype	1	ref	The data received over the BSW Scheduler using this policy.

Table D.42: BswDataReceptionPolicy

Class	***BswEvent*** (abstract)			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	Base class of various kinds of events which are used to trigger a BswModuleEntity of this BSW module or cluster. The event is local to the BSW module or cluster. The short name of the meta-class instance is intended as an input to configure the required API of the BSW Scheduler.			
Base	*ARObject*, *AbstractEvent*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	BswOperationInvokedEvent, *BswScheduleEvent*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
context Limitation	BswDistinguished Partition	*	ref	The existence of this reference indicates that the usage of the event is limited to the context of the referred Bsw DistinguishedPartitions.
disabledInMode	ModeDeclaration	*	iref	The modes, in which this event is disabled. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=disabledInMode
startsOnEvent	BswModuleEntity	1	ref	The entity which is started by the event.

Table D.43: BswEvent

Class	**BswExclusiveAreaPolicy**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	The ExclusiveArea for which the BSW Scheduler using this policy.			
Base	*ARObject*, *BswApiOptions*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
apiPrinciple	ApiPrincipleEnum	0..1	attr	Specifies for this ExclusiveArea if either one common set of Enter and Exit APIs for the whole BSW module is requested from the SchM or if the set of Enter and Exit APIs is expected per BswModuleEntity. The default value is "common".
exclusiveArea	ExclusiveArea	1	ref	The ExclusiveArea for which the BSW Scheduler using this policy.

Table D.44: BswExclusiveAreaPolicy

Enumeration	**BswExecutionContext**
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswInterfaces
Note	Specifies the execution context required or guaranteed for the call associated with this service.
Literal	***Description***
hook	Context of an OS "hook" routine always **Tags:** atp.EnumerationValue=0

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Enumeration	**BswExecutionContext**
interruptCat1	CAT1 interrupt context always **Tags:** atp.EnumerationValue=1
interruptCat2	CAT2 interrupt context always **Tags:** atp.EnumerationValue=2
task	Task context always **Tags:** atp.EnumerationValue=3
unspecified	The execution context is not specified by the API **Tags:** atp.EnumerationValue=4

Table D.45: BswExecutionContext

Class	**BswExternalTriggerOccurredEvent**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	A BswEvent resulting from a trigger released by another module or cluster.			
Base	*ARObject*, *AbstractEvent*, *BswEvent*, *BswScheduleEvent*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
trigger	Trigger	1	ref	The trigger associated with this event. The trigger is external to this module.

Table D.46: BswExternalTriggerOccurredEvent

Class	**BswImplementation**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswImplementation			
Note	Contains the implementation specific information in addition to the generic specification (BswModule Description and BswBehavior). It is possible to have several different BswImplementations referring to the same BswBehavior. **Tags:** atp.recommendedPackage=BswImplementations			
Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *Implementation*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
arRelease Version	RevisionLabelString	1	attr	Version of the AUTOSAR Release on which this implementation is based. The numbering contains three levels (major, minor, revision) which are defined by AUTOSAR.
behavior	BswInternalBehavior	1	ref	The behavior of this implementation. This relation is made as an association because • it follows the pattern of the SWCT • since ARElement cannot be splitted, but we want supply the implementation later, the Bsw Implementation is not aggregated in BswBehavior

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Class	**BswImplementation**			
preconfigured Configuration	EcucModule ConfigurationValues	*	ref	Reference to the set of preconfigured (i.e. fixed) configuration values for this BswImplementation. If the BswImplementation represents a cluster of several modules, more than one EcucModuleConfigurationValues element can be referred (at most one per module), otherwise at most one such element can be referred. **Tags:** xml.roleWrapperElement=true
recommended Configuration	EcucModule ConfigurationValues	*	ref	Reference to one or more sets of recommended configuration values for this module or module cluster.
vendorApiInfix	Identifier	0..1	attr	In driver modules which can be instantiated several times on a single ECU, SRS_BSW_00347 requires that the names of files, APIs, published parameters and memory allocation keywords are extended by the vendorId and a vendor specific name. This parameter is used to specify the vendor specific name. In total, the implementation specific API name is generated as follows: <ModuleName>_<vendorId>_ <vendorApiInfix>_<API name from SWS>. E.g. assuming that the vendorId of the implementer is 123 and the implementer chose a vendorApiInfix of "v11r456" an API name Can_Write defined in the SWS will translate to Can_123_v11r456_Write. This attribute is mandatory for all modules with upper multiplicity > 1. It shall not be used for modules with upper multiplicity =1. See also SWS_BSW_00102.
vendorSpecific ModuleDef	EcucModuleDef	*	ref	Reference to • the vendor specific EcucModuleDef used in this BswImplementation if it represents a single module • several EcucModuleDefs used in this Bsw Implementation if it represents a cluster of modules • one or no EcucModuleDefs used in this Bsw Implementation if it represents a library **Tags:** xml.roleWrapperElement=true

Table D.47: BswImplementation

Class	**BswInternalBehavior**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	Specifies the behavior of a BSW module or a BSW cluster w.r.t. the code entities visible by the BSW Scheduler. It is possible to have several different BswInternalBehaviors referring to the same BswModuleDescription.			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *InternalBehavior*, *Multilanguage Referrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***

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Class	**BswInternalBehavior**			
arTypedPer Instance Memory	VariableDataPrototype	*	aggr	Defines an AUTOSAR typed memory-block that needs to be available for each instance of the Basic Software Module. The aggregation of arTypedPerInstanceMemory is subject to variability with the purpose to support variability in the Basic Software Module's implementations. Typically different algorithms in the implementation are requiring different number of memory objects. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
bswPerInstance MemoryPolicy	BswPerInstance MemoryPolicy	*	aggr	Policy for a arTypedPerInstanceMemory The policy selects the options of the Schedule Manager API generation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
clientPolicy	BswClientPolicy	*	aggr	Policy for a requiredClientServerEntry. The policy selects the options of the Schedule Manager API generation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=clientPolicy, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
distinguished Partition	BswDistinguished Partition	*	aggr	Indicates an abstract partition context in which the enclosing BswModuleEntity can be executed. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.ShortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=60
entity	BswModuleEntity	*	aggr	A code entity for which the behavior is described **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=5
event	BswEvent	*	aggr	An event required by this module behavior. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=10
exclusiveArea Policy	BswExclusiveArea Policy	*	aggr	Policy for an ExclusiveArea in this BswInternalBehavior. The policy selects the options of the Schedule Manager API generation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=exclusiveAreaPolicy, variation Point.shortLabel vh.latestBindingTime=preCompileTime
includedData TypeSet	IncludedDataTypeSet	*	aggr	The includedDataTypeSet is used by a basic software module for its implementation. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=includedDataTypeSet

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Class	BswInternalBehavior			
internal TriggeringPoint	BswInternalTriggering Point	*	aggr	An internal triggering point. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=2
internal TriggeringPoint Policy	BswInternalTriggering PointPolicy	*	aggr	Policy for an internalTriggeringPoint in this BswInternal Behavior.. The policy selects the options of the Schedule Manager API generation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=internalTriggeringPointPolicy, variation Point.shortPoint vh.latestBindingTime=preCompileTime
modeReceiver Policy	BswModeReceiver Policy	*	aggr	Implementation policy for the reception of mode switches. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=modeReceiverPolicy, variation Point.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=25
modeSender Policy	BswModeSenderPolicy	*	aggr	Implementation policy for providing a mode group. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=modeSenderPolicy, variation Point.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=20
parameterPolicy	BswParameterPolicy	*	aggr	Policy for a perInstanceParameter in this BswInternal Behavior. The policy selects the options of the Schedule Manager API generation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=parameterPolicy, variatioPoint.short Label vh.latestBindingTime=preCompileTime
perInstance Parameter	ParameterData Prototype	*	aggr	Describes a read only memory object containing characteristic value(s) needed by this BswInternal Behavior. The role name perInstanceParameter is chosen in analogy to the similar role in the context of SwcInternal Behavior. In contrast to constantMemory, this object is not allocated locally by the module's code, but by the BSW Scheduler and it is accessed from the BSW module via the BSW Scheduler API. The main use case is the support of software emulation of calibration data. The aggregation is subject to variability with the purpose to support implementation variants. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=atp.Splitkey shortName, variation Point.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=45

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Class	BswInternalBehavior			
receptionPolicy	BswDataReception Policy	*	aggr	Data reception policy for inter-partition and/or inter-core communication. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=receptionPolicy, variationPoint.short Label vh.latestBindingTime=preCompileTime xml.sequenceOffset=55
releasedTrigger Policy	BswReleasedTrigger Policy	*	aggr	Policy for a releasedTrigger. The policy selects the options of the Schedule Manager API generation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=releasedTriggerPolicy, variation Point.shortLabel vh.latestBindingTime=preCompileTime
schedulerName Prefix	BswSchedulerName Prefix	*	aggr	Optional definition of one or more prefixes to be used for the BswScheduler. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=schedulerNamePrefix, variation Point.ShortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=50
sendPolicy	BswDataSendPolicy	*	aggr	Policy for a providedData. The policy selects the options of the Schedule Manager API generation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=sendPolicy, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
service Dependency	BswService Dependency	*	aggr	Defines the requirements on AUTOSAR Services for a particular item. The aggregation is subject to variability with the purpose to support the conditional existence of ServiceNeeds. The aggregation is splitable in order to support that ServiceNeeds might be provided in later development steps. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=serviceDependency, variation Point.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=40
triggerDirect Implementation	BswTriggerDirect Implementation	*	aggr	Specifies a trigger to be directly implemented via OS calls. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=triggerDirectImplementation, variation Point.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=15
variationPoint Proxy	VariationPointProxy	*	aggr	Proxy of a variation points in the C/C++ implementation. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=shortName

Table D.48: BswInternalBehavior

Class	**BswInternalTriggerOccurredEvent**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	A BswEvent, which can happen sporadically. The event is activated by explicit calls from the module to the BSW Scheduler. The main purpose for such an event is to cause a context switch, e.g. from an ISR context into a task context. Activation and switching are handled within the same module or cluster only.			
Base	*ARObject*, *AbstractEvent*, *BswEvent*, *BswScheduleEvent*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
eventSource	BswInternalTriggeringPoint	1	ref	The activation point is the source of this event.

Table D.49: BswInternalTriggerOccurredEvent

Class	**BswInternalTriggeringPoint**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	Represents the activation point for one or more BswInternalTriggerOccurredEvents.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
swImplPolicy	SwImplPolicyEnum	0..1	attr	This attribute, when set to value queued, specifies a queued processing of the internal trigger event.

Table D.50: BswInternalTriggeringPoint

Class	**BswInterruptEntity**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	BSW module entity, which is designed to be triggered by an interrupt.			
Base	*ARObject*, *BswModuleEntity*, *ExecutableEntity*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
interruptCategory	BswInterruptCategory	1	attr	Category of the interrupt
interruptSource	String	1	attr	Allows a textual documentation of the intended interrupt source.

Table D.51: BswInterruptEntity

Class	**BswModeReceiverPolicy**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	Specifies the details for the reception of a mode switch for the referred mode group.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
enhancedModeApi	Boolean	0..1	attr	This controls the creation of the enhanced mode API that returns information about the previous mode and the next mode. If set to TRUE the enhanced mode API is supposed to be generated. For more details please refer to the SWS_RTE.
requiredModeGroup	ModeDeclarationGroupPrototype	1	ref	The required mode group for which the policy is specified.

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Class	BswModeReceiverPolicy			
supports Asynchronous ModeSwitch	Boolean	1	attr	Specifies whether the module can handle the reception of an asynchronous mode switch (true) or not (false).

Table D.52: BswModeReceiverPolicy

Class	**BswModeSenderPolicy**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	Specifies the details for the sending of a mode switch for the referred mode group.			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
ackRequest	BswModeSwitchAck Request	0..1	aggr	Request for acknowledgement
enhancedMode Api	Boolean	0..1	attr	This controls the creation of the enhanced mode API that returns information about the previous mode and the next mode. If set to TRUE the enhanced mode API is supposed to be generated. For more details please refer to the SWS_RTE.
providedMode Group	ModeDeclarationGroup Prototype	1	ref	The provided mode group for which the policy is specified.
queueLength	PositiveInteger	1	attr	Length of call queue on the sender side. The queue is implemented by the RTE resp.BswScheduler. The value must be greater or equal to 0. Setting the value of queue Length to 0 implies non-queued communication.

Table D.53: BswModeSenderPolicy

Class	**BswModeSwitchAckRequest**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	Requests acknowledgements that a mode switch has been processed successfully			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
timeout	TimeValue	1	attr	Number of seconds before an error is reported.

Table D.54: BswModeSwitchAckRequest

Class	**BswModeSwitchEvent**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	A BswEvent resulting from a mode switch.			
Base	*ARObject*, *AbstractEvent*, *BswEvent*, *BswScheduleEvent*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
activation	ModeActivationKind	1	attr	Kind of activation w.r.t. to the referred mode.
mode (ordered)	ModeDeclaration	1..2	iref	Reference to one or two Modes that initiate the Mode Switch Event.

Table D.55: BswModeSwitchEvent

Class	**BswModeSwitchedAckEvent**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	The event is raised after a switch of the referenced mode group has been acknowledged or an error occurs. The referenced mode group must be provided by this module.			
Base	*ARObject*, *AbstractEvent*, *BswEvent*, *BswScheduleEvent*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
modeGroup	ModeDeclarationGroup Prototype	1	ref	A mode group provided by this module. The acknowledgement of a switch of this group raises this event.

Table D.56: BswModeSwitchedAckEvent

Class	***BswModuleCallPoint*** (abstract)			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	Represents a point at which a BswModuleEntity handles a procedure call into a BswModuleEntry, either directly or via the BSW Scheduler.			
Base	*ARObject*, *Referrable*			
Subclasses	BswAsynchronousServerCallPoint, BswAsynchronousServerCallResultPoint, BswDirectCallPoint, Bsw SynchronousServerCallPoint			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
context Limitation	BswDistinguished Partition	*	ref	The existence of this reference indicates that the call point is used only in the context of the referred Bsw DistinguishedPartitions.

Table D.57: BswModuleCallPoint

Class	**BswModuleClientServerEntry**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswInterfaces			
Note	This meta-class represents a single API entry into the BSW module or cluster that has the ability to be called in client-server fashion via the BSW Scheduler. In this regard it is more special than BswModuleEntry and can be seen as a wrapper around the Bsw ModuleEntry to which it refers (property encapsulatedEntry). **Tags:** atp.recommendedPackage=BswModuleEntrys			
Base	*ARObject*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
encapsulated Entry	BswModuleEntry	1	ref	The underlying BswModuleEntry. **Tags:** xml.sequenceOffset=5
isReentrant	Boolean	0..1	attr	Reentrancy from the viewpoint of clients invoking the service via the BSW Scheduler: • True: Enables the service to be invoked again, before the service has finished. • False: It is prohibited to invoke the service again before is has finished. **Tags:** xml.sequenceOffset=10

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Class	BswModuleClientServerEntry			
isSynchronous	Boolean	0..1	attr	Synchronicity from the viewpoint of clients invoking the service via the BSW Scheduler: • True: This calls a synchronous service, i.e. the service is completed when the call returns. • False: The service (on semantical level) may not be complete when the call returns. **Tags:** xml.sequenceOffset=15

Table D.58: BswModuleClientServerEntry

Class	BswModuleDependency			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswInterfaces			
Note	This class collects the dependencies of a BSW module or cluster on a certain other BSW module.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
serviceItem	ServiceNeeds	*	aggr	A single item (example: Nv block) for which the quality of a service is defined. The aggregation is marked as «atpSplitable» to allow for extension during the ECU configuration process. This association is deprecated since R4.0.3, since ServiceNeeds shall be associated with the new element BswServiceDependency within the BswInternalBehavior. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=shortName atp.Status=removed xml.sequenceOffset=20
targetModuleId	PositiveInteger	0..1	attr	AUTOSAR identifier of the target module of which the dependencies are defined. This information is optional, because the target module may also be identified by targetModuleRef. **Tags:** xml.sequenceOffset=5
targetModule Ref	BswModuleDescription	0..1	ref	Reference to the target module. It is an «atpUriDef» because the reference shall be used to identify the target module without actually needing the description of that target module. **Stereotypes:** atpUriDef; atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.sequenceOffset=7

Table D.59: BswModuleDependency

Class	BswModuleDescription
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswOverview
Note	Root element for the description of a single BSW module or BSW cluster. In case it describes a BSW module, the short name of this element equals the name of the BSW module. **Tags:** atp.recommendedPackage=BswModuleDescriptions
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*

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Class	BswModuleDescription			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
bswModuleDependency	BswModuleDependency	*	aggr	Describes the dependency to another BSW module. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=20
bswModuleDocumentation	SwComponentDocumentation	0..1	aggr	This adds a documentation to the BSW module. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=bswModuleDocumentation, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=6
expectedEntry	BswModuleEntry	*	ref	Indicates an entry which is required by this module. Replacement of outgoingCallback / requiredEntry. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=expectedEntry, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
implementedEntry	BswModuleEntry	*	ref	Specifies an entry provided by this module which can be called by other modules. This includes "main" functions, interrupt routines, and callbacks. Replacement of providedEntry / expectedCallback. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=implementedEntry, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
internalBehavior	BswInternalBehavior	*	aggr	The various BswInternalBehaviors associated with a BswModuleDescription can be distributed over several physical files. Therefore the aggregation is «atpSplitable». **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=shortName xml.sequenceOffset=65
moduleId	PositiveInteger	0..1	attr	Refers to the BSW Module Identifier defined by the AUTOSAR standard. For non-standardized modules, a proprietary identifier can be optionally chosen. **Tags:** xml.sequenceOffset=5
providedClientServerEntry	BswModuleClientServerEntry	*	aggr	Specifies that this module provides a client server entry which can be called from another parition or core.This entry is declared locally to this context and will be connected to the requiredClientServerEntry of another or the same module via the configuration of the BSW Scheduler. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=45
providedData	VariableDataPrototype	*	aggr	Specifies a data prototype provided by this module in order to be read from another partition or core.The providedData is declared locally to this context and will be connected to the requiredData of another or the same module via the configuration of the BSW Scheduler. ▽

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Class	BswModuleDescription			
				△ **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=55
providedMode Group	ModeDeclarationGroup Prototype	*	aggr	A set of modes which is owned and provided by this module or cluster. It can be connected to the required ModeGroups of other modules or clusters via the configuration of the BswScheduler. It can also be synchronized with modes provided via ports by an associated ServiceSwComponentType, EcuAbstraction SwComponentType or ComplexDeviceDriverSw ComponentType. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=25
releasedTrigger	Trigger	*	aggr	A Trigger released by this module or cluster. It can be connected to the requiredTriggers of other modules or clusters via the configuration of the BswScheduler. It can also be synchronized with Triggers provided via ports by an associated ServiceSwComponentType, Ecu AbstractionSwComponentType or ComplexDeviceDriver SwComponentType. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=35
requiredClient ServerEntry	BswModuleClientServer Entry	*	aggr	Specifies that this module requires a client server entry which can be implemented on another parition or core.This entry is declared locally to this context and will be connected to the providedClientServerEntry of another or the same module via the configuration of the BSW Scheduler. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=50
requiredData	VariableDataPrototype	*	aggr	Specifies a data prototype required by this module in oder to be provided from another partition or core.The required Data is declared locally to this context and will be connected to the providedData of another or the same module via the configuration of the BswScheduler. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=60
requiredMode Group	ModeDeclarationGroup Prototype	*	aggr	Specifies that this module or cluster depends on a certain mode group. The requiredModeGroup is local to this context and will be connected to the providedModeGroup of another module or cluster via the configuration of the BswScheduler. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=30

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Class	**BswModuleDescription**			
requiredTrigger	Trigger	*	aggr	Specifies that this module or cluster reacts upon an external trigger.This requiredTrigger is declared locally to this context and will be connected to the providedTrigger of another module or cluster via the configuration of the BswScheduler. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=40

Table D.60: BswModuleDescription

Class	***BswModuleEntity*** (abstract)			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	Specifies the smallest code fragment which can be described for a BSW module or cluster within AUTOSAR.			
Base	*ARObject*, *ExecutableEntity*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	BswCalledEntity, BswInterruptEntity, BswSchedulableEntity			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
accessedModeGroup	ModeDeclarationGroupPrototype	*	ref	A mode group which is accessed via API call by this entity. It must be a ModeDeclarationGroupPrototype required by this module or cluster. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
activationPoint	BswInternalTriggeringPoint	*	ref	Activation point used by the module entity to activate one or more internal triggers. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
callPoint	BswModuleCallPoint	*	aggr	A call point used in the code of this entitiy. The variablity of this association is especially targeted at debug scenarios: It is possible to have one variant calling into the AUTOSAR debug module and another one which doesn't. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
calledEntry	BswModuleEntry	*	ref	The entry of another (or the same) BSW module which is called by this entry (usually via C function call). This information allows to set up a model of call chains. The variablity of this association is especially targeted at debug scenarios: It is possible to have one variant calling into the AUTOSAR debug module and another one which doesn't. Note that this relation has been merked as obsolete, since the more powerful definition of a callPoint should be used. **Stereotypes:** atpVariation **Tags:** atp.Status=removed vh.latestBindingTime=preCompileTime
dataReceivePoint	BswVariableAccess	*	aggr	The data is received via the BSW Scheduler. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

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Class	BswModuleEntity (abstract)			
dataSendPoint	BswVariableAccess	*	aggr	The data is sent via the BSW Scheduler. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
implemented Entry	BswModuleEntry	1	ref	The entry which is implemented by this module entity.
issuedTrigger	Trigger	*	ref	A trigger issued by this entity via BSW Scheduler API call. It must be a BswTrigger released (i.e. owned) by this module or cluster. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
managedMode Group	ModeDeclarationGroup Prototype	*	ref	A mode group which is managed by this entity. It must be a ModeDeclarationGroupPrototype provided by this module or cluster. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
schedulerName Prefix	BswSchedulerName Prefix	0..1	ref	A prefix to be used in generated names for the Bsw ModuleScheduler in the context of this BswModuleEntity, for example entry point prototypes, macros for dealing with exclusive areas, header file names. Details are defined in the SWS RTE. The prefix supersedes default rules for the prefix of those names.

Table D.61: BswModuleEntity

Class	BswModuleEntry			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswInterfaces			
Note	This class represents a single API entry (C-function prototype) into the BSW module or cluster. The name of the C-function is equal to the short name of this element with one exception: In case of multiple instances of a module on the same CPU, special rules for "infixes" apply, see description of class BswImplementation. **Tags:** atp.recommendedPackage=BswModuleEntrys			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *CollectableElement*, *Identifiable*, *Multilanguage Referrable*, *PackageableElement*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
argument (or-dered)	SwServiceArg	*	aggr	An argument belonging to this BswModuleEntry. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=blueprintDerivationTime xml.sequenceOffset=45
bswEntryKind	BswEntryKindEnum	0..1	attr	This describes whether the entry is concrete or abstract. If the attribute is missing the entry is considered as concrete. **Tags:** xml.sequenceOffset=40
callType	BswCallType	1	attr	The type of call associated with this service. **Tags:** xml.sequenceOffset=25
execution Context	BswExecutionContext	1	attr	Specifies the execution context which is required (in case of entries into this module) or guaranteed (in case of entries called from this module) for this service. **Tags:** xml.sequenceOffset=30

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Class	**BswModuleEntry**			
function Prototype Emitter	NameToken	0..1	attr	This attribute is used to control the generation of function prototypes. If set to "RTE", the RTE generates the function prototypes in the Module Interlink Header File.
isReentrant	Boolean	1	attr	Reentrancy from the viewpoint of function callers: • True: Enables the service to be invoked again, before the service has finished. • False: It is prohibited to invoke the service again before is has finished. **Tags:** xml.sequenceOffset=15
isSynchronous	Boolean	1	attr	Synchronicity from the viewpoint of function callers: • True: This calls a synchronous service, i.e. the service is completed when the call returns. • False: The service (on semantical level) may not be complete when the call returns. **Tags:** xml.sequenceOffset=20
returnType	SwServiceArg	0..1	aggr	The return type belonging to this bswModuleEntry. **Tags:** xml.sequenceOffset=40
role	Identifier	0..1	attr	Specifies the role of the entry in the given context. It shall be equal to the standardized name of the service call, especially in cases where no ServiceIdentifier is specified, e.g. for callbacks. Note that the ShortName is not always sufficient because it maybe vendor specific (e.g. for callbacks which can have more than one instance). **Tags:** xml.sequenceOffset=10
serviceId	PositiveInteger	0..1	attr	Refers to the service identifier of the Standardized Interfaces of AUTOSAR basic software. For non-standardized interfaces, it can optionally be used for proprietary identification. **Tags:** xml.sequenceOffset=5
swServiceImpl Policy	SwServiceImplPolicy Enum	1	attr	Denotes the implementation policy as a standard function call, inline function or macro. This has to be specified on interface level because it determines the signature of the call. **Tags:** xml.sequenceOffset=35

Table D.62: BswModuleEntry

Class	**BswOperationInvokedEvent**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	This event is thrown on operation invocation in Client-Server-Communication via the BSW Scheduler. Its "entry" reference provides the BswClientServerEntry that is called subsequently. Note this event is not needed in case of direct function calls.			
Base	*ARObject*, *AbstractEvent*, *BswEvent*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
entry	BswModuleClientServer Entry	1	ref	The providedClientServerEntry invoked by this event.

Table D.63: BswOperationInvokedEvent

Class	**BswQueuedDataReceptionPolicy**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	Reception policy attributes specific for queued receiving.			
Base	*ARObject*, *BswApiOptions*, *BswDataReceptionPolicy*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
queueLength	PositiveInteger	1	attr	Length of queue for received events.

Table D.64: BswQueuedDataReceptionPolicy

Class	**BswSchedulableEntity**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	BSW module entity, which is designed for control by the BSW Scheduler. It may for example implement a so-called "main" function.			
Base	*ARObject*, *BswModuleEntity*, *ExecutableEntity*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
–	–	–	–	–

Table D.65: BswSchedulableEntity

Class	***BswScheduleEvent*** (abstract)			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	BswEvent that is able to start a BswSchedulabeEntity.			
Base	*ARObject*, *AbstractEvent*, *BswEvent*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	BswAsynchronousServerCallReturnsEvent, BswBackgroundEvent, BswDataReceivedEvent, BswExternalTriggerOccurredEvent, BswInternalTriggerOccurredEvent, BswModeManagerErrorEvent, BswModeSwitchEvent, BswModeSwitchedAckEvent, BswTimingEvent			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
–	–	–	–	–

Table D.66: BswScheduleEvent

Class	**BswSchedulerNamePrefix**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	A prefix to be used in names of generated code artifacts which make up the interface of a BSW module to the BswScheduler.			
Base	*ARObject*, *ImplementationProps*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
–	–	–	–	–

Table D.67: BswSchedulerNamePrefix

Class	**BswSynchronousServerCallPoint**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	Represents a synchronous procedure call point via the BSW Scheduler.			
Base	*ARObject*, *BswModuleCallPoint*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***

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Class	BswSynchronousServerCallPoint			
calledEntry	BswModuleClientServerEntry	1	ref	The entry to be called.
calledFromWithinExclusiveArea	ExclusiveAreaNestingOrder	0..1	ref	This indicates that the call point is located at the deepest level inside one or more ExclusiveAreas that are nested in the given order.

Table D.68: BswSynchronousServerCallPoint

Class	**BswTimingEvent**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	A recurring BswEvent driven by a time period.			
Base	*ARObject*, *AbstractEvent*, *BswEvent*, *BswScheduleEvent*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
period	TimeValue	1	attr	Requirement for the time period (in seconds) by which this event is triggered.

Table D.69: BswTimingEvent

Class	**BswTriggerDirectImplementation**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	Specifies a released trigger to be directly implemented via OS calls, for example in a Complex Driver module.			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
masteredTrigger	Trigger	1	ref	The trigger which is directly mastered by this module. There may be several different BswTriggerDirectImplementations mastering the same Trigger. This may be required e.g. due to memory partitioning.
task	Identifier	1	attr	The name of the OS task, which is controlled by the referred trigger. This means, that the module uses the trigger condition to directly activate an OS task instead of calling an API of the BswScheduler. The task name is required by the RTE generator resp. BswScheduler to raise the appropriate events in components or modules receiving the trigger.

Table D.70: BswTriggerDirectImplementation

Class	**BswVariableAccess**			
Package	M2::AUTOSARTemplates::BswModuleTemplate::BswBehavior			
Note	The presence of a BswVariableAccess implies that a BswModuleEntity needs access to a VariableDataPrototype via the BSW Scheduler. The kind of access is specified by the role in which the class is used.			
Base	*ARObject*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
accessedVariable	VariableDataPrototype	1	ref	The data accessed via the BSW Scheduler.

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Class	**BswVariableAccess**			
context Limitation	BswDistinguished Partition	*	ref	The existence of this reference indicates that the variable is recevied resp. sent only in the context of the referred BswDistinguishedPartitions.

Table D.71: BswVariableAccess

Class	**BufferProperties**			
Package	M2::AUTOSARTemplates::SystemTemplate::Transformer			
Note	Configuration of the buffer properties the transformer needs to work.			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
buffer Computation	CompuScale	0..1	aggr	If the transformer changes the size of the data, the CompuScale can be used to specify a rule to derive the size of the output data based on the size of the input data.
headerLength	Integer	1	attr	Defines the length of the header (in bits) this transformer will add in front of the data.
inPlace	Boolean	1	attr	If set, the transformer uses the input buffer as output buffer.

Table D.72: BufferProperties

Enumeration	**CSTransformerErrorReactionEnum**
Package	M2::AUTOSARTemplates::SystemTemplate::Transformer
Note	Possible kinds of error reaction in case of a hard transformer error.
Literal	*Description*
applicationOnly	The application is responsible for any error reaction. No autonomous error reaction of RTE and transformer. **Tags:** atp.EnumerationValue=0
autonomous	RTE and Transformer coordinate an autonomous error reaction on their own. **Tags:** atp.EnumerationValue=1

Table D.73: CSTransformerErrorReactionEnum

Class	**CalibrationParameterValue**
Package	M2::AUTOSARTemplates::SWComponentTemplate::MeasurementAndCalibration::CalibrationParameter Values
Note	Specifies instance specific calibration parameter values used to initialize the memory objects implementing calibration parameters in the generated RTE code. RTE generator will use the implInitValue to override the initial values specified for the DataPrototypes of a component type. The applInitValue is used to exchange init values with the component vendor not publishing the transformation algorithm between ApplicationDataTypes and ImplementationDataTypes or defining an instance specific initialization of components which are only defined with ApplicationDataTypes. Note: If both representations of init values are available these need to represent the same content. Note further that in this case an explicit mapping of ValueSpecification is not implemented because calibration parameters are delivered back after the calibration phase.
Base	*ARObject*

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Class	CalibrationParameterValue			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
applInitValue	ValueSpecification	0..1	aggr	This is the initial value specification structured according to the ApplicationDataType
implInitValue	ValueSpecification	0..1	aggr	This is the initial value specification structured according to the ImplementationDataType
initialized Parameter	FlatInstanceDescriptor	1	ref	This represents the parameter that is initialized by the CalibrationParameterValue.

Table D.74: CalibrationParameterValue

Class	ClientIdDefinition			
Package	M2::AUTOSARTemplates::SystemTemplate			
Note	Several clients in one client-ECU can communicate via inter-ECU client-server communication with a server on a different ECU, if a client identifier is used to distinguish the different clients. The Client Identifier of the transaction handle that is used by the RTE can be defined by this element.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
clientId	Numerical	1	attr	The Client Identifier of the transaction handle used for an inter-ECU client server communication is defined by this attribute. If defined the RTE generator shall use this client Id.
clientServer Operation	ClientServerOperation	1	iref	Reference to the ClientServerOperation that is called by the client.

Table D.75: ClientIdDefinition

Class	ClientServerApplicationErrorMapping			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	This meta-class represents the ability to map ApplicationErrors onto each other.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
firstApplication Error	ApplicationError	1	ref	This represents the first ApplicationError in the context of the ClientServerApplicationErrorMapping.
second ApplicationError	ApplicationError	1	ref	This represents the second ApplicationError in the context of the ClientServerApplicationErrorMapping.

Table D.76: ClientServerApplicationErrorMapping

Class	ClientServerInterface			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	A client/server interface declares a number of operations that can be invoked on a server by a client. **Tags:** atp.recommendedPackage=PortInterfaces			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *PortInterface*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
operation	ClientServerOperation	1..*	aggr	ClientServerOperation(s) of this ClientServerInterface. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=blueprintDerivationTime

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Class	ClientServerInterface			
possibleError	ApplicationError	*	aggr	Application errors that are defined as part of this interface.

Table D.77: ClientServerInterface

Class	ClientServerInterfaceMapping			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	Defines the mapping of ClientServerOperations in context of two different ClientServerInterfaces.			
Base	*ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *Identifiable*, *MultilanguageReferrable*, *PortInterfaceMapping*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
errorMapping	ClientServerApplicationErrorMapping	*	aggr	Map two different ApplicationErrors defined in the context of two different ClientServerInterfaces.
operationMapping	ClientServerOperationMapping	1..*	aggr	Mapping of two ClientServerOperations in two different ClientServerInterfaces

Table D.78: ClientServerInterfaceMapping

Class	ClientServerOperation			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	An operation declared within the scope of a client/server interface.			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
argument (ordered)	ArgumentDataPrototype	*	aggr	An argument of this ClientServerOperation **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=blueprintDerivationTime
possibleError	ApplicationError	*	ref	Possible errors that may by raised by the referring operation.

Table D.79: ClientServerOperation

Class	ClientServerOperationMapping			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	Defines the mapping of two particular ClientServerOperations in context of two different ClientServerInterfaces.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
argumentMapping	DataPrototypeMapping	*	aggr	Defines the mapping of two particular ArgumentDataPrototypes with unequal names or unequal semantic (resolution or range) in context of Operations.
firstOperation	ClientServerOperation	1	ref	First to-be-mapped ClientServerOperation of a ClientServerInterface.
firstToSecondDataTransformation	DataTransformation	0..1	ref	This reference indicates that a DataTransformation is intended in the context of the ClientServerOperationMapping.
secondOperation	ClientServerOperation	1	ref	Second to-be-mapped ClientServerOperation of a ClientServerInterface.

Table D.80: ClientServerOperationMapping

Class	**ClientServerToSignalMapping**			
Package	M2::AUTOSARTemplates::SystemTemplate::DataMapping			
Note	This element maps the ClientServerOperation to call- and return-SystemSignals.			
Base	*ARObject*, *DataMapping*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
callSignal	SystemSignal	1	ref	Reference to the callSignal to which the IN and INOUT ArgumentDataPrototypes are mapped.
clientServer Operation	ClientServerOperation	1	iref	Reference to a ClientServerOperation, which is mapped to a call SystemSignal and a return SystemSignal.
returnSignal	SystemSignal	0..1	ref	Reference to the returnSignal to which the OUT and INOUT ArgumentDataPrototypes are mapped. **Tags:** atp.Status=shallBecomeMandatory

Table D.81: ClientServerToSignalMapping

Class	**Code**			
Package	M2::AUTOSARTemplates::CommonStructure::Implementation			
Note	A generic code descriptor. The type of the code (source or object) is defined via the category attribute of the associated engineering object.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
artifact Descriptor	AutosarEngineering Object	1..*	aggr	Refers to the artifact belonging to this code descriptor.
callbackHeader	ServiceNeeds	*	ref	The association callbackHeader describes in which header files the function declarations of callback functions are provided to a service module. With this information the service module can include the appropriate header files in its configuration files.

Table D.82: Code

Class	**ComplexDeviceDriverSwComponentType**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	The ComplexDeviceDriverSwComponentType is a special AtomicSwComponentType that has direct access to hardware on an ECU and which is therefore linked to a specific ECU or specific hardware. The ComplexDeviceDriverSwComponentType introduces the possibility to link from the software representation to its hardware description provided by the ECU Resource Template. **Tags:** atp.recommendedPackage=SwComponentTypes			
Base	*ARElement*, *ARObject*, *AtomicSwComponentType*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *Atp Type*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*, *Sw ComponentType*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
hardware Element	HwDescriptionEntity	*	ref	Reference from the ComplexDeviceDriverSwComponent Type to the description of the used HwElements.

Table D.83: ComplexDeviceDriverSwComponentType

Class	CompositionSwComponentType			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Composition			
Note	A CompositionSwComponentType aggregates SwComponentPrototypes (that in turn are typed by Sw ComponentTypes) as well as SwConnectors for primarily connecting SwComponentPrototypes among each others and towards the surface of the CompositionSwComponentType. By this means hierarchical structures of software-components can be created. **Tags:** atp.recommendedPackage=SwComponentTypes			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*, *SwComponentType*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
component	SwComponent Prototype	*	aggr	The instantiated components that are part of this composition. The aggregation of SwComponentPrototype is subject to variability with the purpose to support the conditional existence of a SwComponentPrototype. Please be aware: if the conditional existence of SwComponentPrototypes is resolved post-build the deselected SwComponent Prototypes are still contained in the ECUs build but the instances are inactive in in that they are not scheduled by the RTE. The aggregation is marked as atpSplitable in order to allow the addition of service components to the ECU extract during the ECU integration. The use case for having 0 components owned by the CompositionSwComponentType could be to deliver an empty CompositionSwComponentType to e.g. a supplier for filling the internal structure. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=postBuild
connector	SwConnector	*	aggr	SwConnectors have the principal ability to establish a connection among PortPrototypes. They can have many roles in the context of a CompositionSwComponentType. Details are refined by subclasses. The aggregation of SwConnectors is subject to variability with the purpose to support variant data flow. The aggregation is marked as atpSplitable in order to allow the extension of the ECU extract with AssemblySw Connectors between ApplicationSwComponentTypes and ServiceSwComponentTypes during the ECU integration. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=postBuild
constantValue Mapping	ConstantSpecification MappingSet	*	ref	Reference to the ConstantSpecificationMapping to be applied for initValues of PPortComSpecs and RPortCom Spec. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=constantValueMapping
dataType Mapping	DataTypeMappingSet	*	ref	Reference to the DataTypeMapping to be applied for the used ApplicationDataTypes in PortInterfaces. Background: when developing subsystems it may happen that ApplicationDataTypes are used on the surface of CompositionSwComponentTypes. In this case it would be reasonable to be able to also provide the intended ▽

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Class	CompositionSwComponentType			
				△ mapping to the ImplementationDataTypes. However, this mapping shall be informal and not technically binding for the implementers mainly because the RTE generator is not concerned about the CompositionSwComponent Types. Rationale: if the mapping of ApplicationDataTypes on the delegated and inner PortPrototype matches then the mapping to ImplementationDataTypes is not impacting compatibility. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=dataTypeMapping
instantiation RTEEventProps	InstantiationRTEEvent Props	*	aggr	This allows to define instantiation specific properties for RTE Events, in particular for instance specific scheduling. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortLabel, variationPoint.shortLabel vh.latestBindingTime=codeGenerationTime

Table D.84: CompositionSwComponentType

Class	**CompuConst**			
Package	M2::MSR::AsamHdo::ComputationMethod			
Note	This meta-class represents the fact that the value of a computation method scale is constant.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
compuConst ContentType	CompuConstContent	1	aggr	This is the actual content of the constant compu method scale. **Tags:** xml.roleElement=false xml.roleWrapperElement=false xml.sequenceOffset=10 xml.typeElement=false xml.typeWrapperElement=false

Table D.85: CompuConst

Class	**CompuMethod**			
Package	M2::MSR::AsamHdo::ComputationMethod			
Note	This meta-class represents the ability to express the relationship between a physical value and the mathematical representation. Note that this is still independent of the technical implementation in data types. It only specifies the formula how the internal value corresponds to its physical pendant. **Tags:** atp.recommendedPackage=CompuMethods			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *CollectableElement*, *Identifiable*, *Multilanguage Referrable*, *PackageableElement*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
compuInternal ToPhys	Compu	0..1	aggr	This specifies the computation from internal values to physical values. **Tags:** xml.sequenceOffset=80
compuPhysTo Internal	Compu	0..1	aggr	This represents the computation from physical values to the internal values. **Tags:** xml.sequenceOffset=90

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Class	**CompuMethod**			
displayFormat	DisplayFormatString	0..1	attr	This property specifies, how the physical value shall be displayed e.g. in documents or measurement and calibration tools. **Tags:** xml.sequenceOffset=20
unit	Unit	0..1	ref	This is the physical unit of the Physical values for which the CompuMethod applies. **Tags:** xml.sequenceOffset=30

Table D.86: CompuMethod

Class	**CompuNominatorDenominator**			
Package	M2::MSR::AsamHdo::ComputationMethod			
Note	This class represents the ability to express a polynomial either as Nominator or as Denominator.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
v (ordered)	Numerical	*	attr	this is the list of polynomial factors. Note that the first vf represents the power=0. The polynomial is v[0] * x0̂ + v[1] * x1̂ ... **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.roleElement=true xml.roleWrapperElement=false xml.sequenceOffset=20 xml.typeElement=false xml.typeWrapperElement=false

Table D.87: CompuNominatorDenominator

Class	**CompuRationalCoeffs**			
Package	M2::MSR::AsamHdo::ComputationMethod			
Note	This meta-class represents the ability to express a rational function by specifying the coefficients of nominator and denominator.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
compu Denominator	CompuNominator Denominator	1	aggr	This is the denominator of the expression. **Tags:** xml.sequenceOffset=30
compu Numerator	CompuNominator Denominator	1	aggr	This is the numerator of the rational expression. **Tags:** xml.sequenceOffset=20

Table D.88: CompuRationalCoeffs

Class	**CompuScale**			
Package	M2::MSR::AsamHdo::ComputationMethod			
Note	This meta-class represents the ability to specify one segment of a segmented computation method.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***

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Class	**CompuScale**			
desc	MultiLanguageOverview Paragraph	0..1	aggr	<desc> represents a general but brief description of the object in question. **Tags:** xml.sequenceOffset=30
compuInverse Value	CompuConst	0..1	aggr	This is the inverse value of the constraint. This supports the case that the scale is not reversible per se. **Tags:** xml.sequenceOffset=60
compuScale Contents	CompuScaleContents	0..1	aggr	This represents the computation details of the scale. **Tags:** xml.roleElement=false xml.roleWrapperElement=false xml.sequenceOffset=70 xml.typeElement=false xml.typeWrapperElement=false
lowerLimit	Limit	0..1	attr	This specifies the lower limit of the scale. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.sequenceOffset=40
mask	PositiveInteger	0..1	attr	In difference to all the other computational methods every COMPU-SCALE will be applied including the bit MASK. Therefore it is allowed for this type of COMPU-METHOD, that COMPU-SCALES overlap. To calculate the string reverse to a value, the string has to be split and the according value for each substring has to be summed up. The sum is finally transmitted. The processing has to be done in order of the COMPU-SCALE elements. **Tags:** xml.sequenceOffset=35
shortLabel	Identifier	0..1	attr	This element specifies a short name for the particular scale. The name can for example be used to derive a programming language identifier. **Tags:** xml.sequenceOffset=20
symbol	CIdentifier	0..1	attr	The symbol, if provided, is used by code generators to get a C identifier for the CompuScale. The name will be used as is for the code generation, therefore it needs to be unique within the generation context. **Tags:** xml.sequenceOffset=25
upperLimit	Limit	0..1	attr	This specifies the upper limit of a of the scale. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.sequenceOffset=50

Table D.89: CompuScale

Class	**CompuScaleConstantContents**			
Package	M2::MSR::AsamHdo::ComputationMethod			
Note	This meta-class represents the fact that a particular scale of the computation method is constant.			
Base	*ARObject*, *CompuScaleContents*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
compuConst	CompuConst	1	aggr	This represents the fact that the scale is a constant. The use case is mainly a non interplolated scale. It is a simplification of the fact that a constant scale can also be expressed as Rational Function of oder 0. **Tags:** xml.sequenceOffset=90

Table D.90: CompuScaleConstantContents

Class	CompuScales			
Package	M2::MSR::AsamHdo::ComputationMethod			
Note	This meta-class represents the ability to stepwise express a computation method.			
Base	*ARObject*, *CompuContent*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
compu Scale (ordered)	CompuScale	*	aggr	This represents one scale within the compu method. Note that it contains a Variationpoint in order to support blueprints of enumerations. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=blueprintDerivationTime xml.roleElement=true xml.roleWrapperElement=true xml.sequenceOffset=40 xml.typeElement=false xml.typeWrapperElement=false

Table D.91: CompuScales

Class	«atpMixedString» ConditionByFormula			
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling			
Note	This class represents a condition which is computed based on system constants according to the specified expression. The expected result is considered as boolean value. The result of the expression is interpreted as a condition. • "0" represents "false"; • a value other than zero is considered "true"			
Base	*ARObject*, *FormulaExpression*, *SwSystemconstDependentFormula*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
bindingTime	BindingTimeEnum	1	attr	This attribute specifies the point in time when condition may be evaluated at earliest. At this point in time all referenced system constants shall have a value. **Tags:** xml.attribute=true

Table D.92: ConditionByFormula

Class	ConsistencyNeeds			
Package	M2::AUTOSARTemplates::SWComponentTemplate::ImplicitCommunicationBehavior			
Note	This meta-class represents the ability to define requirements on the implicit communication behavior.			
Base	*ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
dpgDoesNot Require Coherency	DataPrototypeGroup	*	aggr	This group of VariableDataPrototypes does not require coherency with respect to the implicit communication behavior. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime

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Class	ConsistencyNeeds			
dpgRequires Coherency	DataPrototypeGroup	*	aggr	This group of VariableDataPrototypes requires coherency with respect to the implicit communication behavior, i.e. all read and write access to VariableDataPrototypes in the DataPrototypeGroup by the RunnableEntitys of the RunnableEntityGroup need to be handled in a coherent manner. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
regDoesNot RequireStability	RunnableEntityGroup	*	aggr	This group of RunnableEntities does not require stability with respect to the implicit communication behavior. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
regRequires Stability	RunnableEntityGroup	*	aggr	This group of RunnableEntities requires stability with respect to the implicit communication behavior, i.e. all read and write access to VariableDataPrototypes in the DataPrototypeGroup by the RunnableEntitys of the RunnableEntityGroup need to be handled in a stable manner. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime

Table D.93: ConsistencyNeeds

Class	**ConstantSpecificationMapping**			
Package	M2::AUTOSARTemplates::CommonStructure::Constants			
Note	This meta-class is used to create an association of two ConstantSpecifications. One Constant Specification is supposed to be defined in the application domain while the other should be defined in the implementation domain. Hence the ConstantSpecificationMapping needs to be used where a ConstantSpecification defined in one domain needs to be associated to a ConstantSpecification in the other domain. This information is crucial for the RTE generator.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
applConstant	ConstantSpecification	1	ref	A ConstantSpecification defined in the application domain.
implConstant	ConstantSpecification	1	ref	A ConstantSpecification defined in the implementation domain.

Table D.94: ConstantSpecificationMapping

Class	**DataConstr**			
Package	M2::MSR::AsamHdo::Constraints::GlobalConstraints			
Note	This meta-class represents the ability to specify constraints on data. **Tags:** atp.recommendedPackage=DataConstrs			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *CollectableElement*, *Identifiable*, *Multilanguage Referrable*, *PackageableElement*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***

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Class	**DataConstr**			
dataConstrRule	DataConstrRule	*	aggr	This is one particular rule within the data constraints. **Tags:** xml.roleElement=true xml.roleWrapperElement=true xml.sequenceOffset=30 xml.typeElement=false xml.typeWrapperElement=false

Table D.95: DataConstr

Class	***DataMapping*** (abstract)			
Package	M2::AUTOSARTemplates::SystemTemplate::DataMapping			
Note	Mapping of port elements (data elements and parameters) to frames and signals.			
Base	*ARObject*			
Subclasses	ClientServerToSignalMapping, SenderReceiverCompositeElementToSignalMapping, SenderReceiverToSignalGroupMapping, SenderReceiverToSignalMapping, TriggerToSignalMapping			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
communicationDirection	CommunicationDirectionType	0..1	attr	This attribute controls the direction into which the mapped SystemSignal is communicated with respect to the kind of PortPrototype used as the context element of the DataMapping.
eventGroup	ConsumedEventGroup	*	ref	Via this reference a connection between the VFB View and the Ethernet EventGroups can be created.
eventHandler	EventHandler	*	ref	Via this reference a connection between the VFB View and the Ethernet EventHandlers can be created.
introduction	DocumentationBlock	0..1	aggr	This represents introductory documentation about the data mapping.
serviceInstance	AbstractServiceInstance	*	ref	Via this reference a connection between the VFB View and the Ethernet Services can be created.

Table D.96: DataMapping

Class	***DataPrototype*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::DataPrototypes			
Note	Base class for prototypical roles of any data type.			
Base	*ARObject*, *AtpFeature*, *AtpPrototype*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	*ApplicationCompositeElementDataPrototype*, *AutosarDataPrototype*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
swDataDefProps	SwDataDefProps	0..1	aggr	This property allows to specify data definition properties which apply on data prototype level.

Table D.97: DataPrototype

Class	**DataPrototypeGroup**
Package	M2::AUTOSARTemplates::SWComponentTemplate::ImplicitCommunicationBehavior
Note	This meta-class represents the ability to define a collection of DataPrototypes that are subject to the formal definition of implicit communication behavior. The definition of the collection can be nested.
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*

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Class	DataPrototypeGroup			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
dataPrototype Group	DataPrototypeGroup	*	iref	This represents the ability to define nested groups of VariableDataPrototypes. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
implicitData Access	VariableDataPrototype	*	iref	This represents a collection of VariableDataPrototypes that belong to the enclosing DataPrototypeGroup **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.98: DataPrototypeGroup

Class	DataPrototypeMapping			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	Defines the mapping of two particular VariableDataPrototypes, ParameterDataPrototypes or Argument DataPrototypes with unequal names and/or unequal semantic (resolution or range) in context of two different SenderReceiverInterface, NvDataInterface or ParameterInterface or Operations. If the semantic is unequal following rules apply: The textTableMapping is only applicable if the referred DataPrototypes are typed by AutosarDataType referring to CompuMethods of category TEXTTABLE, SCALE_LINEAR_AND_TEXTTABLE or BITFIELD_TEXTTABLE. In the case that the DataPrototypes are typed by AutosarDataType either referring to CompuMethods of category LINEAR, IDENTICAL or referring to no CompuMethod (which is similar as IDENTICAL) the linear conversion factor is calculated out of the factorSiToUnit and offsetSiToUnit attributes of the referred Units and the CompuRationalCoeffs of a compuInternalToPhys of the referred CompuMethods.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
firstData Prototype	AutosarDataPrototype	1	ref	First to be mapped DataPrototype in context of a Sender ReceiverInterface, NvDataInterface, ParameterInterface or Operation.
firstToSecond Data Transformation	DataTransformation	0..1	ref	This reference defines the need to execute the Data Transformation <Mip>_<transformerId> functions of the transformation chain when communicating from the Data PrototypeMapping.firstDataPrototype to the Data PrototypeMapping.secondDataPrototype. This reference also specifies the reverse Data Transformation <Mip>_Inv_<transformerId> functions of the transformation chain (i.e. from the DataPrototype Mapping.secondDataPrototype to the DataPrototype Mapping.firstDataPrototype) if the referenced Data Transformation is symmetric, i.e. attribute Data Transformation.dataTransformationKind is set to symmetric.
secondData Prototype	AutosarDataPrototype	1	ref	Second to be mapped DataPrototype in context of a SenderReceiverInterface, NvDataInterface, Parameter Interface or Operation.
secondToFirst Data Transformation	DataTransformation	0..1	ref	This defines the need to execute the reverse Data Transformation <Mip>_Inv_<transformerId> functions of the transformation chain when communicating from the DataPrototypeMapping.secondDataPrototype to the Data PrototypeMapping.firstDataPrototype.
subElement Mapping	SubElementMapping	*	aggr	This represents the owned SubelementMapping.

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Class	DataPrototypeMapping			
textTable Mapping	TextTableMapping	0..2	aggr	Applied TextTableMapping(s)

Table D.99: DataPrototypeMapping

Class	DataPrototypeTransformationProps			
Package	M2::AUTOSARTemplates::SystemTemplate::Transformer			
Note	DataPrototypeTransformationProps allows to set the attributes for the different Transformation Technologies that are DataPrototype specific.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
dataPrototype Ref	DataPrototypeInSystem Ref	0..1	aggr	Reference to a DataPrototype that is transported in the serialized ISignal.
network Representation Props	SwDataDefProps	0..1	aggr	Specification of the actual network representation for the referenced primitive DataPrototype. If a network representation is provided then the baseType shall be used by the Transformer as input for the serialization/deserilaization.
transformation Props	TransformationProps	0..1	ref	Collection of AutosarDataPrototype related configuration settings for a transformer.

Table D.100: DataPrototypeTransformationProps

Class	DataReceiveErrorEvent			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	This event is raised by the RTE when the Com layer detects and notifies an error concerning the reception of the referenced data element.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
data	VariableDataPrototype	0..1	iref	Data element referenced by event

Table D.101: DataReceiveErrorEvent

Class	DataReceivedEvent			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	The event is raised when the referenced data elements are received.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
data	VariableDataPrototype	0..1	iref	Data element referenced by event

Table D.102: DataReceivedEvent

Class	DataSendCompletedEvent			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	The event is raised when the referenced data elements have been sent or an error occurs.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
eventSource	VariableAccess	1	ref	The variable access that triggers the event.

Table D.103: DataSendCompletedEvent

Class	DataTransformation			
Package	M2::AUTOSARTemplates::SystemTemplate::Transformer			
Note	A DataTransformation represents a transformer chain. It is an ordered list of transformers.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
data Transformation Kind	DataTransformationKind Enum	0..1	attr	This attribute controls the kind of DataTransformation to be applied.
executeDespite Data Unavailability	Boolean	1	attr	Specifies whether the transformer chain is executed even if no input data are available.
transformer Chain (ordered)	Transformation Technology	1..*	ref	This attribute represents the definition of a chain of transformers that are supposed to be executed according to the order of being referenced from DataTransformation.

Table D.104: DataTransformation

Enumeration	DataTransformationErrorHandlingEnum
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::PortAPIOptions
Note	This enumeration defines different ways how a RunnableEntity shall handle transformer errors.
Literal	**Description**
noTransformerError Handling	A runnable does not handle transformer errors. **Tags:** atp.EnumerationValue=0
transformerError Handling	The runnable implements the handling of transformer errors. **Tags:** atp.EnumerationValue=1

Table D.105: DataTransformationErrorHandlingEnum

Class	DataTypeMap			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::Datatypes			
Note	This class represents the relationship between ApplicationDataType and its implementing Abstract ImplementationDataType.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
applicationData Type	ApplicationDataType	1	ref	This is the corresponding ApplicationDataType
implementation DataType	AbstractImplementation DataType	1	ref	This is the corresponding AbstractImplementationData Type.

Table D.106: DataTypeMap

Class	**DataTypeMappingSet**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::Datatypes			
Note	This class represents a list of mappings between ApplicationDataTypes and ImplementationDataTypes. In addition, it can contain mappings between ImplementationDataTypes and ModeDeclarationGroups. **Tags:** atp.recommendedPackage=DataTypeMappingSets			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *CollectableElement*, *Identifiable*, *Multilanguage Referrable*, *PackageableElement*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
dataTypeMap	DataTypeMap	*	aggr	This is one particular association between an Application DataType and its AbstractImplementationDataType.
modeRequest TypeMap	ModeRequestTypeMap	*	aggr	This is one particular association between an Mode DeclarationGroup and its AbstractImplementationData Type.

Table D.107: DataTypeMappingSet

Enumeration	**DataTypePolicyEnum**
Package	M2::AUTOSARTemplates::SystemTemplate::DataMapping
Note	This class lists the supported DataTypePolicies.
Literal	**Description**
legacy	In case the System Description doesn't use a complete Software Component Description (VFB View) this value can be chosen. This supports the inclusion of legacy signals. The aggregation of SwDataDefProps shall be used to configure the "ComSignalDataInvalidValue" and the Data Semantics. **Tags:** atp.EnumerationValue=0
network Representation FromComSpec	Ignore any networkRepresentationProps of this ISignal and use the networkRepresentation from the ComSpec. Please note that the usage does not imply the existence of the SwDataDefProps in the role network Representation aggregated by the SenderComSpec or ReceiverComSpec if an ImplementationData Type is defined. **Tags:** atp.EnumerationValue=1
override	If this value is chosen the requirements specified in the ComSpec (networkRepresentationFromCom Spec) are not fullfilled by the aggregated SwDataDefProps. In this case the networkRepresentation is specified by the aggregated swDataDefProps. **Tags:** atp.EnumerationValue=2
transformingISignal	This literal indicates that a transformer chain shall be used to communicate the ISignal as UINT8_N over the bus. **Tags:** atp.EnumerationValue=4

Table D.108: DataTypePolicyEnum

Class	**DataWriteCompletedEvent**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	This event is raised if an implicit write access was successful or an error occurred.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**

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Class	**DataWriteCompletedEvent**			
eventSource	VariableAccess	1	ref	The variable access that triggers the event.

Table D.109: DataWriteCompletedEvent

Class	**DelegationSwConnector**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Composition			
Note	A delegation connector delegates one inner PortPrototype (a port of a component that is used inside the composition) to a outer PortPrototype of compatible type that belongs directly to the composition (a port that is owned by the composition).			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*, *SwConnector*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
innerPort	PortPrototype	1	iref	The port that belongs to the ComponentPrototype in the composition **Tags:** xml.typeElement=true
outerPort	PortPrototype	1	ref	The port that is located on the outside of the Composition Type

Table D.110: DelegationSwConnector

Class	**DependencyOnArtifact**			
Package	M2::AUTOSARTemplates::CommonStructure::Implementation			
Note	Dependency on the existence of another artifact, e.g. a library.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
artifact Descriptor	AutosarEngineering Object	1	aggr	The specified artifact needs to exist.
usage	DependencyUsage Enum	1..*	attr	Specification for which process step(s) this dependency is required.

Table D.111: DependencyOnArtifact

Class	**EcuAbstractionSwComponentType**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	The ECUAbstraction is a special AtomicSwComponentType that resides between a software-component that wants to access ECU periphery and the Microcontroller Abstraction. The EcuAbstractionSw ComponentType introduces the possibility to link from the software representation to its hardware description provided by the ECU Resource Template. **Tags:** atp.recommendedPackage=SwComponentTypes			
Base	*ARElement*, *ARObject*, *AtomicSwComponentType*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *Atp Type*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*, *Sw ComponentType*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
hardware Element	HwDescriptionEntity	*	ref	Reference from the EcuAbstractionComponentType to the description of the used HwElements.

Table D.112: EcuAbstractionSwComponentType

Class	**EcucDestinationUriDef**			
Package	M2::AUTOSARTemplates::ECUCParameterDefTemplate			
Note	Description of an EcucDestinationUriDef that is used as target of EcucUriReferenceDefs.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
destinationUri Policy	EcucDestinationUri Policy	1	aggr	Description of the targeted EcucContainerDef.

Table D.113: EcucDestinationUriDef

Class	**EcucForeignReferenceDef**			
Package	M2::AUTOSARTemplates::ECUCParameterDefTemplate			
Note	Specify a reference to an XML description of an entity described in another AUTOSAR template.			
Base	*ARObject*, *AtpDefinition*, *EcucAbstractExternalReferenceDef*, *EcucAbstractReferenceDef*, *Ecuc CommonAttributes*, *EcucDefinitionElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
destinationType	String	1	attr	The type in the AUTOSAR Metamodel to which instance this reference is allowed to point to.

Table D.114: EcucForeignReferenceDef

Class	**EcucModuleConfigurationValues**			
Package	M2::AUTOSARTemplates::ECUCDescriptionTemplate			
Note	Head of the configuration of one Module. A Module can be a BSW module as well as the RTE and ECU Infrastructure. As part of the BSW module description, the EcucModuleConfigurationValues element has two different roles: The recommendedConfiguration contains parameter values recommended by the BSW module vendor. The preconfiguredConfiguration contains values for those parameters which are fixed by the implementation and cannot be changed. These two EcucModuleConfigurationValues are used when the base EcucModuleConfigurationValues (as part of the base ECU configuration) is created to fill parameters with initial values. **Tags:** atp.recommendedPackage=EcucModuleConfigurationValuess			
Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *Packageable Element*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
container	EcucContainerValue	1..*	aggr	Aggregates all containers that belong to this module configuration. atpVariation: [RS_ECUC_00078] **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=definition, shortName, variation Point.shortLabel vh.latestBindingTime=postBuild xml.sequenceOffset=10
definition	EcucModuleDef	1	ref	Reference to the definition of this EcucModule ConfigurationValues element. Typically, this is a vendor specific module configuration. **Tags:** xml.sequenceOffset=-10

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Class	**EcucModuleConfigurationValues**			
ecucDefEdition	RevisionLabelString	1	attr	This is the version info of the ModuleDef ECUC Parameter definition to which this values conform to / are based on. For the Definition of ModuleDef ECUC Parameters the AdminData shall be used to express the semantic changes. The compatibility rules between the definition and value revision labels is up to the module's vendor.
implementation ConfigVariant	EcucConfiguration VariantEnum	1	attr	Specifies the kind of deliverable this EcucModule ConfigurationValues element provides. If this element is not used in a particular role (e.g. preconfigured Configuration or recommendedConfiguration) then the value must be one of VariantPreCompile, VariantLink Time, VariantPostBuild.
module Description	BswImplementation	0..1	ref	Referencing the BSW module description, which this EcucModuleConfigurationValues element is configuring. This is optional because the EcucModuleConfiguration Values element is also used to configure the ECU infrastructure (memory map) or Application SW-Cs. However in case the EcucModuleConfigurationValues are used to configure the module, the reference is mandatory in order to fetch module specific "common" published information.
postBuildVariant Used	Boolean	0..1	attr	Indicates whether a module implementation has or plans to have (i.e., introduced at link or post-build time) new post-build variation points. TRUE means yes, FALSE means no. If the attribute is not defined, FALSE semantics shall be assumed.

Table D.115: EcucModuleConfigurationValues

Class	**EcucModuleDef**			
Package	M2::AUTOSARTemplates::ECUCParameterDefTemplate			
Note	Used as the top-level element for configuration definition for Software Modules, including BSW and RTE as well as ECU Infrastructure. **Tags:** atp.recommendedPackage=EcucModuleDefs			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpDefinition*, *CollectableElement*, *Ecuc DefinitionElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
apiServicePrefix	CIdentifier	0..1	attr	For CDD modules this attribute holds the apiService Prefix. The shortName of the module definition of a Complex Driver is always "Cdd". Therefore for CDD modules the module apiServicePrefix is described with this attribute.
container	EcucContainerDef	1..*	aggr	Aggregates the top-level container definitions of this specific module definition. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=shortName xml.sequenceOffset=11
postBuildVariant Support	Boolean	0..1	attr	Indicates if a module supports different post-build variants (previously known as post-build selectable configuration sets). TRUE means yes, FALSE means no.

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Class	EcucModuleDef			
refinedModule Def	EcucModuleDef	0..1	ref	Optional reference from the Vendor Specific Module Definition to the Standardized Module Definition it refines. In case this EcucModuleDef has the category STANDARDIZED_MODULE_DEFINITION this reference shall not be provided. In case this Ecuc ModuleDef has the category VENDOR_SPECIFIC_MODULE_DEFINITION this reference is mandatory. **Stereotypes:** atpUriDef
supported ConfigVariant	EcucConfiguration VariantEnum	*	attr	Specifies which ConfigurationVariants are supported by this software module. This attribute is optional if the EcucModuleDef has the category STANDARDIZED_MODULE_DEFINITION. If the category attribute of the EcucModuleDef is set to VENDOR_SPECIFIC_MODULE_DEFINITION then this attribute is mandatory.

Table D.116: EcucModuleDef

Class	**EcucUriReferenceDef**			
Package	M2::AUTOSARTemplates::ECUCParameterDefTemplate			
Note	Definition of reference with a destination that is specified via a destinationUri. With such a reference it is possible to define a reference to a EcucContainerDef in a different module independent from the concrete definition of the target container.			
Base	*ARObject*, *AtpDefinition*, *EcucAbstractInternalReferenceDef*, *EcucAbstractReferenceDef*, *EcucCommon Attributes*, *EcucDefinitionElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
destinationUri	EcucDestinationUriDef	1	ref	Any EcucContainerDef with a destinationUri that is identical to the destinationUri that is referenced here defines a valid target. **Stereotypes:** atpUriDef

Table D.117: EcucUriReferenceDef

Class	***EngineeringObject*** (abstract)			
Package	M2::AUTOSARTemplates::GenericStructure::GeneralTemplateClasses::EngineeringObject			
Note	This class specifies an engineering object. Usually such an object is represented by a file artifact. The properties of engineering object are such that the artifact can be found by querying an ASAM catalog file. The engineering object is uniquely identified by domain+category+shortLabel+revisionLabel.			
Base	*ARObject*			
Subclasses	AutosarEngineeringObject, BuildEngineeringObject, Graphic			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
category	NameToken	1	attr	This denotes the role of the engineering object in the development cycle. Categories are such as • SWSRC for source code • SWOBJ for object code ▽

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Class	***EngineeringObject*** (abstract)			
				△ • SWHDR for a C-header file Further roles need to be defined via Methodology. **Tags:** xml.sequenceOffset=20
domain	NameToken	0..1	attr	This denotes the domain in which the engineering object is stored. This allows to indicate various segments in the repository keeping the engineering objects. The domain may segregate companies, as well as automotive domains. Details need to be defined by the Methodology. Attribute is optional to support a default domain. **Tags:** xml.sequenceOffset=40
revisionLabel	RevisionLabelString	*	attr	This is a revision label denoting a particular version of the engineering object. **Tags:** xml.sequenceOffset=30
shortLabel	NameToken	1	attr	This is the short name of the engineering object. Note that it is modeled as NameToken and not as Identifier since in ASAM-CC it is also a NameToken. **Tags:** xml.sequenceOffset=10

Table D.118: EngineeringObject

Class	**ExclusiveArea**			
Package	M2::AUTOSARTemplates::CommonStructure::InternalBehavior			
Note	Prevents an executable entity running in the area from being preempted.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
–	–	–	–	–

Table D.119: ExclusiveArea

Class	***ExecutableEntity*** (abstract)			
Package	M2::AUTOSARTemplates::CommonStructure::InternalBehavior			
Note	Abstraction of executable code.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	*BswModuleEntity*, RunnableEntity			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
activation Reason	ExecutableEntity ActivationReason	*	aggr	If the ExecutableEntity provides at least one activation Reason element the RTE resp. BSW Scheduler shall provide means to read the activation vector of this executable entity execution. If no activationReason element is provided the feature of being able to determine the activating RTEEvent is disabled for this ExecutableEntity.
canEnter ExclusiveArea	ExclusiveArea	*	ref	This means that the executable entity can enter/leave the referenced exclusive area through explicit API calls.
exclusiveArea NestingOrder	ExclusiveAreaNesting Order	*	ref	This represents the set of ExclusiveAreaNestingOrders recognized by this ExecutableEntity.

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Class	***ExecutableEntity*** (abstract)			
minimumStart Interval	TimeValue	1	attr	Specifies the time in seconds by which two consecutive starts of an ExecutableEntity are guaranteed to be separated.
reentrancyLevel	ReentrancyLevelEnum	0..1	attr	The reentrancy level of this ExecutableEntity. See the documentation of the enumeration type ReentrancyLevel Enum for details. Please note that nonReentrant interfaces can have also reentrant or multicoreReentrant implementations, and reentrant interfaces can also have multicoreReentrant implementations.
runsInside ExclusiveArea	ExclusiveArea	*	ref	The executable entity runs completely inside the referenced exclusive area.
swAddrMethod	SwAddrMethod	0..1	ref	Addressing method related to this code entity. Via an association to the same SwAddrMethod, it can be specified that several code entities (even of different modules or components) shall be located in the same memory without already specifying the memory section itself.

Table D.120: ExecutableEntity

Class	**ExecutableEntityActivationReason**			
Package	M2::AUTOSARTemplates::CommonStructure::InternalBehavior			
Note	This meta-class represents the ability to define the reason for the activation of the enclosing Executable Entity.			
Base	*ARObject*, *ImplementationProps*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
bitPosition	PositiveInteger	1	attr	This attribute allows for defining the position of the enclosing ExecutableEntityActivationReason in the activation vector.

Table D.121: ExecutableEntityActivationReason

Class	**ExternalTriggerOccurredEvent**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	The event is raised when the referenced trigger have been occurred.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
trigger	Trigger	0..1	iref	Reference to the applicable Trigger.

Table D.122: ExternalTriggerOccurredEvent

Class	**ExternalTriggeringPoint**
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::Trigger
Note	If a RunnableEntity owns an ExternalTriggeringPoint it is entitled to raise an ExternalTriggerOccurred Event.
Base	*ARObject*

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Class	ExternalTriggeringPoint			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
ident	ExternalTriggeringPoint Ident	0..1	aggr	The aggregation in the role ident provides the ability to make the ExternalTriggeringPoint identifiable. From the semantical point of view, the ExternalTriggering Point is considered a first-class Identifiable and therefore the aggregation in the role ident shall always exist (until it may be possible to let ModeAccessPoint directly inherit from Identifiable). **Tags:** atp.Status=shallBecomeMandatory xml.sequenceOffset=-100
trigger	Trigger	0..1	iref	The trigger taken for the ExternalTriggeringPoint. **Tags:** xml.namePlural=TRIGGER-IREF xml.roleElement=false xml.roleWrapperElement=true xml.typeElement=true xml.typeWrapperElement=false

Table D.123: ExternalTriggeringPoint

Class	FlatInstanceDescriptor			
Package	M2::AUTOSARTemplates::CommonStructure::FlatMap			
Note	Represents exactly one node (e.g. a component instance or data element) of the instance tree of a software system. The purpose of this element is to map the various nested representations of this instance to a flat representation and assign a unique name (shortName) to it. Use cases: • Specify unique names of measurable data to be used by MCD tools • Specify unique names of calibration data to be used by MCD tool • Specify a unique name for an instance of a component prototype in the ECU extract of the system description Note that in addition it is possible to assign alias names via AliasNameAssignment.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
ecuExtract Reference	AtpFeature	0..1	iref	Refers to the instance in the ECU extract. This is valid only, if the FlatMap is used in the context of an ECU extract. The reference shall be such that it uniquely defines the object instance. For example, if a data prototype is declared as a role within an SwcInternalBehavior, it is not enough to state the SwcInternalBehavior as context and the aggregated data prototype as target. In addition, the reference shall also include the complete path identifying instance of the component prototype and the Atomic SoftwareComponentType, which is refered by the particular SwcInternalBehavior. **Tags:** xml.sequenceOffset=40

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Class	**FlatInstanceDescriptor**			
role	Identifier	0..1	attr	The role denotes the particular role of the downstream memory location described by this FlatInstanceDescriptor. It applies to use case where one upstream object results in multiple downstream objects, e.g. ModeDeclaration GroupPrototypes which are measurable. In this case the RTE will provide locations for current mode, previous mode and next mode.
rtePluginProps	RtePluginProps	0..1	aggr	The properties of a communication graph with respect to the utilization of RTE Implementation Plug-in. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=rtePluginProps
swDataDef Props	SwDataDefProps	0..1	aggr	The properties of this FlatInstanceDescriptor.
upstream Reference	AtpFeature	0..1	iref	Refers to the instance in the context of an "upstream" descriptions, wich could be the system or system extract description, the basic software module description or (if a flat map is used in preliminary context) a description of an atomic component or composition. This reference is optional in case the flat map is used in ECU context. The reference shall be such that it uniquely defines the object instance in the given context. For example, if a data prototype is declared as a role within an SwcInternal Behavior, it is not enough to state the SwcInternal Behavior as context and the aggregated data prototype as target. In addition, the reference shall also include the complete path identifying the instance of the component prototype that contains the particular instance of Swc InternalBehavior. **Tags:** xml.sequenceOffset=20

Table D.124: FlatInstanceDescriptor

Class	**FlatMap**			
Package	M2::AUTOSARTemplates::CommonStructure::FlatMap			
Note	Contains a flat list of references to software objects. This list is used to identify instances and to resolve name conflicts. The scope is given by the RootSwCompositionPrototype for which it is used, i.e. it can be applied to a system, system extract or ECU-extract. An instance of FlatMap may also be used in a preliminary context, e.g. in the scope of a software component before integration into a system. In this case it is not referred by a RootSwComposition Prototype. **Tags:** atp.recommendedPackage=FlatMaps			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *CollectableElement*, *Identifiable*, *Multilanguage Referrable*, *PackageableElement*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
instance	FlatInstanceDescriptor	1..*	aggr	A descriptor instance aggregated in the flat map. The variation point accounts for the fact, that the system in scope can be subject to variability, and thus the existence of some instances is variable. The aggregation has been made splitable because the content might be contributed by different stakeholders at different times in the workflow. Plus, the overall size might ▽

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Class	FlatMap			
				△ be so big that eventually it becomes more manageable if it is distributed over several files. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=postBuild

Table D.125: FlatMap

Enumeration	**HandleInvalidEnum**
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication
Note	Strategies of handling the reception of invalidValue.
Literal	***Description***
dontInvalidate	Invalidation is switched off. **Tags:** atp.EnumerationValue=0
external Replacement	Replace a received invalidValue. The replacement value is sourced from the externalReplacement. **Tags:** atp.EnumerationValue=1
keep	The application software is supposed to handle signal invalidation on RTE API level either by Data ReceiveErrorEvent or check of error code on read access. **Tags:** atp.EnumerationValue=2
replace	Replace a received invalidValue. The replacement value is specified by the initValue. **Tags:** atp.EnumerationValue=3

Table D.126: HandleInvalidEnum

Enumeration	**HandleOutOfRangeEnum**
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication
Note	A value of this type is taken for controlling the range checking behavior of the AUTOSAR RTE.
Literal	***Description***
default	The RTE will use the initValue if the actual value is out of the specified bounds. **Tags:** atp.EnumerationValue=0
external Replacement	This indicates that the value replacement is sourced from the attribute replaceWith. **Tags:** atp.EnumerationValue=1
ignore	The RTE will ignore any attempt to send or receive the corresponding dataElement if the value is out of the specified range. **Tags:** atp.EnumerationValue=2
invalid	The RTE will use the invalidValue if the value is out of the specified bounds. **Tags:** atp.EnumerationValue=3
none	A range check is not required. **Tags:** atp.EnumerationValue=4
saturate	The RTE will saturate the value of the dataElement such that it is limited to the applicable upper bound if it is greater than the upper bound. Consequently, it is limited to the applicable lower bound if the value is less than the lower bound. **Tags:** atp.EnumerationValue=5

Table D.127: HandleOutOfRangeEnum

Enumeration	**HandleOutOfRangeStatusEnum**
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication
Note	This enumeration defines how the RTE handles values that are out of range.
Literal	*Description*
indicate	The RTE sets the return status to RTE_E_OUT_OF_RANGE if the received value is out of range and the attribute handleOutOfRange is not set to "none" or "invalid". **Tags:** atp.EnumerationValue=0
silent	The RTE sets the return status to RTE_E_OK **Tags:** atp.EnumerationValue=1

Table D.128: HandleOutOfRangeStatusEnum

Enumeration	**HandleTimeoutEnum**
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication
Note	Strategies of handling a reception timeout violation.
Literal	*Description*
none	If set to none no replacement shall take place. **Tags:** atp.EnumerationValue=0
replace	If set to replace, the replacement value shall be the ComInitValue. **Tags:** atp.EnumerationValue=1
replaceByTimeout SubstitutionValue	If set to replace, the replacement value shall be the timeout substitution value. **Tags:** atp.EnumerationValue=2

Table D.129: HandleTimeoutEnum

Class	**HwElement**			
Package	M2::AUTOSARTemplates::EcuResourceTemplate			
Note	This represents the ability to describe Hardware Elements on an instance level. The particular types of hardware are distinguished by the category. This category determines the applicable attributes. The possible categories and attributes are defined in HwCategory. **Tags:** atp.recommendedPackage=HwElements			
Base	*ARElement*, *ARObject*, *CollectableElement*, *HwDescriptionEntity*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
hwElement Connection	HwElementConnector	*	aggr	This represents one particular connection between two hardware elements. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=systemDesignTime xml.sequenceOffset=110
hwPinGroup	HwPinGroup	*	aggr	This aggregation is used to describe the connection facilities of a hardware element. Note that hardware element has no pins but only pingroups. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=systemDesignTime xml.sequenceOffset=90

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Class	**HwElement**			
nestedElement	HwElement	*	ref	This association is used to establish hierarchies of hw elements. Note that one particular HwElement can be target of this association only once. I.e. multiple instantiation of the same HwElement is not supported (at any hierarchy level). **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=systemDesignTime xml.sequenceOffset=70

Table D.130: HwElement

Class	**ISignal**			
Package	M2::AUTOSARTemplates::SystemTemplate::Fibex::FibexCore::CoreCommunication			
Note	Signal of the Interaction Layer. The RTE supports a "signal fan-out" where the same System Signal is sent in different SignalIPdus to multiple receivers. To support the RTE "signal fan-out" each SignalIPdu contains ISignals. If the same System Signal is to be mapped into several SignalIPdus there is one ISignal needed for each ISignalToIPduMapping. ISignals describe the Interface between the Precompile configured RTE and the potentially Postbuild configured Com Stack (see ECUC Parameter Mapping). In case of the SystemSignalGroup an ISignal must be created for each SystemSignal contained in the SystemSignalGroup. **Tags:** atp.recommendedPackage=ISignals			
Base	*ARObject*, *CollectableElement*, *FibexElement*, *Identifiable*, *MultilanguageReferrable*, *Packageable Element*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
data Transformation	DataTransformation	0..1	ref	Optional reference to a DataTransformation which represents the transformer chain that is used to transform the data that shall be placed inside this ISignal. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=dataTransformation, variation Point.shortLabel vh.latestBindingTime=codeGenerationTime
dataTypePolicy	DataTypePolicyEnum	1	attr	With the aggregation of SwDataDefProps an ISignal specifies how it is represented on the network. This representation follows a particular policy. Note that this causes some redundancy which is intended and can be used to support flexible development methodology as well as subsequent integrity checks. If the policy "networkRepresentationFromComSpec" is chosen the network representation from the ComSpec that is aggregated by the PortPrototype shall be used. If the "override" policy is chosen the requirements specified in the PortInterface and in the ComSpec are not fulfilled by the networkRepresentationProps. In case the System Description doesn't use a complete Software Component Description (VFB View) the "legacy" policy can be chosen.
iSignalProps	ISignalProps	0..1	aggr	Additional optional ISignal properties that may be stored in different files. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=iSignalProps
iSignalType	ISignalTypeEnum	0..1	attr	This attribute defines whether this iSignal is an array that results in a UINT8_N / UINT8_DYN ComSignalType in the COM configuration or a primitive type.

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Class	**ISignal**			
initValue	ValueSpecification	0..1	aggr	Optional definition of a ISignal's initValue in case the System Description doesn't use a complete Software Component Description (VFB View). This supports the inclusion of legacy system signals. This value can be used to configure the Signal's "Init Value". If a full DataMapping exist for the SystemSignal this information may be available from a configured Sender ComSpec and ReceiverComSpec. In this case the initvalues in SenderComSpec and/or ReceiverComSpec override this optional value specification. Further restrictions apply from the RTE specification.
length	Integer	1	attr	Size of the signal in bits. The size needs to be derived from the mapped VariableDataPrototype according to the mapping of primitive DataTypes to BaseTypes as used in the RTE. Indicates maximum size for dynamic length signals. The ISignal length of zero bits is allowed.
network Representation Props	SwDataDefProps	0..1	aggr	Specification of the actual network representation. The usage of SwDataDefProps for this purpose is restricted to the attributes compuMethod and baseType. The optional baseType attributes "memAllignment" and "byteOrder" shall not be used. The attribute "dataTypePolicy" in the SystemTemplate element defines whether this network representation shall be ignored and the information shall be taken over from the network representation of the ComSpec. If "override" is chosen by the system integrator the network representation can violate against the requirements defined in the PortInterface and in the network representation of the ComSpec. In case that the System Description doesn't use a complete Software Component Description (VFB View) this element is used to configure "ComSignalDataInvalid Value" and the Data Semantics.
systemSignal	SystemSignal	1	ref	Reference to the System Signal that is supposed to be transmitted in the ISignal.
timeout Substitution Value	ValueSpecification	0..1	aggr	Defines and enables the ComTimeoutSubstituition for this ISignal.
transformation ISignalProps	TransformationISignal Props	*	aggr	A transformer chain consists of an ordered list of transformers. The ISignal specific configuration properties for each transformer are defined in the TransformationISignalProps class. The transformer configuration properties that are common for all ISignals are described in the TransformationTechnology class.

Table D.131: ISignal

Class	**ISignalGroup**			
Package	M2::AUTOSARTemplates::SystemTemplate::Fibex::FibexCore::CoreCommunication			
Note	SignalGroup of the Interaction Layer. The RTE supports a "signal fan-out" where the same System Signal Group is sent in different SignalIPdus to multiple receivers. An ISignalGroup refers to a set of ISignals that shall always be kept together. A ISignalGroup represents a COM Signal Group. Therefore it is recommended to put the ISignalGroup in the same Package as ISignals (see atp.recommendedPackage) **Tags:** atp.recommendedPackage=ISignalGroup			
Base	*ARObject*, *CollectableElement*, *FibexElement*, *Identifiable*, *MultilanguageReferrable*, *Packageable Element*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
comBased SignalGroup Transformation	DataTransformation	0..1	ref	Optional reference to a DataTransformation which represents the transformer chain that is used to transform the data that shall be placed inside this ISignalGroup based on the COMBasedTransformer approach. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=comBasedSignalGroup Transformation, variationPoint.shortLabel vh.latestBindingTime=codeGenerationTime
iSignal	ISignal	*	ref	Reference to a set of ISignals that shall always be kept together.
systemSignal Group	SystemSignalGroup	1	ref	Reference to the SystemSignalGroup that is defined on VFB level and that is supposed to be transmitted in the ISignalGroup.
transformation ISignalProps	TransformationISignal Props	*	aggr	A transformer chain consists of an ordered list of transformers. The ISignalGroup specific configuration properties for each transformer are defined in the TransformationISignalProps class. The transformer configuration properties that are common for all ISignal Groups are described in the TransformationTechnology class.

Table D.132: ISignalGroup

Class	**ISignalProps**			
Package	M2::AUTOSARTemplates::SystemTemplate::Fibex::FibexCore::CoreCommunication			
Note	Additional ISignal properties that may be stored in different files.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
handleOutOf Range	HandleOutOfRange Enum	1	attr	This attribute defines the outOfRangeHandling for received and sent signals.

Table D.133: ISignalProps

Class	***Identifiable*** (abstract)
Package	M2::AUTOSARTemplates::GenericStructure::GeneralTemplateClasses::Identifiable
Note	Instances of this class can be referred to by their identifier (within the namespace borders). In addition to this, Identifiables are objects which contribute significantly to the overall structure of an AUTOSAR description. In particular, Identifiables might contain Identifiables.

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Class	***Identifiable*** (abstract)			
Base	*ARObject*, *MultilanguageReferrable*, *Referrable*			
Subclasses	ARPackage, *AbstractEvent*, *AbstractImplementationDataTypeElement*, *AbstractServiceInstance*, ApplicationEndpoint, ApplicationError, ApplicationPartitionToEcuPartitionMapping, AsynchronousServerCallResultPoint, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpFeature*, AutosarOperationArgumentInstance, AutosarVariableInstance, BswInternalTriggeringPoint, BswModuleDependency, *BuildActionEntity*, BuildActionEnvironment, CanTpAddress, CanTpChannel, CanTpNode, Chapter, ClassContentConditional, ClientIdDefinition, ClientServerOperation, Code, *CollectableElement*, ComManagementMapping, *CommConnectorPort*, *CommunicationConnector*, *CommunicationController*, Compiler, ConsistencyNeeds, ConsumedEventGroup, CouplingPort, *CouplingPortStructuralElement*, *CryptoServiceMapping*, DataPrototypeGroup, DataTransformation, DependencyOnArtifact, *DiagEventDebounceAlgorithm*, DiagnosticConnectedIndicator, DiagnosticDataElement, DiagnosticFunctionInhibitSource, DiagnosticMasterToSlaveEventMapping, *DiagnosticRoutineSubfunction*, DoIpLogicAddress, ECUMapping, *EOCExecutableEntityRefAbstract*, EcuPartition, EcucContainerValue, *EcucDefinitionElement*, EcucDestinationUriDef, EcucEnumerationLiteralDef, EcucQuery, EcucValidationCondition, EndToEndProtection, ExclusiveArea, *ExecutableEntity*, *ExecutionTime*, FMAttributeDef, FMFeatureMapAssertion, FMFeatureMapCondition, FMFeatureMapElement, FMFeatureRelation, FMFeatureRestriction, FMFeatureSelection, FlatInstanceDescriptor, FlexrayArTpNode, FlexrayTpConnectionControl, FlexrayTpNode, FlexrayTpPduPool, *FrameTriggering*, GeneralParameter, GlobalTimeGateway, *GlobalTimeMaster*, *GlobalTimeSlave*, *HeapUsage*, HwAttributeDef, HwAttributeLiteralDef, HwPin, HwPinGroup, IPv6ExtHeaderFilterList, ISignalToIPduMapping, ISignalTriggering, *IdentCaption*, InternalTriggeringPoint, J1939SharedAddressCluster, J1939TpNode, Keyword, LifeCycleState, LinScheduleTable, LinTpNode, Linker, MacMulticastGroup, McDataInstance, MemorySection, ModeDeclaration, ModeDeclarationMapping, ModeSwitchPoint, NetworkEndpoint, *NmCluster*, NmEcu, *NmNode*, NvBlockDescriptor, *PackageableElement*, ParameterAccess, PduToFrameMapping, PduTriggering, PerInstanceMemory, *PhysicalChannel*, PortGroup, *PortInterfaceMapping*, PossibleErrorReaction, ResourceConsumption, RootSwCompositionPrototype, RptComponent, RptContainer, RptExecutableEntity, RptExecutableEntityEvent, RptExecutionContext, RptProfile, RptServicePoint, RunnableEntityGroup, *SdgAttribute*, SdgClass, SecureCommunicationAuthenticationProps, SecureCommunicationFreshnessProps, *ServerCallPoint*, *ServiceNeeds*, SocketAddress, SomeipTpChannel, *SpecElementReference*, *StackUsage*, StructuredReq, SwGenericAxisParamType, SwServiceArg, SwcServiceDependency, SwcToApplicationPartitionMapping, SwcToEcuMapping, SwcToImplMapping, SystemMapping, TcpOptionFilterList, TimingCondition, *TimingConstraint*, *TimingDescription*, TimingExtensionResource, TimingModeInstance, TlsCryptoCipherSuite, Topic1, TpAddress, TraceableText, *TracedFailure*, *TransformationProps*, TransformationTechnology, Trigger, VariableAccess, VariationPointProxy, ViewMap, VlanConfig, WaitPoint			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
desc	MultiLanguageOverviewParagraph	0..1	aggr	This represents a general but brief (one paragraph) description what the object in question is about. It is only one paragraph! Desc is intended to be collected into overview tables. This property helps a human reader to identify the object in question. More elaborate documentation, (in particular how the object is built or used) should go to "introduction". **Tags:** xml.sequenceOffset=-60
category	CategoryString	0..1	attr	The category is a keyword that specializes the semantics of the Identifiable. It affects the expected existence of attributes and the applicability of constraints. **Tags:** xml.sequenceOffset=-50
adminData	AdminData	0..1	aggr	This represents the administrative data for the identifiable object. **Tags:** xml.sequenceOffset=-40
annotation	Annotation	*	aggr	Possibility to provide additional notes while defining a model element (e.g. the ECU Configuration Parameter Values). These are not intended as documentation but are mere design notes. **Tags:** xml.sequenceOffset=-25

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Class	*Identifiable* (abstract)			
introduction	DocumentationBlock	0..1	aggr	This represents more information about how the object in question is built or is used. Therefore it is a DocumentationBlock. **Tags:** xml.sequenceOffset=-30
uuid	String	0..1	attr	The purpose of this attribute is to provide a globally unique identifier for an instance of a meta-class. The values of this attribute should be globally unique strings prefixed by the type of identifier. For example, to include a DCE UUID as defined by The Open Group, the UUID would be preceded by "DCE:". The values of this attribute may be used to support merging of different AUTOSAR models. The form of the UUID (Universally Unique Identifier) is taken from a standard defined by the Open Group (was Open Software Foundation). This standard is widely used, including by Microsoft for COM (GUIDs) and by many companies for DCE, which is based on CORBA. The method for generating these 128-bit IDs is published in the standard and the effectiveness and uniqueness of the IDs is not in practice disputed. If the id namespace is omitted, DCE is assumed. An example is "DCE:2fac1234-31f8-11b4-a222-08002b34c003". The uuid attribute has no semantic meaning for an AUTOSAR model and there is no requirement for AUTOSAR tools to manage the timestamp. **Tags:** xml.attribute=true

Table D.134: Identifiable

Class	*Implementation* (abstract)			
Package	M2::AUTOSARTemplates::CommonStructure::Implementation			
Note	Description of an implementation a single software component or module.			
Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *Packageable Element*, *Referrable*			
Subclasses	BswImplementation, SwcImplementation			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
buildAction Manifest	BuildActionManifest	0..1	ref	A manifest specifying the intended build actions for the software delivered with this implementation. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=codeGenerationTime
codeDescriptor	Code	1..*	aggr	Specifies the provided implementation code.
compiler	Compiler	*	aggr	Specifies the compiler for which this implementation has been released
generated Artifact	DependencyOnArtifact	*	aggr	Relates to an artifact that will be generated during the integration of this Implementation by an associated generator tool. Note that this is an optional information since it might not always be in the scope of a single module or component to provide this information. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
hwElement	HwElement	*	ref	The hardware elements (e.g. the processor) required for this implementation.

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Class	***Implementation*** (abstract)			
linker	Linker	*	aggr	Specifies the linker for which this implementation has been released.
mcSupport	McSupportData	0..1	aggr	The measurement & calibration support data belonging to this implementation. The aggregtion is «atpSplitable» because in case of an already exisiting BSW Implementation model, this description will be added later in the process, namely at code generation time. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=mcSupport
programming Language	Programminglanguage Enum	1	attr	Programming language the implementation was created in.
requiredArtifact	DependencyOnArtifact	*	aggr	Specifies that this Implementation depends on the existance of another artifact (e.g. a library). This aggregation of DependencyOnArtifact is subject to variability with the purpose to support variability in the implementations. Different algorithms in the implementation might cause different dependencies, e.g. the number of used libraries. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
required GeneratorTool	DependencyOnArtifact	*	aggr	Relates this Implementation to a generator tool in order to generate additional artifacts during integration. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
resource Consumption	ResourceConsumption	1	aggr	All static and dynamic resources for each implementation are described within the ResourceConsumption class. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=shortName
swVersion	RevisionLabelString	1	attr	Software version of this implementation. The numbering contains three levels (like major, minor, patch), its values are vendor specific.
swcBsw Mapping	SwcBswMapping	0..1	ref	This allows a mapping between an SWC and a BSW behavior to be attached to an implementation description (for AUTOSAR Service, ECU Abstraction and Complex Driver Components). It is up to the methodology to define whether this reference has to be set for the Swc- or Bsw Implementtion or for both.
usedCode Generator	String	0..1	attr	Optional: code generator used.
vendorId	PositiveInteger	1	attr	Vendor ID of this Implementation according to the AUTOSAR vendor list

Table D.135: Implementation

Class	**ImplementationDataType**
Package	M2::AUTOSARTemplates::CommonStructure::ImplementationDataTypes
Note	Describes a reusable data type on the implementation level. This will typically correspond to a typedef in C-code. **Tags:** atp.recommendedPackage=ImplementationDataTypes
Base	*ARElement*, *ARObject*, *AbstractImplementationDataType*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *AutosarDataType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *Packageable Element*, *Referrable*

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Class	**ImplementationDataType**			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
dynamicArray SizeProfile	String	0..1	attr	Specifies the profile which the array will follow in case this data type is a variable size array.
isStructWith Optional Element	Boolean	0..1	attr	This attribute is only valid if the attribute category is set to STRUCTURE. If set to True, this attribute indicates that the ImplementationDataType has been created with the intention to define at least one element of the structure as optional. **Tags:** atp.Status=draft
subElement (ordered)	ImplementationData TypeElement	*	aggr	Specifies an element of an array, struct, or union data type. The aggregation of ImplementionDataTypeElement is subject to variability with the purpose to support the conditional existence of elements inside a Implementation DataType representing a structure. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
symbolProps	SymbolProps	0..1	aggr	This represents the SymbolProps for the Implementation DataType. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=shortName
typeEmitter	NameToken	0..1	attr	This attribute is used to control which part of the AUTOSAR toolchain is supposed to trigger data type definitions.

Table D.136: ImplementationDataType

Class	**ImplementationDataTypeElement**			
Package	M2::AUTOSARTemplates::CommonStructure::ImplementationDataTypes			
Note	Declares a data object which is locally aggregated. Such an element can only be used within the scope where it is aggregated. This element either consists of further subElements or it is further defined via its swDataDefProps. There are several use cases within the system of ImplementationDataTypes fur such a local declaration: • It can represent the elements of an array, defining the element type and array size • It can represent an element of a struct, defining its type • It can be the local declaration of a debug element.			
Base	*ARObject*, *AbstractImplementationDataTypeElement*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
arraySize	PositiveInteger	0..1	attr	The existence of this attributes (if bigger than 0) defines the size of an array and declares that this Implementation DataTypeElement represents the type of each single array element. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
arraySize Handling	ArraySizeHandling Enum	0..1	attr	The way how the size of the array is handled in case of a variable size array.
arraySize Semantics	ArraySizeSemantics Enum	0..1	attr	This attribute controls the meaning of the value of the array size.

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Class	**ImplementationDataTypeElement**			
isOptional	Boolean	0..1	attr	This attribute represents the ability to declare the enclosing ImplementationDataTypeElement as optional. This means that, at runtime, the ImplementationDataType Element may or may not have a valid value and shall therefore be ignored. The underlying runtime software provides means to set the CppImplementationDataTypeElement as not valid at the sending end of a communication and determine its validity at the receiving end. **Tags:** atp.Status=draft
subElement (ordered)	ImplementationData TypeElement	*	aggr	Element of an array, struct, or union in case of a nested declaration (i.e. without using "typedefs"). The aggregation of ImplementionDataTypeElement is subject to variability with the purpose to support the conditional existence of elements inside a Implementation DataType representing a structure. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
swDataDef Props	SwDataDefProps	0..1	aggr	The properties of this ImplementationDataTypeElement.

Table D.137: ImplementationDataTypeElement

Class	***ImplementationProps*** (abstract)			
Package	M2::AUTOSARTemplates::CommonStructure::Implementation			
Note	Defines a symbol to be used as (depending on the concrete case) either a complete replacement or a prefix when generating code artifacts.			
Base	*ARObject*, *Referrable*			
Subclasses	BswSchedulerNamePrefix, ExecutableEntityActivationReason, SectionNamePrefix, SymbolProps, SymbolicNameProps			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
symbol	CIdentifier	1	attr	The symbol to be used as (depending on the concrete case) either a complete replacement or a prefix.

Table D.138: ImplementationProps

Class	**IncludedDataTypeSet**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::IncludedDataTypes			
Note	An includedDataTypeSet declares that a set of AutosarDataType is used by a basic software module or a software component for its implementation and the AutosarDataType becomes part of the contract. This information is required if the AutosarDataType is not used for any DataPrototype owned by this software component or if the enumeration literals, lowerLimit and upperLimit constants shall be generated with a literalPrefix. The optional literalPrefix is used to add a common prefix on enumeration literals, lowerLimit and upper Limit constants created by the RTE.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
dataType	AutosarDataType	1..*	ref	AutosarDataType belonging to the includedDataTypeSet

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Class	**IncludedDataTypeSet**			
literalPrefix	Identifier	0..1	attr	LiteralPrefix defines a common prefix for all AutosarData Types of the includedDataTypeSet to be added on enumeration literals, lowerLimit and upperLimit constants created by the RTE.

Table D.139: IncludedDataTypeSet

Class	**IncludedModeDeclarationGroupSet**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::ModeDeclarationGroup			
Note	An IncludedModeDeclarationGroupSet declares that a set of ModeDeclarationGroups used by the software component for its implementation and consequently these ModeDeclarationGroups become part of the contract.			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
mode Declaration Group	ModeDeclarationGroup	1..*	ref	This represents the referenced ModeDeclarationGroup.
prefix	Identifier	0..1	attr	The prefix shall be used by the RTE generator as a prefix for the creation of symbols related to the referenced ModeDeclarationGroups, e.g RTE_TRANSITION_<ModeDeclarationGroup>.

Table D.140: IncludedModeDeclarationGroupSet

Class	**InitEvent**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	This RTEEvent is supposed to be used for initialization purposes, i.e. for starting and restarting a partition. It is not guaranteed that all RunnableEntities referenced by this InitEvent are executed before the 'regular' RunnableEntities are executed for the first time. The execution order depends on the task mapping.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
–	–	–	–	–

Table D.141: InitEvent

Class	**InstantiationDataDefProps**
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::InstantiationDataDefProps
Note	This is a general class allowing to apply additional SwDataDefProps to particular instantiations of a Data Prototype. Typically the accessibility and further information like alias names for a particular data is modeled on the level of DataPrototypes (especially VariableDataPrototypes, ParameterDataPrototypes). But due to the recursive structure of the meta-model concerning data types (a composite (data) type consists out of data prototypes) a part of the MCD information is described in the data type (in case of Application CompositeDataType). ▽

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Class	**InstantiationDataDefProps**			
	△ This is a strong restriction in the reuse of data typed because the data type should be re-used for different VariableDataPrototypes and ParameterDataPrototypes to guarantee type compatibility on C-implementation level (e.g. data of a Port is stored in PIM or a ParameterDataPrototype used as ROM Block and shall be typed by the same data type as NVRAM Block). This class overcomes such a restriction if applied properly.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
parameter Instance	AutosarParameterRef	0..1	aggr	This is the particular ParameterDataPrototypes on which the swDataDefProps shall be applied.
swDataDef Props	SwDataDefProps	1	aggr	These are the particular data definition properties which shall be applied
variableInstance	AutosarVariableRef	0..1	aggr	This is the particular VariableDataPrototypes on which the swDataDefProps shall be applied.

Table D.142: InstantiationDataDefProps

Class	***InstantiationRTEEventProps*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Composition			
Note	This meta class represents the ability to refine the properties of RTEEvents for particular instances of a software component.			
Base	*ARObject*			
Subclasses	InstantiationTimingEventProps			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
refinedEvent	RTEEvent	1	iref	This instance ref denotes the Timing Event for which the period shall be refined on an instance level.
shortLabel	Identifier	1	attr	The main purpose of the shortLabel is to contribute to the splitkey of aggregations that are «atpSplitable».

Table D.143: InstantiationRTEEventProps

Class	***InternalBehavior*** (abstract)			
Package	M2::AUTOSARTemplates::CommonStructure::InternalBehavior			
Note	Common base class (abstract) for the internal behavior of both software components and basic software modules/clusters.			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	BswInternalBehavior, SwcInternalBehavior			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
constant Memory	ParameterData Prototype	*	aggr	Describes a read only memory object containing characteristic value(s) implemented by this Internal Behavior. The shortName of ParameterDataPrototype has to be equal to the ”C’ identifier of the described constant. The characteristic value(s) might be shared between SwComponentPrototypes of the same SwComponent Type. ▽

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Class	***InternalBehavior*** (abstract)			
				△ The aggregation of constantMemory is subject to variability with the purpose to support variability in the software component or module implementations. Typically different algorithms in the implementation are requiring different number of memory objects. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
constantValue Mapping	ConstantSpecification MappingSet	*	ref	Reference to the ConstanSpecificationMapping to be applied for the particular InternalBehavior **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=constantValueMapping
dataType Mapping	DataTypeMappingSet	*	ref	Reference to the DataTypeMapping to be applied for the particular InternalBehavior **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=dataTypeMapping
exclusiveArea	ExclusiveArea	*	aggr	This specifies an ExclusiveArea for this InternalBehavior. The exclusiveArea is local to the component resp. module. The aggregation of ExclusiveAreas is subject to variability. Note: the number of ExclusiveAreas might vary due to the conditional existence of RunnableEntities or BswModule Entities. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
exclusiveArea NestingOrder	ExclusiveAreaNesting Order	*	aggr	This represents the set of ExclusiveAreaNestingOrder owned by the InternalBehavior. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
staticMemory	VariableDataPrototype	*	aggr	Describes a read and writeable static memory object representing measurerment variables implemented by this software component. The term "static" is used in the meaning of "non-temporary" and does not necessarily specify a linker encapsulation. This kind of memory is only supported if supportsMultipleInstantiation is FALSE. The shortName of the VariableDataPrototype has to be equal with the "C' identifier of the described variable. The aggregation of staticMemory is subject to variability with the purpose to support variability in the software component's implementations. Typically different algorithms in the implementation are requiring different number of memory objects. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime

Table D.144: InternalBehavior

Class	**InternalTriggerOccurredEvent**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	The event is raised when the referenced internal trigger have been occurred.			
Base	*ARObject, AbstractEvent, AtpClassifier, AtpFeature, AtpStructureElement, Identifiable, MultilanguageReferrable, RTEEvent, Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
eventSource	InternalTriggeringPoint	1	ref	Internal Triggering Point that triggers the event.

Table D.145: InternalTriggerOccurredEvent

Class	**InternalTriggeringPoint**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::Trigger			
Note	If a RunnableEntity owns an InternalTriggeringPoint it is entitled to trigger the execution of Runnable Entities of the corresponding software-component.			
Base	*ARObject, AbstractAccessPoint, AtpClassifier, AtpFeature, AtpStructureElement, Identifiable, MultilanguageReferrable, Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
swImplPolicy	SwImplPolicyEnum	0..1	attr	This attribute, when set to value queued, allows for a queued processing of Triggers.

Table D.146: InternalTriggeringPoint

Class	**InvalidationPolicy**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	Specifies whether the component can actively invalidate a particular dataElement. If no invalidationPolicy points to a dataElement this is considered to yield the identical result as if the handleInvalid attribute was set to dontInvalidate.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
dataElement	VariableDataPrototype	1	ref	Reference to the dataElement for which the Invalidation Policy applies.
handleInvalid	HandleInvalidEnum	0..1	attr	This attribute controls how invalidation is applied to the dataElement.

Table D.147: InvalidationPolicy

Class	**McDataInstance**
Package	M2::AUTOSARTemplates::CommonStructure::MeasurementCalibrationSupport
Note	Describes the specific properties of one data instance in order to support measurement and/or calibration of this data instance. The most important attributes are: • Its shortName is copied from the ECU Flat map (if applicable) and will be used as identifier and for display by the MC system. • The category is copied from the corresponding data type (ApplicationDataType if defined, otherwise ImplementationDataType) as far as applicable. • The symbol is the one used in the programming language. It will be used to find out the actual memory address by the final generation tool with the help of linker generated information. ▽

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Class	**McDataInstance**			
	△ It is assumed that in the M1 model this part and all the aggregated and referred elements (with the exception of the Flat Map and the references from ImplementationElementInParameterInstanceRef and McAccessDetails) are completely generated from "upstream" information. This means, that even if an element like e.g. a CompuMethod is only used via reference here, it will be copied into the M1 artifact which holds the complete McSupportData for a given Implementation.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
arraySize	PositiveInteger	0..1	attr	The existence of this attribute turns the data instance into an array of data. The attribute determines the size of the array in terms of number of elements.
displayIdentifier	McdIdentifier	0..1	attr	An optional attribute to be used to set the ASAM ASAP2 DISPLAY_IDENTIFIER attribute.
flatMapEntry	FlatInstanceDescriptor	0..1	ref	Reference to the corresponding entry in the ECU Flat Map. This allows to trace back to the original specification of the generated data instance. This link shall be added by the RTE generator mainly for documentation purposes. The reference is optional because • The McDataInstance may represent an array or struct in which only the subElements correspond to FlatMap entries. • The McDataInstance may represent a task local buffer for rapid prototyping access which is different from the "main instance" used for measurement access.
instanceIn Memory	ImplementationElement InParameterInstance Ref	0..1	aggr	Reference to the corresponding data instance in the description of calibration data structures published by the RTE generator. This is used to support emulation methods inside the ECU, it is not required for A2L generation.
mcDataAccess Details	McDataAccessDetails	0..1	aggr	Refers to "upstream" information on how the RTE uses this data instance. Use Case: Rapid Prototyping
mcData Assignment	RoleBasedMcData Assignment	*	aggr	An assignment between McDataInstances. This supports the indication of related McDataElement implementing the of "RP global buffer", "RP global measurement buffer", "RP enabler flag".
resulting Properties	SwDataDefProps	0..1	aggr	These are the generated properties resulting from decisions taken by the RTE generator for the actually implemented data instance. Only those properties are relevant here, which are needed for the measurement and calibration system.
resultingRptSw Prototyping Access	RptSwPrototyping Access	0..1	aggr	Describes the implemented accessibility of data and modes by the rapid prototyping tooling.
role	Identifier	0..1	attr	An optional attribute to be used for additional information on the role of this data instance, for example in the context of rapid prototyping.
rptImplPolicy	RptImplPolicy	0..1	aggr	Describes the implemented code preparation for rapid prototyping at data accesses for a hook based bypassing.

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Class	**McDataInstance**			
subElement (ordered)	McDataInstance	*	aggr	This relation indicates, that the target element is part of a "struct" which is given by the source element. This information will be used by the final generator to set up the correct addressing scheme. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
symbol	SymbolString	0..1	attr	This String is used to determine the memory address during final generation of the MC configuration data (e.g. "A2L" file) . It shall be the name of the element in the programming language such that it can be identified in linker generated information. In case the McDataInstance is part of composite data in the programming language, the symbol String may include parts denoting the element context, unless the context is given by the symbol attribute of an enclosing McDataInstance. This means in particular for the C language that the "." character shall be used as a separator between the name of a "struct" variable the name of one of its elements. The symbol can differ from the shortName in case of generated C data declarations. It is an optional attribute since it may be missing in case the instance represents an element (e.g. a single array element) which has no name in the linker map. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=symbol

Table D.148: McDataInstance

Class	**McParameterElementGroup**			
Package	M2::AUTOSARTemplates::CommonStructure::MeasurementCalibrationSupport			
Note	Denotes a group of calibration parameters which are handled by the RTE as one data structure.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
ramLocation	VariableDataPrototype	1	ref	Refers to the RAM location of this parameter group. To be used for the init-RAM method.
romLocation	ParameterDataPrototype	1	ref	Refers to the ROM location of this parameter group. To be used for the init-RAM method.
shortLabel	Identifier	1	attr	Assigns a name to this element. **Tags:** xml.sequenceOffset=-100

Table D.149: McParameterElementGroup

Class	**McSupportData**
Package	M2::AUTOSARTemplates::CommonStructure::MeasurementCalibrationSupport
Note	Root element for all measurement and calibration support data related to one Implementation artifact on an ECU. There shall be one such element related to the RTE implementation (if it owns MC data) and a separate one for each module or component, which owns private MC data.
Base	*ARObject*

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Class	**McSupportData**			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
emulation Support	McSwEmulationMethod Support	*	aggr	Describes the calibration method used by the RTE. This information is not needed for A2L generation, but to setup software emulation in the ECU. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
mcParameter Instance	McDataInstance	*	aggr	A data instance to be used for calibration. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=postBuild
mcVariable Instance	McDataInstance	*	aggr	A data instance to be used for measurement. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=postBuild
measurable System ConstantValues	SwSystemconstant ValueSet	*	ref	Sets of system constant values to be transferred to the MCD system, because the system constants have been specified with "swCalibrationAccess" = readonly.
rptSupportData	RptSupportData	0..1	aggr	The rapid prototyping support data belonging to this implementation. The aggregtion is «atpSplitable» because in case of an already exisiting BSW Implementation model, this description will be added later in the process, namely at code generation time. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=rptSupportData

Table D.150: McSupportData

Class	**McSwEmulationMethodSupport**			
Package	M2::AUTOSARTemplates::CommonStructure::MeasurementCalibrationSupport			
Note	This denotes the method used by the RTE to handle the calibration data. It is published by the RTE generator and can be used e.g. to generate the corresponding emulation method in a Complex Driver. According to the actual method given by the category attribute, not all attributes are always needed: • double pointered method: only baseReference is mandatory • single pointered method: only referenceTable is mandatory • initRam method: only elementGroup(s) are mandatory Note: For single/double pointered method the group locations are implicitly accessed via the reference table and their location can be found from the initial values in the M1 model of the respective pointers. Therefore, the description of elementGroups is not needed in these cases. Likewise, for double pointered method the reference table description can be accessed via the M1 model under baseReference.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
category	Identifier	1	attr	Identifies the actual method. The possible names shall correspond to the symbols of the ECU configuration parameter for the calibration method of the RTE, and can include vendor specific methods. **Tags:** xml.sequenceOffset=-90
baseReference	VariableDataPrototype	0..1	ref	Refers to the base pointer in case of the double-pointered method.

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Class	**McSwEmulationMethodSupport**			
elementGroup	McParameterElementGroup	*	aggr	Denotes the grouping of calibration parameters in the actual RTE code. Depending on the category, this information maybe required to set up the emulation code.
referenceTable	VariableDataPrototype	0..1	ref	Refers to the pointer table in case of the single-pointered method.
shortLabel	Identifier	1	attr	Assigns a name to this element. **Tags:** xml.sequenceOffset=-100

Table D.151: McSwEmulationMethodSupport

Enumeration	**MemoryAllocationKeywordPolicyType**
Package	M2::MSR::DataDictionary::AuxillaryObjects
Note	Enumeration to specify the name pattern of the Memory Allocation Keyword.
Literal	*Description*
addrMethodShortName	The MemorySection shortNames of referring MemorySections and therefore the belonging Memory Allocation Keywords in the code are build with the shortName of the SwAddrMethod. This is the default value if the attribute does not exist. **Tags:** atp.EnumerationValue=0
addrMethodShortNameAndAlignment	The MemorySection shortNames of referring MemorySections and therefore the belonging Memory Allocation Keywords in the code are build with the shortName of the SwAddrMethod and a variable alignment postfix. Thereby the alignment postfix needs to be consistent with the alignment attribute of the related MemorySection. **Tags:** atp.EnumerationValue=1

Table D.152: MemoryAllocationKeywordPolicyType

Class	**MemorySection**
Package	M2::AUTOSARTemplates::CommonStructure::ResourceConsumption::MemorySectionUsage
Note	Provides a description of an abstract memory section used in the Implementation for code or data. It shall be declared by the Implementation Description of the module or component, which actually allocates the memory in its code. This means in case of data prototypes which are allocated by the RTE, that the generated Implementation Description of the RTE shall contain the corresponding MemorySections. The attribute "symbol" (if symbol is missing: "shortName") defines the module or component specific section name used in the code. For details see the document "Specification of Memory Mapping". Typically the section name is build according the pattern: <SwAddrMethod shortName>[_<further specialization nominator>][_<alignment>] where • **[<SwAddrMethod shortName>]** is the shortName of the referenced SwAddrMethod • **[_<further specialization nominator>]** is an optional infix to indicate the specialization in the case that several MemorySections for different purpose of the same Implementation Description referring to the same or equally named SwAddrMethods. • **[_<alignment>]** is the alignment attributes value and is only applicable in the case that the memoryAllocationKeywordPolicy value of the referenced SwAddrMethod is set to addrMethodShortNameAndAlignment ▽

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Class	MemorySection			
	△ MemorySection used to Implement the code of RunnableEntitys and BswSchedulableEntitys shall have a symbol (if missing: shortName) identical to the referred SwAddrMethod to conform to the generated RTE header files. In addition to the section name described above, a prefix is used in the corresponding macro code in order to define a name space. This prefix is by default given by the shortName of the BswModule Description resp. the SwComponentType. It can be superseded by the prefix attribute.			
Base	*ARObject, Identifiable, MultilanguageReferrable, Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
alignment	AlignmentType	0..1	attr	The attribute describes the alignment of objects within this memory section.
executableEntity	ExecutableEntity	*	ref	Reference to the ExecutableEntitites located in this section. This allows to locate different Executable Entitities in different sections even if the associated Sw Addrmethod is the same. This is applicable to code sections only.
memClass Symbol	CIdentifier	0..1	attr	Defines a specific symbol in order to generate the compiler abstraction "memclass" code for this Memory Section. The existence of this attribute supersedes the usage of swAddrmethod.shortName for this purpose. The complete name of the "memclass" preprocessor symbol is constructed as <prefix>_<memClassSymbol> where prefix is defined in the same way as for the enclosing MemorySection. See also AUTOSAR_SWS_CompilerAbstraction SWS_COMPILER_00040.
option	Identifier	*	attr	This attribute introduces the ability to specify further intended properties of this MemorySection. The following two values are standardized (to be used for code sections only and exclusively to each other): • INLINE - The code section is declared with the compiler abstraction macro INLINE. • LOCAL_INLINE - The code section is declared with the compiler abstraction macro LOCAL_INLINE In both cases (INLINE and LOCAL_INLINE) the inline expansion depends on the compiler specific implementation of these macros. Depending on this, the code section either corresponds to an actual section in memory or is put into the section of the caller. See AUTOSAR_SWS_CompilerAbstraction for more details.
prefix	SectionNamePrefix	0..1	ref	The prefix used to set the memory section's namespace in the code. The existence of a prefix element supersedes rules for a default prefix (such as the Bsw ModuleDescription's shortName). This allows the user to define several name spaces for memory sections within the scope of one module, cluster or SWC.
size	PositiveInteger	0..1	attr	The size in bytes of the section.
swAddrmethod	SwAddrMethod	1	ref	This association indicates that this module specific (abstract) memory section is part of an overall SwAddr Method, referred by the upstream declarations (e.g. calibration parameters, data element prototypes, code entities) which share a common addressing strategy. This ▽

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Class	**MemorySection**			
				△ can be evaluated for the ECU configuration of the build support. This association shall always be declared by the Implementation description of the module or component, which allocates the memory in its code. This means in case of data prototypes which are allocated by the RTE, that the software components only declare the grouping of its data prototypes to SwAddrMethods, and the generated Implementation Description of the RTE actually sets up this association.
symbol	Identifier	0..1	attr	Defines the section name as explained in the main description. By using this attribute for code generation (instead of the shortName) it is possible to define several different MemorySections having the same name - e.g. symbol = CODE - but using different sectionName Prefixes.

Table D.153: MemorySection

Class	**ModeAccessPoint**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::ModeDeclarationGroup			
Note	A ModeAccessPoint is required by a RunnableEntity owned by a Mode Manager or Mode User. Its semantics implies the ability to access the current mode (provided by the RTE) of a ModeDeclaration GroupPrototype's ModeDeclarationGroup.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
ident	ModeAccessPointIdent	0..1	aggr	The aggregation in the role ident provides the ability to make the ModeAccessPoint identifiable. From the semantical point of view, the ModeAccessPoint is considered a first-class Identifiable and therefore the aggregation in the role ident shall always exist (until it may be possible to let ModeAccessPoint directly inherit from Identifiable). **Tags:** atp.Status=shallBecomeMandatory xml.sequenceOffset=-100
modeGroup	ModeDeclarationGroup Prototype	0..1	iref	The mode declaration group that is accessed by this runnable. **Tags:** xml.typeElement=true

Table D.154: ModeAccessPoint

Enumeration	**ModeActivationKind**
Package	M2::AUTOSARTemplates::CommonStructure::ModeDeclaration
Note	Kind of mode switch condition used for activation of an event, as further described for each enumeration field.
Literal	***Description***
onEntry	On entering the referred mode. **Tags:** atp.EnumerationValue=0
onExit	On exiting the referred mode. **Tags:** atp.EnumerationValue=1

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Enumeration	**ModeActivationKind**
onTransition	On transition of the 1st referred mode to the 2nd referred mode. **Tags:** atp.EnumerationValue=2

Table D.155: ModeActivationKind

Class	**ModeDeclaration**			
Package	M2::AUTOSARTemplates::CommonStructure::ModeDeclaration			
Note	Declaration of one Mode. The name and semantics of a specific mode is not defined in the meta-model. **Tags:** atp.ManifestKind=ExecutionManifest,MachineManifest			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
value	PositiveInteger	0..1	attr	The RTE shall take the value of this attribute for generating the source code representation of this Mode Declaration.

Table D.156: ModeDeclaration

Class	**ModeDeclarationGroup**			
Package	M2::AUTOSARTemplates::CommonStructure::ModeDeclaration			
Note	A collection of Mode Declarations. Also, the initial mode is explicitly identified. **Tags:** atp.ManifestKind=ExecutionManifest,MachineManifest atp.recommendedPackage=ModeDeclarationGroups			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
initialMode	ModeDeclaration	1	ref	The initial mode of the ModeDeclarationGroup. This mode is active before any mode switches occurred.
mode Declaration	ModeDeclaration	1..*	aggr	The ModeDeclarations collected in this ModeDeclaration Group. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=blueprintDerivationTime
modeManager ErrorBehavior	ModeErrorBehavior	0..1	aggr	This represents the ability to define the error behavior expected by the mode manager in case of errors on the mode user side (e.g. terminated mode user).
modeTransition	ModeTransition	*	aggr	This represents the avaliable ModeTransitions of the ModeDeclarationGroup
modeUserError Behavior	ModeErrorBehavior	0..1	aggr	This represents the definition of the error behavior expected by the mode user in case of errors on the mode manager side (e.g. terminated mode manager).
onTransition Value	PositiveInteger	0..1	attr	The value of this attribute shall be taken into account by the RTE generator for programmatically representing a value used for the transition between two statuses.

Table D.157: ModeDeclarationGroup

Class	ModeDeclarationGroupPrototype			
Package	M2::AUTOSARTemplates::CommonStructure::ModeDeclaration			
Note	The ModeDeclarationGroupPrototype specifies a set of Modes (ModeDeclarationGroup) which is provided or required in the given context. **Tags:** atp.ManifestKind=ExecutionManifest,MachineManifest			
Base	*ARObject*, *AtpFeature*, *AtpPrototype*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
swCalibrationAccess	SwCalibrationAccessEnum	0..1	attr	This allows for specifying whether or not the enclosing ModeDeclarationGroupPrototype can be measured at run-time.
type	ModeDeclarationGroup	1	tref	The "collection of ModeDeclarations" (= ModeDeclarationGroup) supported by a component **Stereotypes:** isOfType

Table D.158: ModeDeclarationGroupPrototype

Class	ModeDeclarationMappingSet			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	This meta-class implements a container for ModeDeclarationGroupMappings **Tags:** atp.recommendedPackage=PortInterfaceMappingSets			
Base	*ARElement*, *ARObject*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
modeDeclarationMapping	ModeDeclarationMapping	1..*	aggr	This represents the collection of ModeDeclarationMappings owned by the enclosing ModeDeclarationMappingSet.

Table D.159: ModeDeclarationMappingSet

Class	ModeErrorBehavior			
Package	M2::AUTOSARTemplates::CommonStructure::ModeDeclaration			
Note	This represents the ability to define the error behavior in the context of mode handling.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
defaultMode	ModeDeclaration	0..1	ref	This represents the ModeDeclaration that is considered the error mode in the context of the enclosing ModeDeclarationGroup.
errorReactionPolicy	ModeErrorReactionPolicyEnum	1	attr	This represents the ability to define the policy in terms of which default model shall apply in case an error occurs.

Table D.160: ModeErrorBehavior

Enumeration	ModeErrorReactionPolicyEnum
Package	M2::AUTOSARTemplates::CommonStructure::ModeDeclaration
Note	This represents the ability to specify the reaction on a mode error.
Literal	**Description**
defaultMode	This represents the ability to switch to the defaultMode in case of a mode error. **Tags:** atp.EnumerationValue=0

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Enumeration	**ModeErrorReactionPolicyEnum**
lastMode	This represents the ability to keep the last mode in case of a mode error. **Tags:** atp.EnumerationValue=1

Table D.161: ModeErrorReactionPolicyEnum

Class	**ModeInterfaceMapping**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	Defines the mapping of ModeDeclarationGroupPrototypes in context of two different ModeInterfaces.			
Base	*ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *Identifiable*, *MultilanguageReferrable*, *PortInterfaceMapping*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
modeMapping	ModeDeclarationGroup PrototypeMapping	1	aggr	Mapping of two ModeDeclarationGroupPrototypes in two different ModeInterfaces

Table D.162: ModeInterfaceMapping

Class	**ModeRequestTypeMap**			
Package	M2::AUTOSARTemplates::CommonStructure::ModeDeclaration			
Note	Specifies a mapping between a ModeDeclarationGroup and an ImplementationDataType. This ImplementationDataType shall be used to implement the ModeDeclarationGroup.			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
implementation DataType	AbstractImplementation DataType	1	ref	This is the corresponding AbstractImplementationData Type. It shall be modeled along the idea of an "unsigned integer-like" data type.
modeGroup	ModeDeclarationGroup	1	ref	This is the corresponding ModeDeclarationGroup.

Table D.163: ModeRequestTypeMap

Class	**ModeSwitchInterface**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	A mode switch interface declares a ModeDeclarationGroupPrototype to be sent and received. **Tags:** atp.recommendedPackage=PortInterfaces			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *PortInterface*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
modeGroup	ModeDeclarationGroup Prototype	1	aggr	The ModeDeclarationGroupPrototype of this mode interface.

Table D.164: ModeSwitchInterface

Class	**ModeSwitchPoint**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::ModeDeclarationGroup			
Note	A ModeSwitchPoint is required by a RunnableEntity owned a Mode Manager. Its semantics implies the ability to initiate a mode switch.			
Base	*ARObject*, *AbstractAccessPoint*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
modeGroup	ModeDeclarationGroupPrototype	0..1	iref	The mode declaration group that is switched by this runnable.

Table D.165: ModeSwitchPoint

Class	**ModeSwitchReceiverComSpec**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	Communication attributes of RPortPrototypes with respect to mode communication			
Base	*ARObject*, *RPortComSpec*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
enhancedModeApi	Boolean	0..1	attr	This controls the creation of the enhanced mode API that returns information about the previous mode and the next mode. If set to "true" the enhanced mode API is supposed to be generated. For more details please refer to the SWS_RTE.
modeGroup	ModeDeclarationGroupPrototype	0..1	ref	ModeDeclarationGroupPrototype (of the same Port Interface) to which these communication attributes apply. **Tags:** atp.Status=shallBecomeMandatory
supportsAsynchronousModeSwitch	Boolean	1	attr	This attribute controls the behavior of the corresponding RPortPrototype with respect to the question whether it can deal with asynchronous mode switch requests, i.e. if set to true, the RPortPrototype is able to deal with an asynchronous mode switch request.

Table D.166: ModeSwitchReceiverComSpec

Class	**ModeSwitchSenderComSpec**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	Communication attributes of PPortPrototypes with respect to mode communication			
Base	*ARObject*, *PPortComSpec*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
enhancedModeApi	Boolean	0..1	attr	This controls the creation of the enhanced mode API that returns information about the previous mode and the next mode. If set to "true" the enhanced mode API is supposed to be generated. For more details please refer to the SWS_RTE.
modeGroup	ModeDeclarationGroupPrototype	1	ref	ModeDeclarationGroupPrototype (of the same Port Interface) to which these communication attributes apply.
modeSwitchedAck	ModeSwitchedAckRequest	0..1	aggr	If this aggregation exists an acknowledgement for the successful processing of the mode switch request is required.
queueLength	PositiveInteger	1	attr	Length of call queue on the mode user side. The queue is implemented by the RTE. The value shall be greater or equal to 1. Setting the value of queueLength to 1 implies that incoming requests are rejected while another request that arrived earlier is being processed.

Table D.167: ModeSwitchSenderComSpec

Class	**ModeSwitchedAckEvent**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	The event is raised when the referenced modes have been received or an error occurs.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
eventSource	ModeSwitchPoint	1	ref	Mode switch point that triggers the event.

Table D.168: ModeSwitchedAckEvent

Class	**ModeSwitchedAckRequest**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	Requests acknowledgements that a mode switch has been proceeded successfully			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
timeout	TimeValue	1	attr	Number of seconds before an error is reported or in case of allowed redundancy, the value is sent again.

Table D.169: ModeSwitchedAckRequest

Class	**NonqueuedReceiverComSpec**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	Communication attributes specific to non-queued receiving.			
Base	*ARObject*, *RPortComSpec*, *ReceiverComSpec*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
aliveTimeout	TimeValue	1	attr	Specify the amount of time (in seconds) after which the software component (via the RTE) needs to be notified if the corresponding data item have not been received according to the specified timing description. If the aliveTimeout attribute is 0 no timeout monitoring shall be performed.
enableUpdate	Boolean	1	attr	This attribute controls whether application code is entitled to check whether the value of the corresponding Variable DataPrototype has been updated.
filter	DataFilter	0..1	aggr	The applicable filter algorithm for filtering the value of the corresponding dataElement.
handleData Status	Boolean	0..1	attr	If this attribute is set to true than the Rte_IStatus API shall exist. If the attribute does not exist or is set to false then the Rte_IStatus API may still exist in response to the existence of further conditions.
handleNever Received	Boolean	1	attr	This attribute specifies whether for the corresponding VariableDataPrototype the "never received" flag is available. If yes, the RTE is supposed to assume that initially the VariableDataPrototype has not been received before. After the first reception of the corresponding VariableData Prototype the flag is cleared. ▽

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Class	NonqueuedReceiverComSpec			
				△ • If the value of this attribute is set to "true" the flag is required. • If set to "false", the RTE shall not support the "never received" functionality for the corresponding VariableDataPrototype.
handleTimeout Type	HandleTimeoutEnum	1	attr	This attribute controls the behavior with respect to the handling of timeouts.
initValue	ValueSpecification	0..1	aggr	Initial value to be used in case the sending component is not yet initialized. If the sender also specifies an initial value the receiver's value will be used.
timeout Substitution Value	ValueSpecification	0..1	aggr	This attribute represents the substitution value applicable in the case of a timeout.

Table D.170: NonqueuedReceiverComSpec

Class	**NonqueuedSenderComSpec**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	Communication attributes for non-queued sender/receiver communication (sender side)			
Base	*ARObject*, *PPortComSpec*, *SenderComSpec*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
initValue	ValueSpecification	1	aggr	Initial value to be sent if sender component is not yet fully initialized, but receiver needs data already.

Table D.171: NonqueuedSenderComSpec

Class	**NumericalRuleBasedValueSpecification**			
Package	M2::AUTOSARTemplates::CommonStructure::Constants			
Note	This meta-class is used to support a rule-based initialization approach for data types with an array-nature (ImplementationDataType of category ARRAY).			
Base	*ARObject*, *AbstractRuleBasedValueSpecification*, *ValueSpecification*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
ruleBased Values	RuleBasedValue Specification	1	aggr	This represents the rule based value specification for the array. **Tags:** xml.roleElement=true xml.roleWrapperElement=false xml.typeWrapperElement=false

Table D.172: NumericalRuleBasedValueSpecification

Class	**NumericalValueSpecification**			
Package	M2::AUTOSARTemplates::CommonStructure::Constants			
Note	A numerical ValueSpecification which is intended to be assigned to a Primitive data element. Note that the numerical value is a variant, it can be computed by a formula.			
Base	*ARObject*, *ValueSpecification*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***

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Class	**NumericalValueSpecification**			
value	Numerical	1	attr	This is the value itself. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.173: NumericalValueSpecification

Class	**NvBlockDataMapping**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::NvBlockComponent			
Note	Defines the mapping between the VariableDataPrototypes in the NvBlockComponents ports and the VariableDataPrototypes of the RAM Block. The data types of the referenced VariableDataPrototypes in the ports and the referenced sub-element (inside a CompositeDataType) of the VariableDataPrototype representing the RAM Block shall be compatible.			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
nvRamBlock Element	AutosarVariableRef	1	aggr	Reference to a VariableDataPrototype of a RAM Block.
readNvData	AutosarVariableRef	0..1	aggr	Reference to a VariableDataPrototype of a pPort of the NvBlockComponent providing read access to the RAM Block.If there is no PortPrototype providing read access (write-only) the reference can be omitted.
writtenNvData	AutosarVariableRef	0..1	aggr	Reference to a VariableDataPrototype of a rPort of the Nv BlockComponent providing write access to the RAM Block. If there is no port providing write access (read-only) the reference can be omitted.
writtenReadNv Data	AutosarVariableRef	0..1	aggr	Reference to a VariableDataPrototype of a PRPort Prototype of the NvBlockSwComponentType providing write and read access to the RAM Block.

Table D.174: NvBlockDataMapping

Class	**NvBlockDescriptor**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::NvBlockComponent			
Note	Specifies the properties of exactly on NVRAM Block.			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
clientServerPort	RoleBasedPort Assignment	*	aggr	The RoleBasedPortAssignement defines which client server port of the NvBlockSwComponentType serves for which kind of service or notification. In case of notifications one common callback function is provided by the RTE for each individual kind of notification defined by the "role". The aggregation of RoleBasedPortAssignment is subject to variability with the purpose to support the conditional existence of ports. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
constantValue Mapping	ConstantSpecification MappingSet	*	ref	Reference to the ConstanSpecificationMapping to be applied for the particular NVRAM Block **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=constantValueMapping

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Class	NvBlockDescriptor			
dataType Mapping	DataTypeMappingSet	*	ref	Reference to the DataTypeMapping to be applied for the particular NVRAM Block. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=dataTypeMapping
instantiation DataDefProps	InstantiationDataDef Props	*	aggr	The purpose of InstantiationDataDefProps are the refinement of some data def properties of individual instantiations within the context of a NvBlockSw ComponentType. The aggregation of InstantiationDataDefProps is subject to variability with the purpose to support the conditional existence of ports, component internal memory objects and those attributes. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
modeSwitch EventTriggered Activity	ModeSwitchEvent TriggeredActivity	*	aggr	This represents the collection of ModeSwitchEvent TriggeredActivities related to the enclosing NvBlock Descriptor. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=modeSwitchEventTriggeredActivity, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
nvBlockData Mapping	NvBlockDataMapping	1..*	aggr	Defines the mapping between the VariableData Prototypes in the NvBlockComponents ports and the VariableDataPrototypes of the RAM Block. The aggregation of NvBlockDataMapping is subject to variability with the purpose to support the conditional existence of nv data ports. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
nvBlockNeeds	NvBlockNeeds	1	aggr	Specifies the abstract needs on the configuration of the NVRAM Manager for the single NVRAM Block described by this NvBlockDescriptor. In addition, it may define requirements for writing strategies in an implementation of an NvBlockSw ComponentType by the RTE. Please note that the attributes nDataSets and nRom Blocks are not relevant for this aggregation because the RTE will allocate just one block anyway. In a different context, however, they do make sense.
ramBlock	VariableDataPrototype	1	aggr	Defines the RAM Block of the NVRAM Block provided by NvBlockSwComponentType.
romBlock	ParameterData Prototype	0..1	aggr	Defines the ROM Block of the NVRAM Block provided by NvBlockSwComponentType.
supportDirty Flag	Boolean	0..1	attr	Specifies whether calling of NvM functions for writing and/or status control of potentially modified RAM Blocks to NV memory shall be controlled by the RTE.
timingEvent	TimingEvent	0..1	ref	this reference can be taken to identify the TimingEvent to be used by the RTE for implementing a cyclic writing strategy for this block

Table D.175: NvBlockDescriptor

Class	**NvBlockNeeds**			
Package	M2::AUTOSARTemplates::CommonStructure::ServiceNeeds			
Note	Specifies the abstract needs on the configuration of a single NVRAM Block.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*, *ServiceNeeds*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
calcRamBlockCrc	Boolean	0..1	attr	Defines if CRC (re)calculation for the permanent RAM Block is required.
checkStaticBlockId	Boolean	0..1	attr	Defines if the Static Block Id check shall be enabled.
cyclicWritingPeriod	TimeValue	0..1	attr	This represents the period for cyclic writing of NvData to store the associated RAM Block.
nDataSets	PositiveInteger	0..1	attr	Number of data sets to be provided by the NVRAM manager for this block. This is the total number of ROM Blocks and RAM Blocks.
nRomBlocks	PositiveInteger	0..1	attr	Number of ROM Blocks to be provided by the NVRAM manager for this block. Please note that these multiple ROM Blocks are given in a contiguous area.
ramBlockStatusControl	RamBlockStatusControlEnum	0..1	attr	This attribute defines how the management of the RAM Block status is controlled.
readonly	Boolean	0..1	attr	True: data of this NVRAM Block are write protected for normal operation (but protection can be disabled) false: no restriction
reliability	NvBlockNeedsReliabilityEnum	0..1	attr	Reliability against data loss on the non-volatile medium.
resistantToChangedSw	Boolean	0..1	attr	Defines whether an NVRAM Block shall be treated resistant to configuration changes (true) or not (false). For details how to handle initialization in the latter case, please refer to the NVRAM specification.
restoreAtStart	Boolean	0..1	attr	Defines whether the associated RAM Block shall be implicitly restored during startup by the basic software.
selectBlockForFirstInitAll	Boolean	0..1	attr	If this attribute is set to true the NvM shall process this block in the NvM_FirstInitAll() function.
storeAtShutdown	Boolean	0..1	attr	Defines whether or not the associated RAM Block shall be implicitly stored during shutdown by the basic software.
storeCyclic	Boolean	0..1	attr	Defines whether or not the associated RAM Block shall be implicitly stored periodically by the basic software.
storeEmergency	Boolean	0..1	attr	Defines whether or not the associated RAM Block shall be implicitly stored in case of ECU failure (e.g. loss of power) by the basic software. If the attribute storeEmergency is set to true the associated RAM Block shall be configured to have immediate priority.
storeImmediate	Boolean	0..1	attr	Defines whether or not the associated RAM Block shall be implicitly stored immediately during or after execution of the according SW-C RunnableEntity by the basic software.
useAutoValidationAtShutDown	Boolean	0..1	attr	If set to true the RAM Block shall be auto validated during shutdown phase.
useCRCCompMechanism	Boolean	0..1	attr	If set to true the CRC of the RAM Block shall be compared during a write job with the CRC which was calculated during the last successful read or write job in order to skip unnecessary NVRAM writings.

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Class	**NvBlockNeeds**			
writeOnlyOnce	Boolean	0..1	attr	Defines write protection after first write: true: This block is prevented from being changed/erased or being replaced with the default ROM data after first initialization by the software-component. false: No such restriction.
writeVerification	Boolean	0..1	attr	Defines if Write Verification shall be enabled for this NVRAM Block.
writing Frequency	PositiveInteger	0..1	attr	Provides the amount of updates to this block from the application point of view. It has to be provided in "number of write access per year".
writingPriority	NvBlockNeedsWriting PriorityEnum	0..1	attr	Requires the priority of writing this block in case of concurrent requests to write other blocks.

Table D.176: NvBlockNeeds

Class	**NvBlockSwComponentType**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	The NvBlockSwComponentType defines non volatile data which data can be shared between Sw ComponentPrototypes. The non volatile data of the NvBlockSwComponentType are accessible via provided and required ports. **Tags:** atp.recommendedPackage=SwComponentTypes			
Base	*ARElement*, *ARObject*, *AtomicSwComponentType*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *Atp Type*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*, *Sw ComponentType*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
nvBlock Descriptor	NvBlockDescriptor	*	aggr	Specification of the properties of exactly one NVRAM Block. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime

Table D.177: NvBlockSwComponentType

Class	**NvDataInterface**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	A non volatile data interface declares a number of VariableDataPrototypes to be exchanged between non volatile block components and atomic software components. **Tags:** atp.recommendedPackage=PortInterfaces			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *DataInterface*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *PortInterface*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
nvData	VariableDataPrototype	1..*	aggr	The VariableDataPrototype of this nv data interface.

Table D.178: NvDataInterface

Class	**NvRequireComSpec**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	Communication attributes of RPortPrototypes with respect to Nv data communication on the required side.			
Base	*ARObject*, *RPortComSpec*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
initValue	ValueSpecification	0..1	aggr	The initial value owned by the NvComSpec
variable	VariableDataPrototype	1	ref	The VariableDataPrototype the ComSpec applies for.

Table D.179: NvRequireComSpec

Class	**OperationInvokedEvent**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	The OperationInvokedEvent references the ClientServerOperation invoked by the client.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *RTEEvent*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
operation	ClientServerOperation	0..1	iref	The operation to be executed as the consequence of the event.

Table D.180: OperationInvokedEvent

Class	**PPortPrototype**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	Component port providing a certain port interface.			
Base	*ARObject*, *AbstractProvidedPortPrototype*, *AtpBlueprintable*, *AtpFeature*, *AtpPrototype*, *Identifiable*, *MultilanguageReferrable*, *PortPrototype*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
providedInterface	PortInterface	1	tref	The interface that this port provides. **Stereotypes:** isOfType

Table D.181: PPortPrototype

Class	**PRPortPrototype**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	This kind of PortPrototype can take the role of both a required and a provided PortPrototype.			
Base	*ARObject*, *AbstractProvidedPortPrototype*, *AbstractRequiredPortPrototype*, *AtpBlueprintable*, *AtpFeature*, *AtpPrototype*, *Identifiable*, *MultilanguageReferrable*, *PortPrototype*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
providedRequiredInterface	PortInterface	1	tref	This represents the PortInterface used to type the PRPortPrototype **Stereotypes:** isOfType

Table D.182: PRPortPrototype

Class	ParameterAccess			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::DataElements			
Note	The presence of a ParameterAccess implies that a RunnableEntity needs access to a ParameterData Prototype.			
Base	*ARObject*, *AbstractAccessPoint*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
accessed Parameter	AutosarParameterRef	1	aggr	Refernce to the accessed calibration parameter.
swDataDef Props	SwDataDefProps	0..1	aggr	This allows denote instance and access specific properties, mainly input values and common axis.

Table D.183: ParameterAccess

Class	ParameterDataPrototype			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::DataPrototypes			
Note	A parameter element used for parameter interface and internal behavior, supporting signal like parameter and characteristic value communication patterns and parameter and characteristic value definition.			
Base	*ARObject*, *AtpFeature*, *AtpPrototype*, *AutosarDataPrototype*, *DataPrototype*, *Identifiable*, *Multilanguage Referrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
initValue	ValueSpecification	0..1	aggr	Specifies initial value(s) of the ParameterDataPrototype

Table D.184: ParameterDataPrototype

Class	ParameterInterface			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	A parameter interface declares a number of parameter and characteristic values to be exchanged between parameter components and software components. **Tags:** atp.recommendedPackage=PortInterfaces			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *DataInterface*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *PortInterface*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
parameter	ParameterData Prototype	1..*	aggr	The ParameterDataPrototype of this ParameterInterface.

Table D.185: ParameterInterface

Class	ParameterProvideComSpec			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	"Communication" specification that applies to parameters on the provided side of a connection.			
Base	*ARObject*, *PPortComSpec*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
initValue	ValueSpecification	0..1	aggr	The initial value applicable for the corresponding ParameterDataPrototype.
parameter	ParameterData Prototype	1	ref	The ParameterDataPrototype to which the Parameter ComSpec applies.

Table D.186: ParameterProvideComSpec

Class	**ParameterRequireComSpec**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	"Communication" specification that applies to parameters on the required side of a connection.			
Base	*ARObject*, *RPortComSpec*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
initValue	ValueSpecification	0..1	aggr	The initial value applicable for the corresponding ParameterDataPrototype.
parameter	ParameterData Prototype	1	ref	The ParameterDataPrototype to which the Parameter RequireComSpec applies.

Table D.187: ParameterRequireComSpec

Class	**ParameterSwComponentType**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	The ParameterSwComponentType defines parameters and characteristic values accessible via provided Ports. The provided values are the same for all connected SwComponentPrototypes **Tags:** atp.recommendedPackage=SwComponentTypes			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*, *SwComponentType*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
constant Mapping	ConstantSpecification MappingSet	*	ref	Reference to the ConstanSpecificationMapping to be applied for the particular ParameterSwComponentType **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=constantMapping
dataType Mapping	DataTypeMappingSet	*	ref	Reference to the DataTypeMapping to be applied for the particular ParameterSwComponentType **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=dataTypeMapping
instantiation DataDefProps	InstantiationDataDef Props	*	aggr	The purpose of this is that within the context of a given SwComponentType some data def properties of individual instantiations can be modified. The aggregation of InstantiationDataDefProps is subject to variability with the purpose to support the conditional existence of PortPrototypes **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.188: ParameterSwComponentType

Class	**PerInstanceMemory**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::PerInstanceMemory			
Note	Defines a 'C' typed memory-block that needs to be available for each instance of the SW-component. This is typically only useful if supportsMultipleInstantiation is set to "true" or if the software-component defines NVRAM access via permanent blocks.			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
initValue	String	0..1	attr	Specifies initial value(s) of the PerInstanceMemory

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Class	**PerInstanceMemory**			
swDataDef Props	SwDataDefProps	0..1	aggr	This represents the ability to to allocate RAM at specific memory sections, for example, to support the RAM Block recovery strategy by mapping to uninitialized RAM.
type	CIdentifier	1	attr	The name of the "C"-type
typeDefinition	String	1	attr	A definition of the type with the syntax of a 'C' typedef.

Table D.189: PerInstanceMemory

Class	**PortAPIOption**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::PortAPIOptions			
Note	Options how to generate the signatures of calls for an AtomicSwComponentType in order to communicate over a PortPrototype (for calls into a RunnableEntity as well as for calls from a Runnable Entity to the PortPrototype).			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
enableTake Address	Boolean	1	attr	If set to true, the software-component is able to use the API reference for deriving a pointer to an object.
errorHandling	DataTransformation ErrorHandlingEnum	0..1	attr	This specifies whether a RunnableEntity accessing a Port Prototype that is referenced by this PortAPIOption shall specifically handle transformer errors or not.
indirectAPI	Boolean	1	attr	If set to true this attribute specifies an "indirect API" to be generated for the associated port which means that the software-component is able to access the actions on a port via a pointer to an object representing a port. This allows e.g. iterating over ports in a loop. This option has no effect for PPortPrototypes of client/server interfaces.
port	PortPrototype	1	ref	The option is valid for generated functions related to communication over this port
portArg Value (ordered)	PortDefinedArgument Value	*	aggr	An argument value defined by this port.
supported Feature	SwcSupportedFeature	*	aggr	This collection specifies which features are supported by the RunnableEntitys which access a PortPrototype that it referenced by this PortAPIOption.

Table D.190: PortAPIOption

Class	**PortDefinedArgumentValue**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::PortAPIOptions			
Note	A PortDefinedArgumentValue is passed to a RunnableEntity dealing with the ClientServerOperations provided by a given PortPrototype. Note that this is restricted to PPortPrototypes of a ClientServer Interface.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
value	ValueSpecification	1	aggr	Specifies the actual value.
valueType	ImplementationData Type	1	tref	The implementation type of this argument value. It should not be composite type or a pointer. **Stereotypes:** isOfType

Table D.191: PortDefinedArgumentValue

Class	***PortInterface*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	Abstract base class for an interface that is either provided or required by a port of a software component.			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Subclasses	ClientServerInterface, *DataInterface*, ModeSwitchInterface, TriggerInterface			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
isService	Boolean	1	attr	This flag is set if the PortInterface is to be used for communication between an • ApplicationSwComponentType or • ServiceProxySwComponentType or • SensorActuatorSwComponentType or • ComplexDeviceDriverSwComponentType • ServiceSwComponentType • EcuAbstractionSwComponentType and a ServiceSwComponentType (namely an AUTOSAR Service) located on the same ECU. Otherwise the flag is not set.
serviceKind	ServiceProviderEnum	0..1	attr	This attribute provides further details about the nature of the applied service.

Table D.192: PortInterface

Class	***PortInterfaceMapping*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	Specifies one PortInterfaceMapping to support the connection of Ports typed by two different Port Interfaces with PortInterface elements having unequal names and/or unequal semantic (resolution or range).			
Base	*ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	ClientServerInterfaceMapping, ModeInterfaceMapping, TriggerInterfaceMapping, VariableAndParameterInterfaceMapping			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
–	–	–	–	–

Table D.193: PortInterfaceMapping

Class	***PortPrototype*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	Base class for the ports of an AUTOSAR software component. The aggregation of PortPrototypes is subject to variability with the purpose to support the conditional existence of ports.			
Base	*ARObject*, *AtpBlueprintable*, *AtpFeature*, *AtpPrototype*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	*AbstractProvidedPortPrototype*, *AbstractRequiredPortPrototype*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
clientServerAnnotation	ClientServerAnnotation	*	aggr	Annotation of this PortPrototype with respect to client/server communication.
delegatedPortAnnotation	DelegatedPortAnnotation	0..1	aggr	Annotations on this delegated port.

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Class	***PortPrototype*** (abstract)			
ioHwAbstraction Server Annotation	IoHwAbstractionServer Annotation	*	aggr	Annotations on this IO Hardware Abstraction port.
modePort Annotation	ModePortAnnotation	*	aggr	Annotations on this mode port.
nvDataPort Annotation	NvDataPortAnnotation	*	aggr	Annotations on this non voilatile data port.
parameterPort Annotation	ParameterPort Annotation	*	aggr	Annotations on this parameter port.
senderReceiver Annotation	SenderReceiver Annotation	*	aggr	Collection of annotations of this ports sender/receiver communication.
triggerPort Annotation	TriggerPortAnnotation	*	aggr	Annotations on this trigger port.

Table D.194: PortPrototype

Class	**PostBuildVariantCondition**			
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling			
Note	This class specifies the value which must be assigned to a particular variant criterion in order to bind the variation point. If multiple criterion/value pairs are specified, they shall all match to bind the variation point. In other words binding can be represented by `(criterion1 == value1) && (condition2 == value2) ...`			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
matching Criterion	PostBuildVariant Criterion	1	ref	This is the criterion which needs to match the value in order to make the PostbuildVariantCondition to be true.
value	Integer	1	attr	This is the particular value of the post-build variant criterion. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.195: PostBuildVariantCondition

Class	**PostBuildVariantCriterion**			
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling			
Note	This class specifies one particular PostBuildVariantSelector. **Tags:** atp.recommendedPackage=PostBuildVariantCriterions			
Base	*ARElement*, *ARObject*, *AtpDefinition*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
compuMethod	CompuMethod	1	ref	The compuMethod specifies the possible values for the variant criterion serving as an enumerator.

Table D.196: PostBuildVariantCriterion

Class	**PostBuildVariantCriterionValue**			
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling			
Note	This class specifies a the value which must be assigned to a particular variant criterion in order to bind the variation point. If multiple criterion/value pairs are specified, they all must must match to bind the variation point.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
annotation	Annotation	*	aggr	This provides the ability to add information why the value is set like it is. **Tags:** xml.sequenceOffset=30
value	Integer	1	attr	This is the particular value of the post-build variant criterion. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.sequenceOffset=20
variantCriterion	PostBuildVariantCriterion	1	ref	This association selects the variant criterion whose value is specified. **Tags:** xml.sequenceOffset=10

Table D.197: PostBuildVariantCriterionValue

Class	**PostBuildVariantCriterionValueSet**			
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling			
Note	This meta-class represents the ability to denote one set of postBuildVariantCriterionValues. **Tags:** atp.recommendedPackage=PostBuildVariantCriterionValueSets			
Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
postBuildVariantCriterionValue	PostBuildVariantCriterionValue	*	aggr	This is is one particular postbuild variant criterion/value pair being part of the PostBuildVariantSet.

Table D.198: PostBuildVariantCriterionValueSet

Class	**PredefinedVariant**			
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling			
Note	This specifies one predefined variant. It is characterized by the union of all system constant values and post-build variant criterion values aggregated within all referenced system constant value sets and post build variant criterion value sets plus the value sets of the included variants. **Tags:** atp.recommendedPackage=PredefinedVariants			
Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
includedVariant	PredefinedVariant	*	ref	The associated variants are considered part of this PredefinedVariant. This means the settings of the included variants are included in the settings of the referencing PredefinedVariant. Nevertheless the included variants might be included in several predefined variants.
postBuildVariantCriterionValueSet	PostBuildVariantCriterionValueSet	*	ref	This is the postBuildVariantCriterionValueSet contributing to the predefinded variant.

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Class	PredefinedVariant			
sw Systemconstant ValueSet	SwSystemconstant ValueSet	*	ref	This ist the set of Systemconstant Values contributing to the predefined variant.

Table D.199: PredefinedVariant

Class	**QueuedReceiverComSpec**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	Communication attributes specific to queued receiving.			
Base	*ARObject*, *RPortComSpec*, *ReceiverComSpec*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
queueLength	PositiveInteger	1	attr	Length of queue for received events.

Table D.200: QueuedReceiverComSpec

Class	**QueuedSenderComSpec**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	Communication attributes specific to distribution of events (PPortPrototype, SenderReceiverInterface and dataElement carries an "event").			
Base	*ARObject*, *PPortComSpec*, *SenderComSpec*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
–	–	–	–	–

Table D.201: QueuedSenderComSpec

Class	**RPortPrototype**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	Component port requiring a certain port interface.			
Base	*ARObject*, *AbstractRequiredPortPrototype*, *AtpBlueprintable*, *AtpFeature*, *AtpPrototype*, *Identifiable*, *MultilanguageReferrable*, *PortPrototype*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
required Interface	PortInterface	1	tref	The interface that this port requires, i.e. the port depends on another port providing the specified interface. **Stereotypes:** isOfType

Table D.202: RPortPrototype

Class	***RTEEvent*** (abstract)
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents
Note	Abstract base class for all RTE-related events
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*
Subclasses	AsynchronousServerCallReturnsEvent, BackgroundEvent, DataReceiveErrorEvent, DataReceivedEvent, DataSendCompletedEvent, DataWriteCompletedEvent, ExternalTriggerOccurredEvent, InitEvent, InternalTriggerOccurredEvent, ModeSwitchedAckEvent, OperationInvokedEvent, SwcModeManagerErrorEvent, SwcModeSwitchEvent, TimingEvent, TransformerHardErrorEvent

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Class	***RTEEvent*** (abstract)			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
disabledMode	ModeDeclaration	*	iref	Reference to the Modes that disable the Event. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=contextPort, contextModeDeclarationGroupPrototype, targetModeDeclaration
startOnEvent	RunnableEntity	0..1	ref	RunnableEntity starts when the corresponding RTEEvent occurs.

Table D.203: RTEEvent

Class	**RapidPrototypingScenario**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::RPTScenario			
Note	This meta class provides the ability to describe a Rapid Prototyping Scenario. Such a Rapid Prototyping Scenario consist out of two main aspects, the description of the byPassPoints and the relation to an rpt Hook. **Tags:** atp.recommendedPackage=RapidPrototypingScenarios			
Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *Packageable Element*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
hostSystem	System	1	ref	System which describes the software components of the host ECU.
rptContainer	RptContainer	1..*	aggr	Top-level rptContainer definitions of this specific rapid prototyping scenario. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
rptProfile	RptProfile	*	aggr	Defiens the applicable Rapid Prototyping profils which are especially defining the smbol of the service functions and the valid id range. The order of the RptProfiles determines the order of the service function invocation by RTE. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=shortName
rptSystem	System	0..1	ref	System which describes the rapid prototyping algorithm in the format of AUTOSAR Software Components. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=rptSystem

Table D.204: RapidPrototypingScenario

Class	***ReceiverComSpec*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	Receiver-specific communication attributes (RPortPrototype typed by SenderReceiverInterface).			
Base	*ARObject*, *RPortComSpec*			
Subclasses	NonqueuedReceiverComSpec, QueuedReceiverComSpec			
Attribute	***Type***	***Mul.***	***Kind***	***Note***

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Class	***ReceiverComSpec*** (abstract)			
composite Network Representation	CompositeNetwork Representation	*	aggr	This represents a CompositeNetworkRepresentation defined in the context of a ReceiverComSpec. The purpose of this aggregation is to be able to specify the network representation of leaf elements of Application CompositeDataTypes.
dataElement	AutosarDataPrototype	0..1	ref	Data element these attributes belong to.
handleOutOf Range	HandleOutOfRange Enum	1	attr	This attribute controls how values that are out of the specified range are handled according to the values of HandleOutOfRangeEnum.
handleOutOf RangeStatus	HandleOutOfRange StatusEnum	0..1	attr	Control the way how return values are created in case of an out-of-range situation.
maxDelta CounterInit	PositiveInteger	0..1	attr	Initial maximum allowed gap between two counter values of two consecutively received valid Data, i.e. how many subsequent lost data is accepted. For example, if the receiver gets Data with counter 1 and MaxDeltaCounter Init is 1, then at the next reception the receiver can accept Counters with values 2 and 3, but not 4. Note that if the receiver does not receive new Data at a consecutive read, then the receiver increments the tolerance by 1. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
maxNoNewOr RepeatedData	PositiveInteger	0..1	attr	The maximum amount of missing or repeated Data which the receiver does not expect to exceed under normal communication conditions.
network Representation	SwDataDefProps	0..1	aggr	A networkRepresentation is used to define how the data Element is mapped to a communication bus.
replaceWith	VariableAccess	0..1	aggr	This aggregation is used to identify the AutosarData Prototype to be taken for sourcing an external replacement in the out-of-range handling.
syncCounterInit	PositiveInteger	0..1	attr	Number of Data required for validating the consistency of the counter that shall be received with a valid counter (i.e. counter within the allowed lock-in range) after the detection of an unexpected behavior of a received counter.
transformation ComSpecProps	TransformationCom SpecProps	*	aggr	This references the TransformationComSpecProps which define port-specific configuration for data transformation.
usesEndToEnd Protection	Boolean	0..1	attr	This indicates whether the corresponding dataElement shall be transmitted using end-to-end protection. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.205: ReceiverComSpec

Class	**ReferenceValueSpecification**			
Package	M2::AUTOSARTemplates::CommonStructure::Constants			
Note	Specifies a reference to a data prototype to be used as an initial value for a pointer in the software.			
Base	*ARObject*, *ValueSpecification*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
referenceValue	DataPrototype	1	ref	The referenced data prototype.

Table D.206: ReferenceValueSpecification

Class	***Referrable*** (abstract)			
Package	M2::AUTOSARTemplates::GenericStructure::GeneralTemplateClasses::Identifiable			
Note	Instances of this class can be referred to by their identifier (while adhering to namespace borders).			
Base	*ARObject*			
Subclasses	*AtpDefinition*, BswDistinguishedPartition, *BswModuleCallPoint*, BswModuleClientServerEntry, BswVariableAccess, CouplingPortTrafficClassAssignment, DiagnosticDebounceAlgorithmProps, *DiagnosticEnvModeElement*, EthernetPriorityRegeneration, EventHandler, ExclusiveAreaNestingOrder, *HwDescriptionEntity*, *ImplementationProps*, LinSlaveConfigIdent, ModeTransition, *MultilanguageReferrable*, PncMappingIdent, *SingleLanguageReferrable*, SocketConnectionBundle, TimeSyncServerConfiguration, TpConnectionIdent			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
shortName	Identifier	1	attr	This specifies an identifying shortName for the object. It needs to be unique within its context and is intended for humans but even more for technical reference. **Tags:** xml.enforceMinMultiplicity=true xml.sequenceOffset=-100
shortName Fragment	ShortNameFragment	*	aggr	This specifies how the Referrable.shortName is composed of several shortNameFragments. **Tags:** xml.sequenceOffset=-90

Table D.207: Referrable

Primitive	**RevisionLabelString**
Package	M2::AUTOSARTemplates::GenericStructure::GeneralTemplateClasses::PrimitiveTypes
Note	This primitive represents a revision label which identifies an engineering object. It represents a pattern which • requires three integers representing from left to right MajorVersion, MinorVersion, PatchVersion. • may add an application specific suffix separated by one of ".", "_", ";". Legal patterns are for example: 4.0.0 4.0.0.1234565 4.0.0_vendor specific;13 4.0.0;12 **Tags:** xml.xsd.customType=REVISION-LABEL-STRING xml.xsd.pattern=[0-9]+\.[0-9]+\.[0-9]+([\._;].*)? xml.xsd.type=string

Table D.208: RevisionLabelString

Class	**RoleBasedPortAssignment**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::ServiceMapping			
Note	This class specifies an assignment of a role to a particular service port (RPortPrototype or PPortPrototype) of an AtomicSwComponentType. With this assignment, the role of the service port can be mapped to a specific ServiceNeeds element, so that a tool is able to create the correct connector.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***

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Class	**RoleBasedPortAssignment**			
portPrototype	PortPrototype	1	ref	Service PortPrototype used in the assigned role. This PortPrototype shall either belong to the same AtomicSwComponentType as the SwcInternalBehavior which owns the ServiceDependency or to the same NvBlockSwComponentType as the NvBlockDescriptor.
role	Identifier	1	attr	This is the role of the assigned Port in the given context. The value shall be a shortName of the Blueprint of a PortInterface as standardized in the Software Specification of the related AUTOSAR Service.

Table D.209: RoleBasedPortAssignment

Class	**RootSwCompositionPrototype**			
Package	M2::AUTOSARTemplates::SystemTemplate			
Note	The RootSwCompositionPrototype represents the top-level-composition of software components within a given System. According to the use case of the System, this may for example be the a more or less complete VFB description, the software of a System Extract or the software of a flat ECU Extract with only atomic SWCs. Therefore the RootSwComposition will only occasionally contain all atomic software components that are used in a complete VFB System. The OEM is primarily interested in the required functionality and the interfaces defining the integration of the Software Component into the System. The internal structure of such a component contains often substantial intellectual property of a supplier. Therefore a top-level software composition will often contain empty compositions which represent subsystems. The contained SwComponentPrototypes are fully specified by their SwComponentTypes (including PortPrototypes, PortInterfaces, VariableDataPrototypes, SwcInternalBehavior etc.), and their ports are interconnected using SwConnectorPrototypes.			
Base	*ARObject*, *AtpFeature*, *AtpPrototype*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
calibrationParameterValueSet	CalibrationParameterValueSet	*	ref	Used CalibrationParameterValueSet for instance specific initialization of calibration parameters. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=calibrationParameterValueSet
flatMap	FlatMap	0..1	ref	The FlatMap used in the scope of this RootSwCompositionPrototype. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=flatMap
softwareComposition	CompositionSwComponentType	1	tref	We assume that there is exactly one top-level composition that includes all Component instances of the system **Stereotypes:** isOfType

Table D.210: RootSwCompositionPrototype

Enumeration	**RptAccessEnum**
Package	M2::AUTOSARTemplates::CommonStructure::MeasurementCalibrationSupport::RptSupport
Note	Determines the access rights to a data object with respect to rapid prototyping.
Literal	***Description***
enabled	The related data element is accessible by RP tool. **Tags:** atp.EnumerationValue=0

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Enumeration	**RptAccessEnum**
none	The related data element is not accessible by RP tool. **Tags:** atp.EnumerationValue=1
protected	The data element is known to the RP tool however its usage for RP can be restricted. Use case: limitation based on access rights **Tags:** atp.EnumerationValue=2

Table D.211: RptAccessEnum

Class	**RptContainer**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::RPTScenario			
Note	This meta class defines a byPassPoint and the relation to a rptHook. Additionally it may contain further rptContainers if the byPassPoint is not atomic. For example a byPass Point refereing to a RunnableEntity may contain rptContainers referring to the data access points of the RunnableEntity. The RptContainer structure on M1 shall follow the M1 structure of the Software Component Descriptions. The category attribute denotes which level of the Software Component Description is annotated.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
byPassPoint	AtpFeature	1..*	iref	byPassPoint desribes the required preparation of the host ECU. At a byPassPoint the host ECU shall be capable to communicate with a RPT System in order to support the execution of the rapid prototyping algorithms with the original data calculated by the host system and to replace dedicated results of the host system by the results of the rapid prototyping algorithm. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=byPassPoint vh.latestBindingTime=preCompileTime
explicitRpt ProfileSelection	RptProfile	*	ref	This attribute defines the applicable RptProfiles for the specific RptContainer. If not any references to a specific RptProfile is defined, all RptProfiles defined in the Rapid PrototypingScenario are applicable. **Tags:** atp.Splitkey=explicitRptProfileSelection
rptContainer	RptContainer	*	aggr	Sub-level rptContainer definitions of this specific rapid prototyping scenario. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
rptExecutable EntityProperties	RptExecutableEntity Properties	0..1	aggr	Describes the required code preparation for rapid prototyping at ExecutableEntity invocation.
rptHook	RptHook	0..1	aggr	The rptHook describes the link between a byPassPoint and the rapid prototyping algorithm. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=rptHook, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
rptImplPolicy	RptImplPolicy	0..1	aggr	Describes the required code preparation for rapid prototyping at data accesses.
rptSw Prototyping Access	RptSwPrototyping Access	0..1	aggr	Describes the required accessibility of data and modes by the rapid prototyping tooling.

Table D.212: RptContainer

Enumeration	**RptEnablerImplTypeEnum**
Package	M2::AUTOSARTemplates::CommonStructure::MeasurementCalibrationSupport::RptSupport
Note	Describes the required / implemented usage of enabler flags for data access in the code.
Literal	*Description*
none	No "RP enabler" is implemented. **Tags:** atp.EnumerationValue=0
rptEnablerRam	"RP enabler" is implemented as a RAM variable **Tags:** atp.EnumerationValue=1
rptEnablerRamAnd Rom	The RTE generator implements both the RAM and ROM "RP enabler". **Tags:** atp.EnumerationValue=3
rptEnablerRom	"RP enabler" is implemented as a calibrateable ROM variable. **Tags:** atp.EnumerationValue=2

Table D.213: RptEnablerImplTypeEnum

Class	**RptExecutableEntityEvent**			
Package	M2::AUTOSARTemplates::CommonStructure::MeasurementCalibrationSupport::RptSupport			
Note	This describes an ExecutableEntity event instance which can be bypassed.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
execution Context	RptExecutionContext	1..*	ref	This describes the context in which the event of the executable entity is executed.
mcData Assignment	RoleBasedMcData Assignment	*	aggr	Reference to related McDataElements describing the implementation of "RP runnable disabler flag" and "stimulation enabler flag" The possible roles of the RoleBasedMcData Assignment.role attribute are: • RpRunnableDisablerFlag"
rptEventId	PositiveInteger	1	attr	RPT event id used for service points call.
rptExecutable EntityProperties	RptExecutableEntity Properties	1	aggr	Describes the implemented code preparation for rapid prototyping at ExecutableEntity invocation.
rptImplPolicy	RptImplPolicy	0..1	aggr	Describes the RptImplPolicy of a RptExecutableEvent for service based bypassing.
rptServicePoint Post	RptServicePoint	1..*	ref	This describes the applicable Post Service Points for a RTEEvent / BswEvent of a bypassed ExecutableEntity.
rptServicePoint Pre	RptServicePoint	1..*	ref	This describes the applicable Pre Service Points for a RTEEvent / BswEvent of a bypassed ExecutableEntity.

Table D.214: RptExecutableEntityEvent

Class	**RptExecutableEntityProperties**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::RPTScenario			
Note	Describes the code preparation for rapid prototyping at ExecutableEntity invocation.			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
maxRptEventId	PositiveInteger	1	attr	Highest RPT event id useable for RTE generated service points. This attribute is relevant, if dedicated id range shall be applied to the ExecutableEntitys of a software component or specific ExecutableEntitys.

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Class	RptExecutableEntityProperties			
minRptEventId	PositiveInteger	1	attr	Lowest RPT event id useable for RTE generated service points. This attribute is relevant, if dedicated id range shall be applied to the ExecutableEntitys of a software component or specific ExecutableEntitys.
rptExecution Control	RptExecutionControl Enum	1	attr	This attribute specifies the rapid prototyping control of the executable
rptServicePoint	RptServicePointEnum	1	attr	Enables generation of service points by the RTE generator.

Table D.215: RptExecutableEntityProperties

Enumeration	**RptExecutionControlEnum**
Package	M2::AUTOSARTemplates::CommonStructure::MeasurementCalibrationSupport::RptSupport
Note	Determines rapid prototyping preparation of an ExecutableEntity.
Literal	***Description***
conditional	The ExecutableEntity is only executed when the rapid prototyping disable flag is NOT set. **Tags:** atp.EnumerationValue=0
none	The ExecutableEntity is executed without specific rapid prototyping condition. **Tags:** atp.EnumerationValue=1

Table D.216: RptExecutionControlEnum

Class	**RptImplPolicy**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::RPTScenario			
Note	Describes the code preparation for rapid prototyping at data accesses.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
rptEnablerImpl Type	RptEnablerImplType Enum	1	attr	For Level 2 or Level3 this property determines how the RTE implements the additional "RP enabler" flag.
rptPreparation Level	RptPreparationEnum	1	attr	Mandates RP preparation level for access to VariableData Prototype within generated RTE implementation.

Table D.217: RptImplPolicy

Enumeration	**RptPreparationEnum**
Package	M2::AUTOSARTemplates::CommonStructure::MeasurementCalibrationSupport::RptSupport
Note	Determines the RP preparation level for access to VariableDataPrototypes within the generated RTE implementation.
Literal	***Description***
none	No RP preparation for VariableDataPrototype. **Tags:** atp.EnumerationValue=0
rptLevel1	The RTE implementation uses an "RP global buffer" for measurement and post-build hooking purposes. **Tags:** atp.EnumerationValue=1

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Enumeration	**RptPreparationEnum**
rptLevel2	As rpLevel1 but the RTE implementation also uses both "RP enabler flag" to permit RP overwrite at run-time. **Tags:** atp.EnumerationValue=2
rptLevel3	As rpLevel2 but the RTE implementation also uses "RP global measurement buffer" to record the original ECU-generated value in addition to the RP value. **Tags:** atp.EnumerationValue=3

Table D.218: RptPreparationEnum

Class	**RptProfile**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::RPTScenario			
Note	The RptProfile describes the common properties of a Rapid Prototyping method.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
maxServicePointId	PositiveInteger	1	attr	Highest service point id useable for RTE generated service points.
minServicePointId	PositiveInteger	1	attr	Lowest service point id useable for RTE generated service points.
servicePointSymbolPost	CIdentifier	1	attr	Complete symbol of the function implementing the post service point. This symbol is used for post-build hooking purposes.
servicePointSymbolPre	CIdentifier	1	attr	Complete symbol of the function implementing the pre service point. This symbol is used for post-build hooking purposes.
stimEnabler	RptEnablerImplTypeEnum	1	attr	Defines if the service points support the stimulation enabler. If RptProfile.stimEnabler is "none" then no stimulation enabler is passed to the service function. Otherwise the stimulation enabler will be passed as a parameter.

Table D.219: RptProfile

Class	**RptSupportData**			
Package	M2::AUTOSARTemplates::CommonStructure::MeasurementCalibrationSupport::RptSupport			
Note	Root element for rapid prototyping support data related to one Implementation artifact on an ECU, in particular the RTE. The rapid prototyping support data may reference to elements provided for McSupportData.			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
executionContext	RptExecutionContext	1..*	aggr	Defines an environment for the execution of Executable Entites.
rptComponent	RptComponent	1..*	aggr	Description of components for which rapid prototyping support is implemented. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
rptServicePoint	RptServicePoint	1..*	aggr	This aggregation represents the collection of service points associated with the enclosing RptSuportData **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.220: RptSupportData

Class	RptSwPrototypingAccess			
Package	M2::AUTOSARTemplates::CommonStructure::MeasurementCalibrationSupport::RptSupport			
Note	Describes the accessibility of data and modes by the rapid prototyping tooling.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
rptHookAccess	RptAccessEnum	1	attr	The related data element can be modified using a post-build hooking tool. An ENABLED VariableData Prototype is implicitly READABLE/WRITABLE.
rptReadAccess	RptAccessEnum	1	attr	The related data element can be used as input for bypass functionality by RP tool. If rptImplPolicy is not specified then RTE generation must ensure at least suitable MC read points are created.
rptWriteAccess	RptAccessEnum	1	attr	The related data element can be used as output for bypass functionality by RP tool. The data element must be prepared to rptLevel2 and related write service points are present.

Table D.221: RptSwPrototypingAccess

Class	RtePluginProps			
Package	M2::AUTOSARTemplates::CommonStructure::FlatMap			
Note	The properties of a communication graph with respect to the utilization of RTE Implementation Plug-in.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
associatedRte Plugin	EcucContainerValue	1	ref	This associates a communication graph to a specific RTE Implementation Plug-in.

Table D.222: RtePluginProps

Class	RuleBasedValueSpecification			
Package	M2::AUTOSARTemplates::CommonStructure::Constants			
Note	This meta-class is used to support a rule-based initialization approach for data types with an array-nature (ApplicationArrayDataType and ImplementationDataType of category ARRAY) or a compound Application PrimitiveDataType (which also boils down to an array-nature).			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
arguments	RuleArguments	1	aggr	This represents the arguments for the RuleBasedValue Specification. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.sequenceOffset=30
maxSizeToFill	Integer	0..1	attr	If a rule is chosen which does not fill until the end, this determines until which size the rule shall fill the values. **Tags:** xml.sequenceOffset=40

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Class	**RuleBasedValueSpecification**			
rule	Identifier	1	attr	This denotes the name of the rule of the RuleBasedValue Specification. The rule determines the calculation specification according which the arguments are used to calculated the values. **Tags:** xml.sequenceOffset=20

Table D.223: RuleBasedValueSpecification

Class	**RunnableEntity**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior			
Note	A RunnableEntity represents the smallest code-fragment that is provided by an AtomicSwComponent Type and are executed under control of the RTE. RunnableEntities are for instance set up to respond to data reception or operation invocation on a server.			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *ExecutableEntity*, *Identifiable*, *Multilanguage Referrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
argument (ordered)	RunnableEntity Argument	*	aggr	This represents the formal definition of a an argument to a RunnableEntity.
asynchronous ServerCall ResultPoint	AsynchronousServer CallResultPoint	*	aggr	The server call result point admits a runnable to fetch the result of an asynchronous server call. The aggregation of AsynchronousServerCallResultPoint is subject to variability with the purpose to support the conditional existence of client server PortPrototypes and the variant existence of server call result points in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
canBeInvoked Concurrently	Boolean	1	attr	If the value of this attribute is set to "true" the enclosing RunnableEntity can be invoked concurrently (even for one instance of the corresponding AtomicSwComponent Type). This implies that it is the responsibility of the implementation of the RunnableEntity to take care of this form of concurrency. Note that the default value of this attribute is set to "false".
dataRead Access	VariableAccess	*	aggr	RunnableEntity has implicit read access to dataElement of a sender-receiver PortPrototype or nv data of a nv data PortPrototype. The aggregation of dataReadAccess is subject to variability with the purpose to support the conditional existence of sender receiver ports or the variant existence of dataReadAccess in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
dataReceive PointBy Argument	VariableAccess	*	aggr	RunnableEntity has explicit read access to dataElement of a sender-receiver PortPrototype or nv data of a nv data PortPrototype. The result is passed back to the application by means of an argument in the function signature. The aggregation of dataReceivePointByArgument is subject to variability with the purpose to support the ▽

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Class	RunnableEntity			
				△ conditional existence of sender receiver PortPrototype or the variant existence of data receive points in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
dataReceive PointByValue	VariableAccess	*	aggr	RunnableEntity has explicit read access to dataElement of a sender-receiver PortPrototype or nv data of a nv data PortPrototype. The result is passed back to the application by means of the return value. The aggregation of dataReceivePointByValue is subject to variability with the purpose to support the conditional existence of sender receiver ports or the variant existence of data receive points in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
dataSendPoint	VariableAccess	*	aggr	RunnableEntity has explicit write access to dataElement of a sender-receiver PortPrototype or nv data of a nv data PortPrototype. The aggregation of dataSendPoint is subject to variability with the purpose to support the conditional existence of sender receiver PortPrototype or the variant existence of data send points in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
dataWrite Access	VariableAccess	*	aggr	RunnableEntity has implicit write access to dataElement of a sender-receiver PortPrototype or nv data of a nv data PortPrototype. The aggregation of dataWriteAccess is subject to variability with the purpose to support the conditional existence of sender receiver ports or the variant existence of dataWriteAccess in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
external TriggeringPoint	ExternalTriggeringPoint	*	aggr	The aggregation of ExternalTriggeringPoint is subject to variability with the purpose to support the conditional existence of trigger ports or the variant existence of external triggering points in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=externalTriggeringPoint, variation Point.shortLabel vh.latestBindingTime=preCompileTime
internal TriggeringPoint	InternalTriggeringPoint	*	aggr	The aggregation of InternalTriggeringPoint is subject to variability with the purpose to support the variant existence of internal triggering points in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime

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Class	**RunnableEntity**			
modeAccess Point	ModeAccessPoint	*	aggr	The runnable has a mode access point. The aggregation of ModeAccessPoint is subject to variability with the purpose to support the conditional existence of mode ports or the variant existence of mode access points in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=modeAccessPoint, variation Point.shortLabel vh.latestBindingTime=preCompileTime
modeSwitch Point	ModeSwitchPoint	*	aggr	The runnable has a mode switch point. The aggregation of ModeSwitchPoint is subject to variability with the purpose to support the conditional existence of mode ports or the variant existence of mode switch points in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
parameter Access	ParameterAccess	*	aggr	The presence of a ParameterAccess implies that a RunnableEntity needs read only access to a Parameter DataPrototype which may either be local or within a Port Prototype. The aggregation of ParameterAccess is subject to variability with the purpose to support the conditional existence of parameter ports and component local parameters as well as the variant existence of Parameter Access (points) in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
readLocal Variable	VariableAccess	*	aggr	The presence of a readLocalVariable implies that a RunnableEntity needs read access to a VariableData Prototype in the role of implicitInterRunnableVariable or explicitInterRunnableVariable. The aggregation of readLocalVariable is subject to variability with the purpose to support the conditional existence of implicitInterRunnableVariable and explicit InterRunnableVariable or the variant existence of read LocalVariable (points) in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
serverCallPoint	ServerCallPoint	*	aggr	The RunnableEntity has a ServerCallPoint. The aggregation of ServerCallPoint is subject to variability with the purpose to support the conditional existence of client server PortPrototypes or the variant existence of server call points in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
symbol	CIdentifier	1	attr	The symbol describing this RunnableEntity's entry point. This is considered the API of the RunnableEntity and is required during the RTE contract phase.
waitPoint	WaitPoint	*	aggr	The WaitPoint associated with the RunnableEntity.

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Class	RunnableEntity			
writtenLocal Variable	VariableAccess	*	aggr	The presence of a writtenLocalVariable implies that a RunnableEntity needs write access to a VariableData Prototype in the role of implicitInterRunnableVariable or explicitInterRunnableVariable. The aggregation of writtenLocalVariable is subject to variability with the purpose to support the conditional existence of implicitInterRunnableVariable and explicit InterRunnableVariable or the variant existence of written LocalVariable (points) in the implementation. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime

Table D.224: RunnableEntity

Class	**RunnableEntityArgument**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RunnableEntity			
Note	This meta-class represents the ability to provide specific information regarding the arguments to a RunnableEntity.			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
symbol	CIdentifier	1	attr	This represents the symbol to be generated into the actual signature on the level of the C programming language.

Table D.225: RunnableEntityArgument

Class	**RunnableEntityGroup**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::ImplicitCommunicationBehavior			
Note	This meta-class represents the ability to define a collection of RunnableEntities. The collection can be nested.			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
runnableEntity	RunnableEntity	*	iref	This represents a collection of RunnableEntitys that belong to the enclosing RunnableEntityGroup. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
runnableEntity Group	RunnableEntityGroup	*	iref	This represents the ability to define nested groups of RunnableEntitys. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.226: RunnableEntityGroup

Class	**Sdg**			
Package	M2::MSR::AsamHdo::SpecialData			
Note	Sdg (SpecialDataGroup) is a generic model which can be used to keep arbitrary information which is not explicitly modeled in the meta-model. Sdg can have various contents as defined by sdgContentsType. Special Data should only be used moderately since all elements should be defined in the meta-model. Thereby SDG should be considered as a temporary solution when no explicit model is available. If an sdg Caption is available, it is possible to establish a reference to the sdg structure.			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
gid	NameToken	1	attr	This attributes specifies an identifier. Gid comes from the SGML/XML-Term "Generic Identifier" which is the element name in XML. The role of this attribute is the same as the name of an XML - element. **Tags:** xml.attribute=true
sdgCaption	SdgCaption	0..1	aggr	This aggregation allows to assign the properties of Identifiable to the sdg. By this, a shortName etc. can be assigned to the Sdg. **Tags:** xml.sequenceOffset=20
sdgCaptionRef	SdgCaption	0..1	ref	This association allows to reuse an already existing caption. **Tags:** xml.name=SDG-CAPTION-REF xml.sequenceOffset=25
sdgContents Type	SdgContents	0..1	aggr	This is the content of the Sdg. **Tags:** xml.roleElement=false xml.roleWrapperElement=false xml.sequenceOffset=30 xml.typeElement=false xml.typeWrapperElement=false

Table D.227: Sdg

Class	**ScaleConstr**			
Package	M2::MSR::AsamHdo::Constraints::GlobalConstraints			
Note	This meta-class represents the ability to specify constraints as a list of intervals (called scales).			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
desc	MultiLanguageOverview Paragraph	0..1	aggr	<desc> represents a general but brief description of the object in question. **Tags:** xml.sequenceOffset=30
lowerLimit	Limit	0..1	attr	This specifies the lower limit of the scale. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.sequenceOffset=40
shortLabel	Identifier	0..1	attr	This element specifies a short name for the scaleConstr. This can for example be used to create more specific messages of a constraint checker. The constraints cannot be associated in the meta-model, therefore shortLabel is somehow a substitute for shortName. **Tags:** xml.sequenceOffset=20

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Class	**ScaleConstr**			
upperLimit	Limit	0..1	attr	This specifies the upper limit of a the scale. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.sequenceOffset=50
validity	ScaleConstrValidity Enum	0..1	attr	Specifies if the values defined by the scales are considered to be valid. If the attribute is missing then the default value is "VALID". **Tags:** xml.attribute=true

Table D.228: ScaleConstr

Class	**SectionNamePrefix**			
Package	M2::AUTOSARTemplates::CommonStructure::ResourceConsumption::MemorySectionUsage			
Note	A prefix to be used for generated code artifacts defining a memory section name in the source code of the using module or SWC.			
Base	*ARObject*, *ImplementationProps*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
implementedIn	DependencyOnArtifact	0..1	ref	Optional reference that allows to Indicate the code artifact (header file) containing the preprocessor implementation of memory sections with this prefix. The usage of this link supersedes the usage of a memory mapping header with the default name (derived from the BswModuleDescription's shortName).

Table D.229: SectionNamePrefix

Class	***SenderComSpec*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	Communication attributes for a sender port (PPortPrototype typed by SenderReceiverInterface).			
Base	*ARObject*, *PPortComSpec*			
Subclasses	NonqueuedSenderComSpec, QueuedSenderComSpec			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
composite Network Representation	CompositeNetwork Representation	*	aggr	This represents a CompositeNetworkRepresentation defined in the context of a SenderComSpec.
dataElement	AutosarDataPrototype	0..1	ref	Data element these quality of service attributes apply to.
handleOutOf Range	HandleOutOfRange Enum	1	attr	This attribute controls how out-of-range values shall be dealt with.
network Representation	SwDataDefProps	0..1	aggr	A networkRepresentation is used to define how the data Element is mapped to a communication bus.
transmission Acknowledge	Transmission Acknowledgement Request	0..1	aggr	Requested transmission acknowledgement for data element.
usesEndToEnd Protection	Boolean	0..1	attr	This indicates whether the corresponding dataElement shall be transmitted using end-to-end protection. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.230: SenderComSpec

Class	**SenderReceiverInterface**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	A sender/receiver interface declares a number of data elements to be sent and received. **Tags:** atp.recommendedPackage=PortInterfaces			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *DataInterface*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *PortInterface*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
dataElement	VariableDataPrototype	1..*	aggr	The data elements of this SenderReceiverInterface.
invalidation Policy	InvalidationPolicy	*	aggr	InvalidationPolicy for a particular dataElement

Table D.231: SenderReceiverInterface

Class	**SenderReceiverToSignalGroupMapping**			
Package	M2::AUTOSARTemplates::SystemTemplate::DataMapping			
Note	Mapping of a sender receiver communication data element with a composite datatype to a signal group.			
Base	*ARObject*, *DataMapping*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
dataElement	VariableDataPrototype	1	iref	Reference to a data element with a composite datatype which is mapped to a signal group.
signalGroup	SystemSignalGroup	1	ref	Reference to the signal group, which contain all primitive datatypes of the composite type
typeMapping	SenderRecComposite TypeMapping	1	aggr	The CompositeTypeMapping maps the the Application ArrayElements and ApplicationRecordElements to Signals of the SignalGroup.

Table D.232: SenderReceiverToSignalGroupMapping

Class	**SenderReceiverToSignalMapping**			
Package	M2::AUTOSARTemplates::SystemTemplate::DataMapping			
Note	Mapping of a sender receiver communication data element to a signal.			
Base	*ARObject*, *DataMapping*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
dataElement	VariableDataPrototype	1	iref	Reference to the data element.
systemSignal	SystemSignal	1	ref	Reference to the system signal used to carry the data element.

Table D.233: SenderReceiverToSignalMapping

Class	**SensorActuatorSwComponentType**
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components
Note	The SensorActuatorSwComponentType introduces the possibility to link from the software representation of a sensor/actuator to its hardware description provided by the ECU Resource Template. **Tags:** atp.recommendedPackage=SwComponentTypes
Base	*ARElement*, *ARObject*, *AtomicSwComponentType*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*, *SwComponentType*

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Class	**SensorActuatorSwComponentType**			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
sensorActuator	HwDescriptionEntity	1	ref	Reference from the Sensor Actuator Software Component Type to the description of the actual hardware.

Table D.234: SensorActuatorSwComponentType

Enumeration	**ServerArgumentImplPolicyEnum**
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface
Note	This defines how the argument type of the servers RunnableEntity is implemented.
Literal	**Description**
useArgumentType	The argument type of the RunnableEntity is derived from the AutosarDataType of the Argument Prototype. **Tags:** atp.EnumerationValue=0
useVoid	The argument type of the RunnableEntity is void. **Tags:** atp.EnumerationValue=2

Table D.235: ServerArgumentImplPolicyEnum

Class	***ServerCallPoint*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::ServerCall			
Note	If a RunnableEntity owns a ServerCallPoint it is entitled to invoke a particular ClientServerOperation of a specific RPortPrototype of the corresponding AtomicSwComponentType			
Base	*ARObject*, *AbstractAccessPoint*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	AsynchronousServerCallPoint, SynchronousServerCallPoint			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
operation	ClientServerOperation	0..1	iref	The operation that is called by this runnable.
timeout	TimeValue	1	attr	Time in seconds before the server call times out and returns with an error message. It depends on the call type (synchronous or asynchronous) how this is reported.

Table D.236: ServerCallPoint

Class	**ServerComSpec**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	Communication attributes for a server port (PPortPrototype and ClientServerInterface).			
Base	*ARObject*, *PPortComSpec*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
operation	ClientServerOperation	0..1	ref	Operation these communication attributes apply to.
queueLength	PositiveInteger	1	attr	Length of call queue on the server side. The queue is implemented by the RTE. The value shall be greater or equal to 1. Setting the value of queueLength to 1 implies that incoming requests are rejected while another request that arrived earlier is being processed.
transformation ComSpecProps	TransformationCom SpecProps	*	aggr	This references the TransformationComSpecProps which define port-specific configuration for data transformation.

Table D.237: ServerComSpec

Class	**ServiceProxySwComponentType**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	This class provides the ability to express a software-component which provides access to an internal service for remote ECUs. It acts as a proxy for the service providing access to the service. An important use case is the request of vehicle mode switches: Such requests can be communicated via sender-receiver interfaces across ECU boundaries, but the mode manager being responsible to perform the mode switches is an AUTOSAR Service which is located in the Basic Software and is not visible in the VFB view. To handle this situation, a ServiceProxySwComponentType will act as proxy for the mode manager. It will have R-Ports to be connected with the mode requestors on VFB level and Service-Ports to be connected with the local mode manager at ECU integration time. Apart from the semantics, a ServiceProxySwComponentType has these specific properties: • A prototype of it can be mapped to more than one ECUs in the system description. • Exactly one additional instance of it will be created in the ECU-Extract per ECU to which the prototype has been mapped. • For remote communication, it can have only R-Ports with sender-receiver interfaces and 1:n semantics. • There shall be no connectors between two prototypes of any ServiceProxySwComponentType. **Tags:** atp.recommendedPackage=SwComponentTypes			
Base	*ARElement*, *ARObject*, *AtomicSwComponentType*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*, *SwComponentType*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
–	–	–	–	–

Table D.238: ServiceProxySwComponentType

Class	**ServiceSwComponentType**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	ServiceSwComponentType is used for configuring services for a given ECU. Instances of this class are only to be created in ECU Configuration phase for the specific purpose of the service configuration. **Tags:** atp.recommendedPackage=SwComponentTypes			
Base	*ARElement*, *ARObject*, *AtomicSwComponentType*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*, *SwComponentType*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
–	–	–	–	–

Table D.239: ServiceSwComponentType

Class	**SubElementMapping**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	This meta-class allows for the definition of mappings of elements of a composite data type.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
firstElement	SubElementRef	0..1	aggr	This represents the first element referenced in the scope of the mapping. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

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Class	**SubElementMapping**			
secondElement	SubElementRef	0..1	aggr	This represents the second element referenced in the scope of the mapping. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
textTable Mapping	TextTableMapping	0..2	aggr	This allows for the text-table translation of individual elements of a composite data type.

Table D.240: SubElementMapping

Class	**SwAddrMethod**			
Package	M2::MSR::DataDictionary::AuxillaryObjects			
Note	Used to assign a common addressing method, e.g. common memory section, to data or code objects. These objects could actually live in different modules or components. **Tags:** atp.recommendedPackage=SwAddrMethods			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *CollectableElement*, *Identifiable*, *Multilanguage Referrable*, *PackageableElement*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
memory Allocation KeywordPolicy	MemoryAllocation KeywordPolicyType	0..1	attr	Enumeration to specify the name pattern of the Memory Allocation Keyword.
option	Identifier	*	attr	This attribute introduces the ability to specify further intended properties of the MemorySection in with the related objects shall be placed. These properties are handled as to be selected. The intended options are mentioned in the list. In the Memory Mapping configuration, this option list is used to determine an appropriate MemMapAddressing ModeSet.
section Initialization Policy	SectionInitialization PolicyType	0..1	attr	Specifies the expected initialization of the variables (inclusive those which are implementing VariableData Prototypes). Therefore this is an implementation constraint for initialization code of BSW modules (especially RTE) as well as the start-up code which initializes the memory segment to which the AutosarData Prototypes referring to the SwAddrMethod's are later on mapped. If the attribute is not defined it has the identical semantic as the attribute value "INIT"
sectionType	MemorySectionType	0..1	attr	Defines the type of memory sections which can be associated with this addresssing method.

Table D.241: SwAddrMethod

Class	**SwBaseType**
Package	M2::MSR::AsamHdo::BaseTypes
Note	This meta-class represents a base type used within ECU software. **Tags:** atp.recommendedPackage=BaseTypes
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *BaseType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*

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Class	**SwBaseType**			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
–	–	–	–	–

Table D.242: SwBaseType

Enumeration	**SwCalibrationAccessEnum**
Package	M2::MSR::DataDictionary::DataDefProperties
Note	Determines the access rights to a data object w.r.t. measurement and calibration.
Literal	***Description***
notAccessible	The element will not be accessible via MCD tools, i.e. will not appear in the ASAP file. **Tags:** atp.EnumerationValue=0
readOnly	The element will only appear as read-only in an ASAP file. **Tags:** atp.EnumerationValue=1
readWrite	The element will appear in the ASAP file with both read and write access. **Tags:** atp.EnumerationValue=2

Table D.243: SwCalibrationAccessEnum

Class	**SwComponentPrototype**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Composition			
Note	Role of a software component within a composition.			
Base	*ARObject*, *AtpFeature*, *AtpPrototype*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
type	SwComponentType	1	tref	Type of the instance. **Stereotypes:** isOfType

Table D.244: SwComponentPrototype

Class	***SwComponentType*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	Base class for AUTOSAR software components.			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Subclasses	*AtomicSwComponentType*, CompositionSwComponentType, ParameterSwComponentType			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
consistency Needs	ConsistencyNeeds	*	aggr	This represents the collection of ConsistencyNeeds owned by the enclosing SwComponentType. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime

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Class	***SwComponentType*** (abstract)			
port	PortPrototype	*	aggr	The PortPrototypes through which this SwComponent Type can communicate. The aggregation of PortPrototype is subject to variability with the purpose to support the conditional existence of PortPrototypes. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
portGroup	PortGroup	*	aggr	A port group being part of this component. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
swComponent Documentation	SwComponent Documentation	0..1	aggr	This adds a documentation to the SwComponentType. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=swComponentDocumentation, variationPoint.shortLabel vh.latestBindingTime=preCompileTime xml.sequenceOffset=-10
unitGroup	UnitGroup	*	ref	This allows for the specification of which UnitGroups are relevant in the context of referencing SwComponentType.

Table D.245: SwComponentType

Class	***SwConnector*** (abstract)			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Composition			
Note	The base class for connectors between ports. Connectors have to be identifiable to allow references from the system constraint template.			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Subclasses	AssemblySwConnector, DelegationSwConnector, PassThroughSwConnector			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
mapping	PortInterfaceMapping	0..1	ref	Reference to a PortInterfaceMapping specifying the mapping of unequal named PortInterface elements of the two different PortInterfaces typing the two PortPrototypes which are referenced by the ConnectorPrototype.

Table D.246: SwConnector

Class	«atpVariation» **SwDataDefProps**
Package	M2::MSR::DataDictionary::DataDefProperties
Note	This class is a collection of properties relevant for data objects under various aspects. One could consider this class as a "pattern of inheritance by aggregation". The properties can be applied to all objects of all classes in which SwDataDefProps is aggregated. Note that not all of the attributes or associated elements are useful all of the time. Hence, the process definition (e.g. expressed with an OCL or a Document Control Instance MSR-DCI) has the task of implementing limitations. SwDataDefProps covers various aspects: • Structure of the data element for calibration use cases: is it a single value, a curve, or a map, but also the recordLayouts which specify how such elements are mapped/converted to the Data ▽

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Class	«atpVariation» **SwDataDefProps**			
	△ Types in the programming language (or in AUTOSAR). This is mainly expressed by properties like swRecordLayout and swCalprmAxisSet • Implementation aspects, mainly expressed by swImplPolicy, swVariableAccessImplPolicy, swAddrMethod, swPointerTagetProps, baseType, implementationDataType and additionalNativeTypeQualifier • Access policy for the MCD system, mainly expressed by swCalibrationAccess • Semantics of the data element, mainly expressed by compuMethod and/or unit, dataConstr, invalidValue • Code generation policy provided by swRecordLayout **Tags:** vh.latestBindingTime=codeGenerationTime			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
additionalNativeTypeQualifier	NativeDeclarationString	0..1	attr	This attribute is used to declare native qualifiers of the programming language which can neither be deduced from the baseType (e.g. because the data object describes a pointer) nor from other more abstract attributes. Examples are qualifiers like "volatile", "strict" or "enum" of the C-language. All such declarations have to be put into one string. **Tags:** xml.sequenceOffset=235
annotation	Annotation	*	aggr	This aggregation allows to add annotations (yellow pads ...) related to the current data object. **Tags:** xml.roleElement=true xml.roleWrapperElement=true xml.sequenceOffset=20 xml.typeElement=false xml.typeWrapperElement=false
baseType	SwBaseType	0..1	ref	Base type associated with the containing data object. **Tags:** xml.sequenceOffset=50
compuMethod	CompuMethod	0..1	ref	Computation method associated with the semantics of this data object. **Tags:** xml.sequenceOffset=180
dataConstr	DataConstr	0..1	ref	Data constraint for this data object. **Tags:** xml.sequenceOffset=190
displayFormat	DisplayFormatString	0..1	attr	This property describes how a number is to be rendered e.g. in documents or in a measurement and calibration system. **Tags:** xml.sequenceOffset=210
displayPresentation	DisplayPresentationEnum	0..1	attr	This attribute controls the presentation of the related data for measurement and calibration tools.
implementationDataType	AbstractImplementationDataType	0..1	ref	This association denotes the ImplementationDataType of a data declaration via its aggregated SwDataDefProps. It is used whenever a data declaration is not directly referring to a base type. Especially • redefinition of an ImplementationDataType via a "typedef" to another ImplementationDatatype • the target type of a pointer (see SwPointerTargetProps), if it does not refer to a base type directly ▽

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Class	«atpVariation» **SwDataDefProps**			
				△ • the data type of an array or record element within an ImplementationDataType, if it does not refer to a base type directly • the data type of an SwServiceArg, if it does not refer to a base type directly **Tags:** xml.sequenceOffset=215
invalidValue	ValueSpecification	0..1	aggr	Optional value to express invalidity of the actual data element. **Tags:** xml.sequenceOffset=255
stepSize	Float	0..1	attr	This attribute can be used to define a value which is added to or subtracted from the value of a DataPrototype when using up/down keys while calibrating.
swAddrMethod	SwAddrMethod	0..1	ref	Addressing method related to this data object. Via an association to the same SwAddrMethod it can be specified that several DataPrototypes shall be located in the same memory without already specifying the memory section itself. **Tags:** xml.sequenceOffset=30
swAlignment	AlignmentType	0..1	attr	The attribute describes the intended alignment of the DataPrototype. If the attribute is not defined the alignment is determined by the swBaseType size and the memory AllocationKeywordPolicy of the referenced SwAddr Method. **Tags:** xml.sequenceOffset=33
swBit Representation	SwBitRepresentation	0..1	aggr	Description of the binary representation in case of a bit variable. **Tags:** xml.sequenceOffset=60
swCalibration Access	SwCalibrationAccess Enum	0..1	attr	Specifies the read or write access by MCD tools for this data object. **Tags:** xml.sequenceOffset=70
swCalprmAxis Set	SwCalprmAxisSet	0..1	aggr	This specifies the properties of the axes in case of a curve or map etc. This is mainly applicable to calibration parameters. **Tags:** xml.sequenceOffset=90
swComparison Variable	SwVariableRefProxy	*	aggr	Variables used for comparison in an MCD process. **Tags:** xml.sequenceOffset=170 xml.typeElement=false
swData Dependency	SwDataDependency	0..1	aggr	Describes how the value of the data object has to be calculated from the value of another data object (by the MCD system). **Tags:** xml.sequenceOffset=200
swHostVariable	SwVariableRefProxy	0..1	aggr	Contains a reference to a variable which serves as a host-variable for a bit variable. Only applicable to bit objects. **Tags:** xml.sequenceOffset=220 xml.typeElement=false
swImplPolicy	SwImplPolicyEnum	0..1	attr	Implementation policy for this data object. **Tags:** xml.sequenceOffset=230
swIntended Resolution	Numerical	0..1	attr	The purpose of this element is to describe the requested quantization of data objects early on in the design process. The resolution ultimately occurs via the conversion formula present (compuMethod), which specifies the transition from the physical world to the standardized world (and vice-versa) (here, "the slope per bit" is present implicitly in the conversion formula). In the case of a development phase without a fixed conversion formula, a pre-specification can occur through swIntendedResolution. The resolution is specified in the physical domain

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Class	«atpVariation» **SwDataDefProps**			
swInterpolationMethod	Identifier	0..1	attr	This is a keyword identifying the mathematical method to be applied for interpolation. The keyword needs to be related to the interpolation routine which needs to be invoked. **Tags:** xml.sequenceOffset=250
swIsVirtual	Boolean	0..1	attr	This element distinguishes virtual objects. Virtual objects do not appear in the memory, their derivation is much more dependent on other objects and hence they shall have a swDataDependency . **Tags:** xml.sequenceOffset=260
swPointerTargetProps	SwPointerTargetProps	0..1	aggr	Specifies that the containing data object is a pointer to another data object. **Tags:** xml.sequenceOffset=280
swRecordLayout	SwRecordLayout	0..1	ref	Record layout for this data object. **Tags:** xml.sequenceOffset=290
swRefreshTiming	MultidimensionalTime	0..1	aggr	This element specifies the frequency in which the object involved shall be or is called or calculated. This timing can be collected from the task in which write access processes to the variable run. But this cannot be done by the MCD system. So this attribute can be used in an early phase to express the desired refresh timing and later on to specify the real refresh timing. **Tags:** xml.sequenceOffset=300
swTextProps	SwTextProps	0..1	aggr	the specific properties if the data object is a text object. **Tags:** xml.sequenceOffset=120
swValueBlockSize	Numerical	0..1	attr	This represents the size of a Value Block **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.sequenceOffset=80
swValueBlockSizeMult (ordered)	Numerical	*	attr	This attribute is used to specify the dimensions of a value block (VAL_BLK) for the case that that value block has more than one dimension. The dimensions given in this attribute are ordered such that the first entry represents the first dimension, the second entry represents the second dimension, and so on. For one-dimensional value blocks the attribute swValueBlockSize shall be used and this attribute shall not exist. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
unit	Unit	0..1	ref	Physical unit associated with the semantics of this data object. This attribute applies if no compuMethod is specified. If both units (this as well as via compuMethod) are specified the units shall be compatible. **Tags:** xml.sequenceOffset=350

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Class	«atpVariation» **SwDataDefProps**			
valueAxisData Type	ApplicationPrimitive DataType	0..1	ref	The referenced ApplicationPrimitiveDataType represents the primitive data type of the value axis within a compound primitive (e.g. curve, map). It supersedes CompuMethod, Unit, and BaseType. **Tags:** xml.sequenceOffset=355

Table D.247: SwDataDefProps

Enumeration	**SwImplPolicyEnum**
Package	M2::MSR::DataDictionary::DataDefProperties
Note	Specifies the implementation strategy with respect to consistency mechanisms of variables.
Literal	***Description***
const	forced implementation such that the running software within the ECU shall not modify it. For example implemented with the "const" modifier in C. This can be applied for parameters (not for those in NVRAM) as well as argument data prototypes. **Tags:** atp.EnumerationValue=0
fixed	This data element is fixed. In particular this indicates, that it might also be implemented e.g. as in place data, (#DEFINE). **Tags:** atp.EnumerationValue=1
measurementPoint	The data element is created for measurement purposes only. The data element is never read directly within the ECU software. In contrast to a "standard" data element in an unconnected provide port is, this unconnection is guaranteed for measurementPoint data elements. **Tags:** atp.EnumerationValue=2
queued	The content of the data element is queued and the data element has 'event' semantics, i.e. data elements are stored in a queue and all data elements are processed in 'first in first out' order. The queuing is intended to be implemented by RTE Generator. This value is not applicable for parameters. **Tags:** atp.EnumerationValue=3
standard	This is applicable for all kinds of data elements. For variable data prototypes the 'last is best' semantics applies. For parameter there is no specific implementation directive. **Tags:** atp.EnumerationValue=4

Table D.248: SwImplPolicyEnum

Class	**SwPointerTargetProps**			
Package	M2::MSR::DataDictionary::DataDefProperties			
Note	This element defines, that the data object (which is specified by the aggregating element) contains a reference to another data object or to a function in the CPU code. This corresponds to a pointer in the C-language. The attributes of this element describe the category and the detailed properties of the target which is either a data description or a function signature.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
functionPointer Signature	BswModuleEntry	0..1	ref	The referenced BswModuleEntry serves as the signature of a function pointer definition. Primary use case: function pointer passed as argument to other function. **Tags:** xml.sequenceOffset=40

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Class	**SwPointerTargetProps**			
swDataDef Props	SwDataDefProps	0..1	aggr	The properties of the target data type. **Tags:** xml.sequenceOffset=30
targetCategory	Identifier	0..1	attr	This specifies the category of the target: • In case of a data pointer, it shall specify the category of the referenced data. • In case of a function pointer, it could be used to denote the category of the referenced Bsw ModuleEntry. Since currently no categories for BswModuleEntry are defined it will be empty. **Tags:** xml.sequenceOffset=5

Table D.249: SwPointerTargetProps

Class	**SwRecordLayout**			
Package	M2::MSR::DataDictionary::RecordLayout			
Note	Defines how the data objects (variables, calibration parameters etc.) are to be stored in the ECU memory. As an example, this definition specifies the sequence of axis points in the ECU memory. Iterations through axis values are stored within the sub-elements swRecordLayoutGroup. **Tags:** atp.recommendedPackage=SwRecordLayouts			
Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *Packageable Element*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
swRecord LayoutGroup	SwRecordLayoutGroup	1	aggr	This is the top level record layout group. **Tags:** xml.roleElement=true xml.roleWrapperElement=false xml.sequenceOffset=20 xml.typeElement=false xml.typeWrapperElement=false

Table D.250: SwRecordLayout

Class	**SwServiceArg**			
Package	M2::MSR::DataDictionary::ServiceProcessTask			
Note	Specifies the properties of a data object exchanged during the call of an SwService, e.g. an argument or a return value. The SwServiceArg can also be used in the argument list of a C-macro. For this purpose the category shall be set to "MACRO". A reference to implementationDataType can optional be added if the actual argument has an implementationDataType.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
direction	ArgumentDirection Enum	0..1	attr	Specifies the direction of the data transfer. The direction shall indicate the direction of the actual information that is being consumed by the caller and/or the callee, not the direction of formal arguments in C. The attribute is optional for backwards compatibility reasons. For example, if a pointer is used to pass a memory address for the expected result, the direction shall be ▽

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Class	SwServiceArg			
				△ "out". If a pointer is used to pass a memory address with content to be read by the callee, its direction shall be "in". **Tags:** xml.sequenceOffset=10
swArraysize	ValueList	0..1	aggr	This turns the argument of the service to an array. **Tags:** xml.sequenceOffset=20
swDataDef Props	SwDataDefProps	0..1	aggr	Data properties of this SwServiceArg. **Tags:** xml.sequenceOffset=30

Table D.251: SwServiceArg

Class	**SwSystemconst**			
Package	M2::MSR::DataDictionary::SystemConstant			
Note	This element defines a system constant which serves an input to select a particular variation point. In particular a system constant serves as an operand of the binding function (swSyscond) in a Variation point. Note that the binding process can only happen if a value was assigned to to the referenced system constants. **Tags:** atp.recommendedPackage=SwSystemconsts			
Base	*ARElement*, *ARObject*, *AtpDefinition*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
swDataDef Props	SwDataDefProps	0..1	aggr	This denotes the data defintion properties of the system constant. This supports to express the limits and optionally a conversion within the internal to physical values by a compu method. **Tags:** xml.sequenceOffset=40

Table D.252: SwSystemconst

Class	«atpMixedString» ***SwSystemconstDependentFormula*** (abstract)			
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling			
Note	This class represents an expression depending on system constants.			
Base	*ARObject*, *FormulaExpression*			
Subclasses	*AttributeValueVariationPoint*, BlueprintFormula, ConditionByFormula, *FMFormulaByFeaturesAndSwSystemconsts*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
sysc	SwSystemconst	1	ref	This refers to a system constant. The internal (coded) value of the system constant shall be used. **Tags:** xml.sequenceOffset=50
syscString	SwSystemconst	1	ref	syscString indicates that the referenced system constant shall be evaluated as a string according to [TPS_SWCT_01431].

Table D.253: SwSystemconstDependentFormula

Class	SwSystemconstValue			
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling			
Note	This meta-class assigns a particular value to a system constant.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
annotation	Annotation	*	aggr	This provides the ability to add information why the value is set like it is. **Tags:** xml.sequenceOffset=30
swSystemconst	SwSystemconst	1	ref	This is the system constant to which the value applies. **Tags:** xml.sequenceOffset=10
value	Numerical	1	attr	This is the particular value of a system constant. It is specified as Numerical. Further restrictions may apply by the definition of the system constant. The value attribute defines the internal value of the Sw Systemconst as it is processed in the Formula Language. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.sequenceOffset=20

Table D.254: SwSystemconstValue

Class	SwSystemconstantValueSet			
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling			
Note	This meta-class represents the ability to specify a set of system constant values. **Tags:** atp.recommendedPackage=SwSystemconstantValueSets			
Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *Packageable Element*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
sw Systemconstant Value	SwSystemconstValue	*	aggr	This is one particular value of a system constant.

Table D.255: SwSystemconstantValueSet

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Class	«atpMixed» **SwValues**			
Package	M2::MSR::CalibrationData::CalibrationValue			
Note	This meta-class represents a list of values. These values can either be the input values of a curve (abscissa values) or the associated values (ordinate values). In case of multidimensional structures, the values are ordered such that the lowest index runs the fastest. In particular for maps and cuboids etc. the resulting long value list can be subsectioned using Value Group. But the processing needs to be done as if vg is not there. Note that numerical values and textual values should not be mixed.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
v	Numerical	1	attr	This is a non variant Value. It is provided for sake of Compatibility to ASAM CDF. **Tags:** xml.sequenceOffset=40
vf	Numerical	1	attr	This allows to specify the value as VariationPoint. It is distinguished to non variant for sake of compatibility to ASAM CDF 2.0. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.sequenceOffset=20

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Class	«atpMixed» **SwValues**			
vg	ValueGroup	1	aggr	This allows to have intersections in the values in order to support specific rendering (eg. using stylesheets). For tools it is important that the v values are always processed in the same (flattened) order and the tool is able to interpret it without respecting vg. **Tags:** xml.sequenceOffset=50
vt	VerbatimString	1	attr	This represents the values of textual data elements (Strings). Note that vt uses the | to separate the values for the different bitfield masks in case that the semantics of the related DataPrototype is described by means of a BITFIELD_TEXTTABLE in the associated CompuMethod. **Tags:** xml.sequenceOffset=30
vtf	NumericalOrText	1	aggr	Thias aggregation represents the ability to provide a value that is either numerical or text which existence is subject to variability. From the formal point of view, the aggregation needs to have the multiplicity 1 because SwValues is modelled with stereotype «atpMixed». Nevertheless, the existence of vtf is optional and subject to constraints. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.256: SwValues

Class	**SwcBswMapping**			
Package	M2::AUTOSARTemplates::CommonStructure::SwcBswMapping			
Note	Maps an SwcInternalBehavior to an BswInternalBehavior. This is required to coordinate the API generation and the scheduling for AUTOSAR Service Components, ECU Abstraction Components and Complex Driver Components by the RTE and the BSW scheduling mechanisms. **Tags:** atp.recommendedPackage=SwcBswMappings			
Base	*ARElement*, *ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
bswBehavior	BswInternalBehavior	1	ref	The mapped BswInternalBehavior
runnable Mapping	SwcBswRunnable Mapping	*	aggr	A mapping between a pair of SWC and BSW runnables. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
swcBehavior	SwcInternalBehavior	1	ref	The mapped SwcInternalBehavior.
synchronized ModeGroup	SwcBswSynchronized ModeGroupPrototype	*	aggr	A pair of SWC and BSW mode group prototypes to be synchronized by the scheduler. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
synchronized Trigger	SwcBswSynchronized Trigger	*	aggr	A pair of SWC and BSW Triggers to be synchronized by the scheduler. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

Table D.257: SwcBswMapping

Class	**SwcBswRunnableMapping**			
Package	M2::AUTOSARTemplates::CommonStructure::SwcBswMapping			
Note	Maps a BswModuleEntity to a RunnableEntity if it is implemented as part of a BSW module (in the case of an AUTOSAR Service, a Complex Driver or an ECU Abstraction). The mapping can be used by a tool to find relevant information on the behavior, e.g. whether the bswEntity shall be running in interrupt context.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
bswEntity	BswModuleEntity	1	ref	The mapped BswModuleEntity
swcRunnable	RunnableEntity	1	ref	The mapped SWC runnable.

Table D.258: SwcBswRunnableMapping

Class	**SwcBswSynchronizedTrigger**			
Package	M2::AUTOSARTemplates::CommonStructure::SwcBswMapping			
Note	Synchronizes a Trigger provided by a component via a port with a Trigger provided by a BSW module or cluster.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
bswTrigger	Trigger	1	ref	The BSW Trigger.
swcTrigger	Trigger	1	iref	The SWC Trigger provided by a particular port.

Table D.259: SwcBswSynchronizedTrigger

Class	**SwcExclusiveAreaPolicy**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior			
Note	Options how to generate the ExclusiveArea related APIs. If no SwcExclusiveAreaPolicy is specified for an ExclusiveArea the default values apply.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
apiPrinciple	ApiPrincipleEnum	1	attr	Specifies for this ExclusiveArea if either one common set of Enter and Exit APIs for the whole software component is requested from the Rte or if the set of Enter and Exit APIs is expected per RunnableEntity. The default value is "common".
exclusiveArea	ExclusiveArea	1	ref	This reference represents the ExclusiveArea for which the policy applies.

Table D.260: SwcExclusiveAreaPolicy

Class	**SwcImplementation**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcImplementation			
Note	This meta-class represents a specialization of the general Implementation meta-class with respect to the usage in application software. **Tags:** atp.recommendedPackage=SwcImplementations			
Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *Implementation*, *MultilanguageReferrable*, *PackageableElement*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**

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Class	SwcImplementation			
behavior	SwcInternalBehavior	1	ref	The internal behavior implemented by this Implementation.
perInstance MemorySize	PerInstanceMemory Size	*	aggr	Allows a definition of the size of the per-instance memory for this implementation. The aggregation of PerInstanceMemorySize is subject to variability with the purpose to support variability in the software components implementations. Typically different algorithms in the implementation are requiring different number of memory objects, in this case PerInstance Memory. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
required RTEVendor	String	0..1	attr	Identify a specific RTE vendor. This information is potentially important at the time of integrating (in particular: linking) the application code with the RTE. The semantics is that (if the association exists) the corresponding code has been created to fit to the vendor-mode RTE provided by this specific vendor. Attempting to integrate the code with another RTE generated in vendor mode is in general not possible.

Table D.261: SwcImplementation

Class	**SwcInternalBehavior**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior			
Note	The SwcInternalBehavior of an AtomicSwComponentType describes the relevant aspects of the software-component with respect to the RTE, i.e. the RunnableEntities and the RTEEvents they respond to.			
Base	*ARObject, AtpClassifier, AtpFeature, AtpStructureElement, Identifiable, InternalBehavior, Multilanguage Referrable, Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
arTypedPer Instance Memory	VariableDataPrototype	*	aggr	Defines an AUTOSAR typed memory-block that needs to be available for each instance of the SW-component. This is typically only useful if supportsMultipleInstantiation is set to "true" or if the component defines NVRAM access via permanent blocks. The aggregation of arTypedPerInstanceMemory is subject to variability with the purpose to support variability in the software component's implementations. Typically different algorithms in the implementation are requiring different number of memory objects. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
event	RTEEvent	*	aggr	This is a RTEEvent specified for the particular Swc InternalBehavior. The aggregation of RTEEvent is subject to variability with the purpose to support the conditional existence of RTE events. Note: the number of RTE events might vary due to the conditional existence of PortPrototypes using Data ▽

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Class	**SwcInternalBehavior**			
				△ ReceivedEvents or due to different scheduling needs of algorithms. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
exclusiveArea Policy	SwcExclusiveArea Policy	*	aggr	Options how to generate the ExclusiveArea related APIs. When no SwcExclusiveAreaPolicy is specified for an ExclusiveArea the default values apply. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=exclusiveAreaPolicy vh.latestBindingTime=preCompileTime
explicitInter Runnable Variable	VariableDataPrototype	*	aggr	Implement state message semantics for establishing communication among runnables of the same component. The aggregation of explicitInterRunnableVariable is subject to variability with the purpose to support variability in the software components implementations. Typically different algorithms in the implementation are requiring different number of memory objects. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
handle TerminationAnd Restart	HandleTerminationAnd RestartEnum	1	attr	This attribute controls the behavior with respect to stopping and restarting. The corresponding AtomicSw ComponentType may either not support stop and restart, or support only stop, or support both stop and restart.
implicitInter Runnable Variable	VariableDataPrototype	*	aggr	Implement state message semantics for establishing communication among runnables of the same component. The aggregation of implicitInterRunnableVariable is subject to variability with the purpose to support variability in the software components implementations. Typically different algorithms in the implementation are requiring different number of memory objects. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
includedData TypeSet	IncludedDataTypeSet	*	aggr	The includedDataTypeSet is used by a software component for its implementation. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=includedDataTypeSet
includedMode Declaration GroupSet	IncludedMode DeclarationGroupSet	*	aggr	This aggregation represents the included Mode DeclarationGroups **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=includedModeDeclarationGroupSet
instantiation DataDefProps	InstantiationDataDef Props	*	aggr	The purpose of this is that within the context of a given SwComponentType some data def properties of individual instantiations can be modified. The aggregation of InstantiationDataDefProps is subject to variability with the purpose to support the conditional existence of PortPrototypes and component local memories like "perInstanceParameter" or "arTypedPer InstanceMemory". ▽

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Class	SwcInternalBehavior			
				△ **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=instantiationDataDefProps, variation Point.shortLabel vh.latestBindingTime=preCompileTime
perInstance Memory	PerInstanceMemory	*	aggr	Defines a per-instance memory object needed by this software component. The aggregation of PerInstanceMemory is subject to variability with the purpose to support variability in the software components implementations. Typically different algorithms in the implementation are requiring different number of memory objects. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
perInstance Parameter	ParameterData Prototype	*	aggr	Defines parameter(s) or characteristic value(s) that needs to be available for each instance of the software-component. This is typically only useful if supportsMultipleInstantiation is set to "true". The aggregation of perInstanceParameter is subject to variability with the purpose to support variability in the software components implementations. Typically different algorithms in the implementation are requiring different number of memory objects. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
portAPIOption	PortAPIOption	*	aggr	Options for generating the signature of port-related calls from a runnable to the RTE and vice versa. The aggregation of PortPrototypes is subject to variability with the purpose to support the conditional existence of ports. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=portAPIOption, variationPoint.short Label vh.latestBindingTime=preCompileTime
runnable	RunnableEntity	*	aggr	This is a RunnableEntity specified for the particular Swc InternalBehavior. The aggregation of RunnableEntity is subject to variability with the purpose to support the conditional existence of RunnableEntities. Note: the number of RunnableEntities might vary due to the conditional existence of Port Prototypes using DataReceivedEvents or due to different scheduling needs of algorithms. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
service Dependency	SwcService Dependency	*	aggr	Defines the requirements on AUTOSAR Services for a particular item. The aggregation of SwcServiceDependency is subject to variability with the purpose to support the conditional existence of ports as well as the conditional existence of ServiceNeeds. The SwcServiceDependency owned by an SwcInternal Behavior can be located in a different physical file in order ▽

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Class	**SwcInternalBehavior**			
				△ to support that SwcServiceDependency might be provided in later development steps or even by different expert domain (e.g OBD expert for Obd related Service Needs) tools. Therefore the aggregation is «atpSplitable». **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
shared Parameter	ParameterData Prototype	*	aggr	Defines parameter(s) or characteristic value(s) shared between SwComponentPrototypes of the same Sw ComponentType The aggregation of sharedParameter is subject to variability with the purpose to support variability in the software components implementations. Typically different algorithms in the implementation are requiring different number of memory objects. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=preCompileTime
supports Multiple Instantiation	Boolean	1	attr	Indicate whether the corresponding software-component can be multiply instantiated on one ECU. In this case the attribute will result in an appropriate component API on programming language level (with or without instance handle).
variationPoint Proxy	VariationPointProxy	*	aggr	Proxy of a variation points in the C/C++ implementation. **Stereotypes:** atpSplitable **Tags:** atp.Splitkey=shortName

Table D.262: SwcInternalBehavior

Class	**SwcModeManagerErrorEvent**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	This represents the ability to react on errors occurring during mode handling.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
modeGroup	ModeDeclarationGroup Prototype	1	iref	This represents the ModeDeclarationGroupPrototype for which the error behavior of the mode manager applies.

Table D.263: SwcModeManagerErrorEvent

Class	**SwcModeSwitchEvent**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	This event is raised upon a received mode change.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
activation	ModeActivationKind	1	attr	Specifies if the event is activated on entering or exiting the referenced Mode.

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Class	**SwcModeSwitchEvent**			
mode (ordered)	ModeDeclaration	1..2	iref	Reference to one or two Modes that initiate the SwcMode SwitchEvent.

Table D.264: SwcModeSwitchEvent

Class	**SwcServiceDependency**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::ServiceMapping			
Note	Specialization of ServiceDependency in the context of an SwcInternalBehavior. It allows to associate ports, port groups and (in special cases) data defined for an atomic software component to a given ServiceNeeds element.			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*, *ServiceDependency*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
assignedData	RoleBasedData Assignment	*	aggr	Defines the role of an associated data object of the same component. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
assignedPort	RoleBasedPort Assignment	*	aggr	Defines the role of an associated port of the same component. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=assignedPort, variationPoint.short Label vh.latestBindingTime=preCompileTime
representedPort Group	PortGroup	0..1	ref	This reference specifies an association between the ServiceNeeeds and a PortGroup, for example to request a communication mode which applies for communication via these ports. The referred PortGroup shall be local to this atomic SWC, but via the links between the Port Groups, a tool can evaluate this information such that all the ports linked via this port group on the same ECU can be found.
serviceNeeds	ServiceNeeds	1	aggr	The associated ServiceNeeds.

Table D.265: SwcServiceDependency

Class	**SymbolProps**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Components			
Note	This meta-class represents the ability to attach with the symbol attribute a symbolic name that is conform to C language requirements to another meta-class, e.g. AtomicSwComponentType, that is a potential subject to a name clash on the level of RTE source code.			
Base	*ARObject*, *ImplementationProps*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
–	–	–	–	–

Table D.266: SymbolProps

Class	SynchronousServerCallPoint			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::ServerCall			
Note	This means that the RunnableEntity is supposed to perform a blocking wait for a response from the server.			
Base	*ARObject, AbstractAccessPoint, AtpClassifier, AtpFeature, AtpStructureElement, Identifiable, MultilanguageReferrable, Referrable, ServerCallPoint*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
calledFromWithinExclusiveArea	ExclusiveAreaNestingOrder	0..1	ref	This indicates that the call point is located at the deepest level inside one or more ExclusiveAreas that are nested in the given order.

Table D.267: SynchronousServerCallPoint

Class	SystemMapping			
Package	M2::AUTOSARTemplates::SystemTemplate			
Note	The system mapping aggregates all mapping aspects (mapping of SW components to ECUs, mapping of data elements to signals, and mapping constraints).			
Base	*ARObject, Identifiable, MultilanguageReferrable, Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
applicationPartitionToEcuPartitionMapping	ApplicationPartitionToEcuPartitionMapping	*	aggr	Mapping of ApplicationPartitions to EcuPartitions **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=postBuild
comManagementMapping	ComManagementMapping	*	aggr	Mappings between Mode Management PortGroups and communication channels. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=systemDesignTime
cryptoServiceMapping	CryptoServiceMapping	*	aggr	This aggregation represents the collection of crypto service mappings in the context of the enclosing System Mapping. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=postBuild
dataMapping	DataMapping	*	aggr	The data mappings defined. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=postBuild
ecuResourceMapping	ECUMapping	*	aggr	Mapping of hardware related topology elements onto their counterpart definitions in the ECU Resource Template. atpVariation: The ECU Resource type might be variable. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=systemDesignTime
j1939ControllerApplicationToJ1939NmNodeMapping	J1939ControllerApplicationToJ1939NmNodeMapping	*	aggr	Mapping of a J1939ControllerApplication to a J1939Nm Node.
mappingConstraint	MappingConstraint	*	aggr	Constraints that limit the mapping freedom for the mapping of SW components to ECUs. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=systemDesignTime

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Class	SystemMapping			
pncMapping	PncMapping	*	aggr	Mappings between Virtual Function Clusters and Partial Network Clusters. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=systemDesignTime
resource Estimation	EcuResourceEstimation	*	aggr	Resource estimations for this set of mappings, zero or one per ECU instance. atpVariation: Used ECUs are variable. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=systemDesignTime
signalPath Constraint	SignalPathConstraint	*	aggr	Constraints that limit the mapping freedom for the mapping of data elements to signals. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=systemDesignTime
swImplMapping	SwcToImplMapping	*	aggr	The mappings of AtomicSoftwareComponent Instances to Implementations. atpVariation: Derived, because SwcToEcuMapping is variable. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
swMapping	SwcToEcuMapping	*	aggr	The mappings of SW components to ECUs. atpVariation: SWC shall be mapped to other ECUs. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
swcTo Application Partition Mapping	SwcToApplication PartitionMapping	*	aggr	Allows to map a given SwComponentPrototype to a formally defined partition at a point in time when the corresponding EcuInstance is not yet known or defined. **Stereotypes:** atpSplitable; atpVariation **Tags:** atp.Splitkey=shortName, variationPoint.shortLabel vh.latestBindingTime=postBuild

Table D.268: SystemMapping

Class	SystemSignal			
Package	M2::AUTOSARTemplates::SystemTemplate::Fibex::FibexCore::CoreCommunication			
Note	The system signal represents the communication system's view of data exchanged between SW components which reside on different ECUs. The system signals allow to represent this communication in a flattened structure, with exactly one system signal defined for each data element prototype sent and received by connected SW component instances. **Tags:** atp.recommendedPackage=SystemSignals			
Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *Packageable Element*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
dynamicLength	Boolean	1	attr	The length of dynamic length signals is variable in run-time. Only a maximum length of such a signal is specified in the configuration (attribute length in ISignal element).
physicalProps	SwDataDefProps	0..1	aggr	Specification of the physical representation.

Table D.269: SystemSignal

Class	**SystemSignalGroup**			
Package	M2::AUTOSARTemplates::SystemTemplate::Fibex::FibexCore::CoreCommunication			
Note	A signal group refers to a set of signals that must always be kept together. A signal group is used to guarantee the atomic transfer of AUTOSAR composite data types. The SystemSignalGroup defines a signal grouping on VFB level. On cluster level the Signal grouping is described by the ISignalGroup element. **Tags:** atp.recommendedPackage=SystemSignalGroups			
Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *Packageable Element*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
systemSignal	SystemSignal	*	ref	Reference to a set of SystemSignals that must always be kept together.
transforming SystemSignal	SystemSignal	0..1	ref	Optional reference to the SystemSignal which shall contain the transformed (linear) data.

Table D.270: SystemSignalGroup

Class	**TextTableMapping**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	Defines the mapping of two DataPrototypes typed by AutosarDataTypes that refer to CompuMethods of category TEXTTABLE, SCALE_LINEAR_AND_TEXTTABLE or BITFIELD_TEXTTABLE.			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
bitfieldTextTable MaskFirst	PositiveInteger	0..1	attr	This attribute can be used to support the mapping of bit field to bit field, boolean values to bit fields, and vice versa. The attribute defines the bit mask for the first element of the TextTableMapping. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
bitfieldTextTable MaskSecond	PositiveInteger	0..1	attr	This attribute can be used to support the mapping of bit field to bit field, boolean values to bit fields, and vice versa. The attribute defines the bit mask for the second element of the TextTableMapping. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime
identical Mapping	Boolean	1	attr	If identicalMapping is set == true the values of the two referenced DataPrototypes do not need any conversion of the values.
mapping Direction	MappingDirectionEnum	1	attr	Specifies the conversion direction for which the TextTable Mapping is applicable.
valuePair	TextTableValuePair	*	aggr	Defines a pair of values which are translated into each other.

Table D.271: TextTableMapping

Class	**TextValueSpecification**			
Package	M2::AUTOSARTemplates::CommonStructure::Constants			
Note	The purpose of TextValueSpecification is to define the labels that correspond to enumeration values.			
Base	*ARObject*, *ValueSpecification*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
value	VerbatimString	1	attr	This is the value itself. Note that vt uses the | operator to separate the values for the different bitfield masks in case that the semantics of the related DataPrototype is described by means of a BITFIELD_TEXTTABLE in the associated CompuMethod.

Table D.272: TextValueSpecification

Class	**TimingEvent**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	TimingEvent references the RunnableEntity that need to be started in response to the TimingEvent			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
offset	TimeValue	0..1	attr	The value makes an assumption about the time offset of the first activation of the RunnableEntity triggered by the mapped TimingEvent relative to the periodic activation of the time base of this TimingEvent. Unit: second.
period	TimeValue	1	attr	Period of timing event in seconds. The value of this attribute shall be greater than zero.

Table D.273: TimingEvent

Class	«atpVariation» ***TransformationISignalProps*** (abstract)			
Package	M2::AUTOSARTemplates::SystemTemplate::Transformer			
Note	TransformationISignalProps holds all the attributes for the different TransformationTechnologies that are ISignal specific. **Tags:** vh.latestBindingTime=postBuild			
Base	*ARObject*, *Describable*			
Subclasses	EndToEndTransformationISignalProps, SOMEIPTransformationISignalProps, UserDefinedTransformation ISignalProps			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
csErrorReaction	CSTransformerError ReactionEnum	0..1	attr	Defines whether the transformer chain of client/server communication coordinates an autonomous error reaction together with the RTE or whether any error reaction is the responsibility of the application.
dataPrototype Transformation Props	DataPrototype TransformationProps	*	aggr	Fine granular modeling of TransfromationProps on the level of DataPrototypes.
transformer	Transformation Technology	1	ref	Reference to the TransformationTechnology description that contains transformer specific and ISignal independent configuration properties.

Table D.274: TransformationISignalProps

Class	**TransformationTechnology**			
Package	M2::AUTOSARTemplates::SystemTemplate::Transformer			
Note	A TransformationTechnology is a transformer inside a transformer chain. **Tags:** xml.namePlural=TRANSFORMATION-TECHNOLOGIES			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
bufferProperties	BufferProperties	1	aggr	Aggregation of the mandatory BufferProperties.
hasInternal State	Boolean	0..1	attr	This attribute defines whether the Transformer has an internal state or not.
needsOriginal Data	Boolean	0..1	attr	Specifies whether this transformer gets access to the SWC's original data.
protocol	String	1	attr	Specifies the protocol that is implemented by this transformer.
transformation Description	Transformation Description	0..1	aggr	A transformer can be configured with transformer specific parameters which are represented by the Transformer Description. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=postBuild
transformer Class	TransformerClassEnum	1	attr	Specifies to which transformer class this transformer belongs.
version	String	1	attr	Version of the implemented protocol.

Table D.275: TransformationTechnology

Enumeration	**TransformerClassEnum**
Package	M2::AUTOSARTemplates::SystemTemplate::Transformer
Note	Specifies the transformer class of a transformer.
Literal	***Description***
custom	The transformer is a custom transformer. **Tags:** atp.EnumerationValue=0
safety	The transformer is a safety transformer. **Tags:** atp.EnumerationValue=1
security	The transformer is a security transformer. **Tags:** atp.EnumerationValue=2
serializer	The transformer is a serializing transformer. **Tags:** atp.EnumerationValue=3

Table D.276: TransformerClassEnum

Class	**TransformerHardErrorEvent**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	The event is raised when data are received which should trigger a Client/Server operation or an external trigger but during transformation of the data a hard transformer error occurred.			
Base	*ARObject*, *AbstractEvent*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *Multilanguage Referrable*, *RTEEvent*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***

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Class	**TransformerHardErrorEvent**			
operation	ClientServerOperation	0..1	iref	This represents the ClientServerOperation to which the TransformerHardErrorEvent refers to.
trigger	Trigger	0..1	iref	Trigger for which the transformer can trigger this TransformerHardErrorEvent

Table D.277: TransformerHardErrorEvent

Class	**TransmissionAcknowledgementRequest**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Communication			
Note	Requests transmission acknowledgement that data has been sent successfully. Success/failure is reported via a SendPoint of a RunnableEntity.			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
timeout	TimeValue	1	attr	Number of seconds before an error is reported or in case of allowed redundancy, the value is sent again.

Table D.278: TransmissionAcknowledgementRequest

Class	**Trigger**			
Package	M2::AUTOSARTemplates::CommonStructure::TriggerDeclaration			
Note	A trigger which is provided (i.e. released) or required (i.e. used to activate something) in the given context.			
Base	*ARObject*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
swImplPolicy	SwImplPolicyEnum	0..1	attr	This attribute, when set to value queued, allows for a queued processing of Triggers.
triggerPeriod	MultidimensionalTime	0..1	aggr	Optional definition of a period in case of a periodically (time or angle) driven external trigger.

Table D.279: Trigger

Class	**TriggerInterface**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	A trigger interface declares a number of triggers that can be sent by an trigger source. **Tags:** atp.recommendedPackage=PortInterfaces			
Base	*ARElement*, *ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *AtpClassifier*, *AtpType*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *PackageableElement*, *PortInterface*, *Referrable*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
trigger	Trigger	1..*	aggr	The Trigger of this trigger interface.

Table D.280: TriggerInterface

Class	**TriggerInterfaceMapping**			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	Defines the mapping of unequal named Triggers in context of two different TriggerInterfaces.			
Base	*ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *Identifiable*, *MultilanguageReferrable*, *PortInterfaceMapping*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
triggerMapping	TriggerMapping	1..*	aggr	Mapping of two Trigger in two different TriggerInterface

Table D.281: TriggerInterfaceMapping

Class	**TriggerToSignalMapping**			
Package	M2::AUTOSARTemplates::SystemTemplate::DataMapping			
Note	This meta-class represents the ability to map a trigger to a SystemSignal of size 0. The Trigger does not transport any other information than its existence, therefore the limitation in terms of signal length.			
Base	*ARObject*, *DataMapping*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
systemSignal	SystemSignal	1	ref	This is the SystemSignal taken to transport the Trigger over the network. **Tags:** xml.sequenceOffset=20
trigger	Trigger	1	iref	This represents the Trigger that shall be used to trigger RunnableEntities deployed to a remote ECU. **Tags:** xml.sequenceOffset=10

Table D.282: TriggerToSignalMapping

Class	**Unit**			
Package	M2::MSR::AsamHdo::Units			

Note	This is a physical measurement unit. All units that might be defined should stem from SI units. In order to convert one unit into another factor and offset are defined.
	For the calculation from SI-unit to the defined unit the factor (factorSiToUnit) and the offset (offsetSiToUnit) are applied as follows:
	`x [{unit}] := y * [{siUnit}] * factorSiToUnit [[unit]/{siUnit}] + of`
	For the calculation from a unit to SI-unit the reciprocal of the factor (factorSiToUnit) and the negation of the offset (offsetSiToUnit) are applied.
	`y {siUnit} := (x*{unit} - offsetSiToUnit [{unit}]) / (factorSiToUnit [[u`
	Tags: atp.recommendedPackage=Units			

Base	*ARElement*, *ARObject*, *CollectableElement*, *Identifiable*, *MultilanguageReferrable*, *Packageable Element*, *Referrable*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
displayName	SingleLanguageUnit Names	0..1	aggr	This specifies how the unit shall be displayed in documents or in user interfaces of tools.The displayName corresponds to the Unit.Display in an ASAM MCD-2MC file. **Tags:** xml.sequenceOffset=20
factorSiToUnit	Float	0..1	attr	This is the factor for the conversion from SI Units to units. The inverse is used for conversion from units to SI Units. **Tags:** xml.sequenceOffset=30

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Class	**Unit**			
offsetSiToUnit	Float	0..1	attr	This is the offset for the conversion from and to siUnits. **Tags:** xml.sequenceOffset=40
physical Dimension	PhysicalDimension	0..1	ref	This association represents the physical dimension to which the unit belongs to. Note that only values with units of the same physical dimensions might be converted. **Tags:** xml.sequenceOffset=50

Table D.283: Unit

Class	«atpMixed» **ValueList**			
Package	M2::MSR::DataDictionary::DataDefProperties			
Note	This is a generic list of numerical values.			
Base	*ARObject*			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
v	Numerical	1	attr	This is a particular numerical value without variation. **Tags:** xml.sequenceOffset=30
vf (ordered)	Numerical	*	attr	This is one entry in the list of numerical values **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.roleElement=true xml.roleWrapperElement=false xml.typeElement=false xml.typeWrapperElement=false

Table D.284: ValueList

Class	***ValueSpecification*** (abstract)			
Package	M2::AUTOSARTemplates::CommonStructure::Constants			
Note	Base class for expressions leading to a value which can be used to initialize a data object.			
Base	*ARObject*			
Subclasses	*AbstractRuleBasedValueSpecification*, ApplicationValueSpecification, *CompositeValueSpecification*, ConstantReference, NotAvailableValueSpecification, NumericalValueSpecification, ReferenceValue Specification, TextValueSpecification			
Attribute	*Type*	*Mul.*	*Kind*	*Note*
shortLabel	Identifier	0..1	attr	This can be used to identify particular value specifications for human readers, for example elements of a record type.

Table D.285: ValueSpecification

Class	**VariableAccess**
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::DataElements
Note	The presence of a VariableAccess implies that a RunnableEntity needs access to a VariableData Prototype. The kind of access is specified by the role in which the class is used.
Base	*ARObject*, *AbstractAccessPoint*, *AtpClassifier*, *AtpFeature*, *AtpStructureElement*, *Identifiable*, *MultilanguageReferrable*, *Referrable*

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Class	VariableAccess			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
accessed Variable	AutosarVariableRef	1	aggr	This denotes the accessed variable.
scope	VariableAccessScope Enum	0..1	attr	This attribute allows for constraining the scope of the corresponding communication. For example, it possible to express whether the communication is intended to cross the boundary of an ECU or whether it is intended not to cross the boundary of a single partition.

Table D.286: VariableAccess

Class	VariableAndParameterInterfaceMapping			
Package	M2::AUTOSARTemplates::SWComponentTemplate::PortInterface			
Note	Defines the mapping of VariableDataPrototypes or ParameterDataPrototypes in context of two different SenderReceiverInterfaces, NvDataInterfaces or ParameterInterfaces.			
Base	*ARObject*, *AtpBlueprint*, *AtpBlueprintable*, *Identifiable*, *MultilanguageReferrable*, *PortInterfaceMapping*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
dataMapping	DataPrototypeMapping	1..*	aggr	Defines the mapping of two particular VariableData Prototypes or ParameterDataPrototypes with unequal names and/or unequal semantic (resolution or range) in context of two different SenderReceiverInterfaces, Nv DataInterfaces or ParameterInterfaces

Table D.287: VariableAndParameterInterfaceMapping

Class	VariableDataPrototype			
Package	M2::AUTOSARTemplates::SWComponentTemplate::Datatype::DataPrototypes			
Note	A VariableDataPrototype is used to contain values in an ECU application. This means that most likely a VariableDataPrototype allocates "static" memory on the ECU. In some cases optimization strategies might lead to a situation where the memory allocation can be avoided. In particular, the value of a VariableDataPrototype is likely to change as the ECU on which it is used executes.			
Base	*ARObject*, *AtpFeature*, *AtpPrototype*, *AutosarDataPrototype*, *DataPrototype*, *Identifiable*, *Multilanguage Referrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
initValue	ValueSpecification	0..1	aggr	Specifies initial value(s) of the VariableDataPrototype

Table D.288: VariableDataPrototype

Class	VariationPoint			
Package	M2::AUTOSARTemplates::GenericStructure::VariantHandling			
Note	This meta-class represents the ability to express a "structural variation point". The container of the variation point is part of the selected variant if swSyscond evaluates to true and each postBuildVariant Criterion is fulfilled.			
Base	*ARObject*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
desc	MultiLanguageOverview Paragraph	0..1	aggr	This allows to describe shortly the purpose of the variation point. **Tags:** xml.sequenceOffset=20

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Class	**VariationPoint**			
blueprint Condition	DocumentationBlock	0..1	aggr	This represents a description that documents how the variation point shall be resolved when deriving objects from the blueprint. Note that variationPoints are not allowed within a blueprintCondition. **Tags:** xml.sequenceOffset=28
formalBlueprint Condition	BlueprintFormula	0..1	aggr	This denotes a formal blueprintCondition. This shall be not in contradiction with blueprintCondition or formal BlueprintGenerator. It is recommended only to use one of the two. **Tags:** atp.Status=obsolete xml.sequenceOffset=29
formalBlueprint Generator	BlueprintGenerator	0..1	aggr	This represents a description that documents how the variation point shall be resolved when deriving objects from the blueprint by using ARMQL. Note that variationPoints are not allowed within a formal BlueprintGenerator. **Tags:** atp.Status=draft xml.sequenceOffset=30
postBuildVariant Condition	PostBuildVariant Condition	*	aggr	This is the set of post build variant conditions which all shall be fulfilled in order to (postbuild) bind the variation point. **Tags:** xml.sequenceOffset=40
sdg	Sdg	0..1	aggr	An optional special data group is attached to every variation point. These data can be used by external software systems to attach application specific data. For example, a variant management system might add an identifier, an URL or a specific classifier. **Tags:** xml.sequenceOffset=50
shortLabel	Identifier	0..1	attr	This provides a name to the particular variation point to support the RTE generator. It is necessary for supporting splitable aggregations and if binding time is later than codeGenerationTime, as well as some RTE conditions. It needs to be unique with in the enclosing Identifiables with the same ShortName. **Tags:** xml.sequenceOffset=10
swSyscond	ConditionByFormula	0..1	aggr	This condition acts as Binding Function for the Variation Point. Note that the mulitplicity is 0..1 in order to support pure postBuild variants. **Tags:** xml.sequenceOffset=30

Table D.289: VariationPoint

Class	**VariationPointProxy**
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::VariantHandling
Note	The VariationPointProxy represents variation points of the C/C++ implementation. In case of bindingTime = compileTime the RTE provides defines which can be used for Pre Processor directives to implement compileTime variability.
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*

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Class	VariationPointProxy			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
conditionAccess	ConditionByFormula	0..1	aggr	This condition acts as Binding Function for the Variation Point.
implementation DataType	ImplementationData Type	0..1	ref	This association to ImplementationDataType shall be taken as an implementation hint by the RTE generator.
postBuildValue Access	PostBuildVariant Criterion	0..1	ref	This represents the applicable PostBuildVariantCriterion in the context of a VariationPointProxy. Note that the technical details how to access the particular postBuildValueAccess are still considered internal to the RTE and are consequently not standardized.
postBuildVariant Condition	PostBuildVariant Condition	*	aggr	This represents that applicable PostBuoldVariant Condition in the context of aVariationPointProxy.
valueAccess	AttributeValueVariation Point	0..1	aggr	This value acts as Binding Function for the VariationPoint.

Table D.290: VariationPointProxy

Class	WaitPoint			
Package	M2::AUTOSARTemplates::SWComponentTemplate::SwcInternalBehavior::RTEEvents			
Note	This defines a wait-point for which the RunnableEntity can wait.			
Base	*ARObject*, *Identifiable*, *MultilanguageReferrable*, *Referrable*			
Attribute	**Type**	**Mul.**	**Kind**	**Note**
timeout	TimeValue	1	attr	Time in seconds before the WaitPoint times out and the blocking wait call returns with an error indicating the timeout.
trigger	RTEEvent	1	ref	This is the RTEEvent this WaitPoint is waiting for.

Table D.291: WaitPoint

Class	«atpVariation» **SwDataDefProps**
Package	M2::MSR::DataDictionary::DataDefProperties
Note	This class is a collection of properties relevant for data objects under various aspects. One could consider this class as a "pattern of inheritance by aggregation". The properties can be applied to all objects of all classes in which SwDataDefProps is aggregated. Note that not all of the attributes or associated elements are useful all of the time. Hence, the process definition (e.g. expressed with an OCL or a Document Control Instance MSR-DCI) has the task of implementing limitations. SwDataDefProps covers various aspects: • Structure of the data element for calibration use cases: is it a single value, a curve, or a map, but also the recordLayouts which specify how such elements are mapped/converted to the Data Types in the programming language (or in AUTOSAR). This is mainly expressed by properties like swRecordLayout and swCalprmAxisSet • Implementation aspects, mainly expressed by swImplPolicy, swVariableAccessImplPolicy, sw AddrMethod, swPointerTagetProps, baseType, implementationDataType and additionalNative TypeQualifier • Access policy for the MCD system, mainly expressed by swCalibrationAccess ▽

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Class	«atpVariation» **SwDataDefProps**			
	△ • Semantics of the data element, mainly expressed by compuMethod and/or unit, dataConstr, invalidValue • Code generation policy provided by swRecordLayout **Tags:** vh.latestBindingTime=codeGenerationTime			
Base	*ARObject*			
Attribute	***Type***	***Mul.***	***Kind***	***Note***
additionalNative TypeQualifier	NativeDeclarationString	0..1	attr	This attribute is used to declare native qualifiers of the programming language which can neither be deduced from the baseType (e.g. because the data object describes a pointer) nor from other more abstract attributes. Examples are qualifiers like "volatile", "strict" or "enum" of the C-language. All such declarations have to be put into one string. **Tags:** xml.sequenceOffset=235
annotation	Annotation	*	aggr	This aggregation allows to add annotations (yellow pads ...) related to the current data object. **Tags:** xml.roleElement=true xml.roleWrapperElement=true xml.sequenceOffset=20 xml.typeElement=false xml.typeWrapperElement=false
baseType	SwBaseType	0..1	ref	Base type associated with the containing data object. **Tags:** xml.sequenceOffset=50
compuMethod	CompuMethod	0..1	ref	Computation method associated with the semantics of this data object. **Tags:** xml.sequenceOffset=180
dataConstr	DataConstr	0..1	ref	Data constraint for this data object. **Tags:** xml.sequenceOffset=190
displayFormat	DisplayFormatString	0..1	attr	This property describes how a number is to be rendered e.g. in documents or in a measurement and calibration system. **Tags:** xml.sequenceOffset=210
display Presentation	DisplayPresentation Enum	0..1	attr	This attribute controls the presentation of the related data for measurement and calibration tools.
implementation DataType	AbstractImplementation DataType	0..1	ref	This association denotes the ImplementationDataType of a data declaration via its aggregated SwDataDefProps. It is used whenever a data declaration is not directly referring to a base type. Especially • redefinition of an ImplementationDataType via a "typedef" to another ImplementationDatatype • the target type of a pointer (see SwPointerTarget Props), if it does not refer to a base type directly • the data type of an array or record element within an ImplementationDataType, if it does not refer to a base type directly • the data type of an SwServiceArg, if it does not refer to a base type directly **Tags:** xml.sequenceOffset=215
invalidValue	ValueSpecification	0..1	aggr	Optional value to express invalidity of the actual data element. **Tags:** xml.sequenceOffset=255

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Class	«atpVariation» **SwDataDefProps**			
stepSize	Float	0..1	attr	This attribute can be used to define a value which is added to or subtracted from the value of a DataPrototype when using up/down keys while calibrating.
swAddrMethod	SwAddrMethod	0..1	ref	Addressing method related to this data object. Via an association to the same SwAddrMethod it can be specified that several DataPrototypes shall be located in the same memory without already specifying the memory section itself. **Tags:** xml.sequenceOffset=30
swAlignment	AlignmentType	0..1	attr	The attribute describes the intended alignment of the DataPrototype. If the attribute is not defined the alignment is determined by the swBaseType size and the memory AllocationKeywordPolicy of the referenced SwAddr Method. **Tags:** xml.sequenceOffset=33
swBit Representation	SwBitRepresentation	0..1	aggr	Description of the binary representation in case of a bit variable. **Tags:** xml.sequenceOffset=60
swCalibration Access	SwCalibrationAccess Enum	0..1	attr	Specifies the read or write access by MCD tools for this data object. **Tags:** xml.sequenceOffset=70
swCalprmAxis Set	SwCalprmAxisSet	0..1	aggr	This specifies the properties of the axes in case of a curve or map etc. This is mainly applicable to calibration parameters. **Tags:** xml.sequenceOffset=90
swComparison Variable	SwVariableRefProxy	*	aggr	Variables used for comparison in an MCD process. **Tags:** xml.sequenceOffset=170 xml.typeElement=false
swData Dependency	SwDataDependency	0..1	aggr	Describes how the value of the data object has to be calculated from the value of another data object (by the MCD system). **Tags:** xml.sequenceOffset=200
swHostVariable	SwVariableRefProxy	0..1	aggr	Contains a reference to a variable which serves as a host-variable for a bit variable. Only applicable to bit objects. **Tags:** xml.sequenceOffset=220 xml.typeElement=false
swImplPolicy	SwImplPolicyEnum	0..1	attr	Implementation policy for this data object. **Tags:** xml.sequenceOffset=230
swIntended Resolution	Numerical	0..1	attr	The purpose of this element is to describe the requested quantization of data objects early on in the design process. The resolution ultimately occurs via the conversion formula present (compuMethod), which specifies the transition from the physical world to the standardized world (and vice-versa) (here, "the slope per bit" is present implicitly in the conversion formula). ▽

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Class	«atpVariation» **SwDataDefProps**			
				△ In the case of a development phase without a fixed conversion formula, a pre-specification can occur through swIntendedResolution. The resolution is specified in the physical domain according to the property "unit". **Tags:** xml.sequenceOffset=240
swInterpolation Method	Identifier	0..1	attr	This is a keyword identifying the mathematical method to be applied for interpolation. The keyword needs to be related to the interpolation routine which needs to be invoked. **Tags:** xml.sequenceOffset=250
swIsVirtual	Boolean	0..1	attr	This element distinguishes virtual objects. Virtual objects do not appear in the memory, their derivation is much more dependent on other objects and hence they shall have a swDataDependency . **Tags:** xml.sequenceOffset=260
swPointerTarget Props	SwPointerTargetProps	0..1	aggr	Specifies that the containing data object is a pointer to another data object. **Tags:** xml.sequenceOffset=280
swRecord Layout	SwRecordLayout	0..1	ref	Record layout for this data object. **Tags:** xml.sequenceOffset=290
swRefresh Timing	MultidimensionalTime	0..1	aggr	This element specifies the frequency in which the object involved shall be or is called or calculated. This timing can be collected from the task in which write access processes to the variable run. But this cannot be done by the MCD system. So this attribute can be used in an early phase to express the desired refresh timing and later on to specify the real refresh timing. **Tags:** xml.sequenceOffset=300
swTextProps	SwTextProps	0..1	aggr	the specific properties if the data object is a text object. **Tags:** xml.sequenceOffset=120
swValueBlock Size	Numerical	0..1	attr	This represents the size of a Value Block **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime xml.sequenceOffset=80
swValueBlock Size Mult (ordered)	Numerical	*	attr	This attribute is used to specify the dimensions of a value block (VAL_BLK) for the case that that value block has more than one dimension. The dimensions given in this attribute are ordered such that the first entry represents the first dimension, the second entry represents the second dimension, and so on. For one-dimensional value blocks the attribute swValue BlockSize shall be used and this attribute shall not exist. **Stereotypes:** atpVariation **Tags:** vh.latestBindingTime=preCompileTime

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Class	«atpVariation» **SwDataDefProps**			
unit	Unit	0..1	ref	Physical unit associated with the semantics of this data object. This attribute applies if no compuMethod is specified. If both units (this as well as via compuMethod) are specified the units shall be compatible. **Tags:** xml.sequenceOffset=350
valueAxisDataType	ApplicationPrimitiveDataType	0..1	ref	The referenced ApplicationPrimitiveDataType represents the primitive data type of the value axis within a compound primitive (e.g. curve, map). It supersedes CompuMethod, Unit, and BaseType. **Tags:** xml.sequenceOffset=355

Table D.292: SwDataDefProps

E Referenced ECUC Configuration Parameters

E.1 Com

E.1.1 ComGroupSignal

SWS Item	[ECUC_Com_00520]		
Container Name	ComGroupSignal		
Description	This container contains the configuration parameters of group signals. I.e. signals that are included within a signal group.		
Post-Build Variant Multiplicity	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Configuration Parameters			

Name	ComBitPosition [ECUC_Com_00259]		
Parent Container	ComGroupSignal		
Description	Starting position within the I-PDU. This parameter refers to the position in the I-PDU and not in the shadow buffer. If the endianness conversion is configured to Opaque the parameter ComBitPosition shall define the bit0 of the first byte like in little endian byte order		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 4294967295		
Default Value			
Post-Build Variant Value	true		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComBitSize [ECUC_Com_00158]	
Parent Container	ComGroupSignal	
Description	Size in bits, for integer signal types. For ComSignalType UINT8_N and UINT8_DYN the size shall be configured by ComSignalLength. For ComSignalTypes FLOAT32 and FLOAT64 the size is already defined by the signal type and therefore may be omitted.	
Multiplicity	0..1	
Type	EcucIntegerParamDef	
Range	0 .. 64	
Default Value		
Post-Build Variant Multiplicity	true	

Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComHandleId [ECUC_Com_00165]		
Parent Container	ComGroupSignal		
Description	The numerical value used as the ID. This ID identifies signals and signal groups in the COM APIs using Com_SignalIdType or Com_SignalGroupIdType parameter respectively.		
Multiplicity	0..1		
Type	EcucIntegerParamDef (Symbolic Name generated for this parameter)		
Range	0 .. 65535		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	ComSignalDataInvalidValue [ECUC_Com_00391]		
Parent Container	ComGroupSignal		
Description	Defines the data invalid value of the signal. In case the ComSignalType is UINT8, UINT16, UINT32, UINT64, SINT8, SINT16, SINT32, SINT64 the string shall be interpreted as defined in the chapter Integer Type in the AUTOSAR EcuC specification. In case the ComSignalType is FLOAT32, FLOAT64 the string shall be interpreted as defined in the chapter Float Type in the AUTOSAR EcuC specification. In case the ComSignalType is BOOLEAN the string shall be interpreted as defined in the chapter Boolean Type in the AUTOSAR EcuC specification. In case the ComSignal is a UINT8_N, UINT8_DYN the string shall be interpreted as a decimal representation of the characters separated by blanks, e.g. "97 98 100" means a string "abd", where the char "a" is in byte 0(lowest address), "b" is in byte 1, and "d" is in byte 2 and (highest address). For the ComSignalType UINT8_DYN the dynamic length shall be set to the number of configured characters. An empty string "" shall be interpreted as 0-sized dynamic signal.		
Multiplicity	0..1		
Type	EcucStringParamDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local dependency: In case of UINT8_N the length of ComSignalDataInvalidValue has to be the same as ComSignalLength.		

Name	ComSignalEndianness [ECUC_Com_00157]	
Parent Container	ComGroupSignal	
Description	Defines the endianness of the signal's network representation.	
Multiplicity	1	
Type	EcucEnumerationParamDef	
Range	BIG_ENDIAN	
	LITTLE_ENDIAN	
	OPAQUE	
Post-Build Variant Value	true	

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComSignalInitValue [ECUC_Com_00170]		
Parent Container	ComGroupSignal		
Description	Initial value for this signal. In case of UINT8_N the default value is a string of length ComSignalLength with all bytes set to 0x00. In case of UINT8_DYN the initial size shall be 0. In case the ComSignalType is UINT8, UINT16, UINT32, UINT64, SINT8, SINT16, SINT32, SINT64 the string shall be interpreted as defined in the chapter Integer Type in the AUTOSAR EcuC specification. In case the ComSignalType is FLOAT32, FLOAT64 the string shall be interpreted as defined in the chapter Float Type in the AUTOSAR EcuC specification. In case the ComSignalType is BOOLEAN the string shall be interpreted as defined in the chapter Boolean Type in the AUTOSAR EcuC specification. In case the ComSignal is a UINT8_N, UINT8_DYN the string shall be interpreted as a decimal representation of the characters separated by blanks, e.g. "97 98 100" means a string "abd", where the char "a" is in byte 0(lowest address), "b" is in byte 1, and "d" is in byte 2 and (highest address). For the ComSignalType UINT8_DYN the dynamic length shall be set to the number of configured characters. An empty string "" shall be interpreted as 0-sized dynamic signal.		
Multiplicity	0..1		
Type	EcucStringParamDef		
Default Value	0		
Regular Expression			
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local dependency: In case of UINT8_N the length of ComSignalInitValue has to be the same as ComSignalLength.		

Name	ComSignalLength [ECUC_Com_00437]		
Parent Container	ComGroupSignal		
Description	Description: For ComSignalType UINT8_N this parameter specifies the length n in bytes. For ComSignalType UINT8_DYN it specifies the maximum length in bytes. For all other types this parameter shall be ignored. The supported maximum length is restricted by the used transportation system. For non TP-PDUs the maximum size of a PDU, and therefore also of any included signal, is limited by the concrete bus characteristic. For example, the limit is 8 bytes for CAN and LIN, 64 bytes for CAN FD and 254 for FlexRay.		
Multiplicity	0..1		
Type	EcucIntegerParamDef		
Range	0 .. 4294967295		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComSignalType [ECUC_Com_00127]	
Parent Container	ComGroupSignal	
Description	The AUTOSAR type of the signal. Whether or not the signal is signed or unsigned can be found by examining the value of this attribute. This type could also be used to reserved appropriate storage in AUTOSAR COM.	
Multiplicity	1	
Type	EcucEnumerationParamDef	
Range	BOOLEAN	
	FLOAT32	
	FLOAT64	
	SINT16	
	SINT32	
	SINT64	
	SINT8	
	UINT16	
	UINT32	
	UINT64	
	UINT8	

Post-Build Variant Value	UINT8_DYN		
	UINT8_N		
	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComTimeoutSubstitutionValue [ECUC_Com_10006]		
Parent Container	ComGroupSignal		
Description	The signal substitution value will be used in case of a timeout and ComRxDataTimeoutAction is set to SUBSTITUTE. In case of UINT8_N the default value is a string of length ComSignalLength with all bytes set to 0x00. In case ofUINT8_DYN the initial size shall be 0. In case the ComSignalType is UINT8, UINT16, UINT32, UINT64, SINT8, SINT16, SINT32, SINT64 the string shall be interpreted as defined in the chapter Integer Type in the AUTOSAR EcuC specification. In case the ComSignalType is FLOAT32, FLOAT64 the string shall be interpreted as defined in the chapter Float Type in the AUTOSAR EcuC specification. In case the ComSignalType is BOOLEAN the string shall be interpreted as defined in the chapter Boolean Type in the AUTOSAR EcuC specification. In case the ComSignal is a UINT8_N, UINT8_DYN the string shall be interpreted as a decimal representation of the characters separated by blanks, e.g. "97 98 100" means a string "abd", where the char "a" is in byte 0(lowest address), "b" is in byte 1, and "d" is in byte 2 and (highest address). For the ComSignalType UINT8_DYN the dynamic length shall be set to the number of configured characters. An empty string "" shall be interpreted as 0-sized dynamic signal.		
Multiplicity	0..1		
Type	EcucStringParamDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComTransferProperty [ECUC_Com_00560]	
Parent Container	ComGroupSignal	
Description	Optionally defines whether this group signal shall contribute to the TRIGGERED_ON_CHANGE transfer property of the signal group. If at least one group signal of a signal group has the "ComTransferProperty" configured all other group signals of that signal group shall have the attribute configured as well.	
Multiplicity	0..1	
Type	EcucEnumerationParamDef	
Range	PENDING	A change of the value of this group signal shall not be considered in the evaluation of the signal groups ComTransferProperty.
	TRIGGERED_ON_CHANGE	A change of the value of this group signal shall be considered in the evaluation of the signal groups ComTransferProperty.
Post-Build Variant Multiplicity	true	
Post-Build Variant Value	true	

Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComSystemTemplateSystemSignalRef [ECUC_Com_00002]
Parent Container	ComGroupSignal
Description	Reference to the ISignalToIPduMapping that contains a reference to the ISignal (System Template) which this ComSignal (or ComGroupSignal) represents.
Multiplicity	0..1
Type	Foreign reference to I-SIGNAL-TO-I-PDU-MAPPING
Post-Build Variant Multiplicity	true
Post-Build Variant Value	true

Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: ECU		

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
ComFilter	0..1	This container contains the configuration parameters of the AUTOSAR COM module's Filters. Note: On sender side the container is used to specify the transmission mode conditions.

E.1.2 ComIPdu

SWS Item	[ECUC_Com_00340]		
Container Name	ComIPdu		
Description	Contains the configuration parameters of the AUTOSAR COM module's I-PDUs.		
Post-Build Variant Multiplicity	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Configuration Parameters			

Name	ComIPduCallout [ECUC_Com_00387]		
Parent Container	ComIPdu		
Description	This parameter defines the existence and the name of a callout function for the corresponding I-PDU. If this parameter is omitted no I-PDU callout shall take place for the corresponding I-PDU.		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	

Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComIPduCancellationSupport [ECUC_Com_00709]		
Parent Container	ComIPdu		
Description	Defines for I-PDUs with ComIPduType NORMAL: If the underlying IF-modul supports cancellation of transmit requests. Defines for I-PDUs with ComIPduType TP: If the underlying TP-module supports RX and TX cancellation of ongoing requests.		
Multiplicity	0..1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	–	
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	–	
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: ECU dependency: This parameter shall not be set to true if ComCancellationSupport is set to false		

Name	ComIPduDirection [ECUC_Com_00493]		
Parent Container	ComIPdu		
Description	The direction defines if this I-PDU, and therefore the contributing signals and signal groups, shall be sent or received.		
Multiplicity	1		
Type	EcucEnumerationParamDef		
Range	RECEIVE		
	SEND		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local dependency: If configured to Sent also a ComTxIpdu container shall be included, see ECUC_Com_00496		

Name	ComIPduHandleId [ECUC_Com_00175]		
Parent Container	ComIPdu		
Description	The numerical value used as the ID of this I-PDU. The ComIPduHandleId is required by the API calls Com_RxIndication, Com_TpRxIndication, Com_StartOfReception and Com_CopyRxData to receive I-PDUs from the PduR (ComIP-duDirection: Receive), as well as the PduId passed to an Rx-I-PDU-callout. For Tx-I-PDUs (ComIPduDirection: Send), this handle Id is used for the APIs calls Com_TxConfirmation, Com_TriggerTransmit, Com_TriggerIPDUSend or Com_TriggerIPDUSendWithMetaData, Com_CopyTxData and Com_TpTxConfirmation to transmit respectively confirm transmissions of I-PDUs, as well as the PduId passed to the Tx-I-PDU-callout configured with ComIPduCallout and/or ComIPduTriggerTransmitCallout.		
Multiplicity	0..1		
Type	EcucIntegerParamDef (Symbolic Name generated for this parameter)		
Range	0 .. 65535		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	ComIPduSignalProcessing [ECUC_Com_00119]		
Parent Container	ComIPdu		
Description	For the definition of the two modes Immediate and Deferred.		
Multiplicity	1		
Type	EcucEnumerationParamDef		
Range	DEFERRED	signal indication / confirmations are deferred for example to a cyclic task	
	IMMEDIATE	the signal indications / confirmations are performed in Com_RxIndication/ Com_TxConfirmation	
Post-Build Variant Value	true		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComIPduTriggerTransmitCallout [ECUC_Com_00765]		
Parent Container	ComIPdu		
Description	If there is a trigger transmit callout defined for this I-PDU this parameter contains the name of the callout function.		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComIPduType [ECUC_Com_00761]		
Parent Container	ComIPdu		
Description	Defines if this I-PDU is a normal I-PDU that can be sent unfragmented or if this is a large I-PDU that shall be sent via the Transport Protocol of the underlying bus.		
Multiplicity	1		
Type	EcucEnumerationParamDef		
Range	NORMAL	sent or received via normal L-PDU	
	TP	sent or received via TP	
Post-Build Variant Value	true		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComIPduGroupRef [ECUC_Com_00206]
Parent Container	ComIPdu
Description	Reference to the I-PDU groups this I-PDU belongs to.
Multiplicity	0..*
Type	Reference to ComIPduGroup
Post-Build Variant Multiplicity	true
Post-Build Variant Value	true

Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComIPduSignalGroupRef [ECUC_Com_00519]		
Parent Container	ComIPdu		
Description	References to all signal groups contained in this I-Pdu		
Multiplicity	0..*		
Type	Reference to ComSignalGroup		
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComIPduSignalRef [ECUC_Com_00518]		
Parent Container	ComIPdu		
Description	References to all signals contained in this I-PDU.		
Multiplicity	0..*		
Type	Reference to ComSignal		
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComPduIdRef [ECUC_Com_00711]		
Parent Container	ComIPdu		
Description	Reference to the "global" Pdu structure to allow harmonization of handle IDs in the COM-Stack.		
Multiplicity	1		
Type	Reference to Pdu		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency			

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
ComIPduCounter	0..1	This optional container contains the configuration parameters of PDU Counter.
ComIPduReplication	0..1	This optional container contains the information needed for each I-PDU replicated.
ComTxIPdu	0..1	This container contains additional transmission related configuration parameters of the AUTOSAR COM module's I-PDUs.

E.1.3 ComSignal

SWS Item	[ECUC_Com_00344]		
Container Name	ComSignal		
Description	Contains the configuration parameters of the AUTOSAR COM module's signals.		
Post-Build Variant Multiplicity	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Configuration Parameters			

Name	ComBitPosition [ECUC_Com_00259]	
Parent Container	ComSignal	
Description	Starting position within the I-PDU. This parameter refers to the position in the I-PDU and not in the shadow buffer. If the endianness conversion is configured to Opaque the parameter ComBitPosition shall define the bit0 of the first byte like in little endian byte order	
Multiplicity	1	
Type	EcucIntegerParamDef	
Range	0 .. 4294967295	
Default Value		

Post-Build Variant Value	true		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComBitSize [ECUC_Com_00158]		
Parent Container	ComSignal		
Description	Size in bits, for integer signal types. For ComSignalType UINT8_N and UINT8_DYN the size shall be configured by ComSignalLength. For ComSignalTypes FLOAT32 and FLOAT64 the size is already defined by the signal type and therefore may be omitted.		
Multiplicity	0..1		
Type	EcucIntegerParamDef		
Range	0 .. 64		
Default Value			
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComDataInvalidAction [ECUC_Com_00314]	
Parent Container	ComSignal	
Description	This parameter defines the action performed upon reception of an invalid signal. Relating to signal groups the action in case if one of the included signals is an invalid signal. If Replace is used the ComSignalInitValue will be used for the replacement.	
Multiplicity	0..1	
Type	EcucEnumerationParamDef	
Range	NOTIFY	
	REPLACE	Literal for DataInvalidAction
Post-Build Variant Multiplicity	false	
Post-Build Variant Value	false	

Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComErrorNotification [ECUC_Com_00499]		
Parent Container	ComSignal		
Description	Only valid on sender side: Name of Com_CbkTxErr callback function to be called. If this parameter is omitted no error notification shall take place.		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComFirstTimeout [ECUC_Com_00183]	
Parent Container	ComSignal	
Description	Defines the length of the first deadline monitoring timeout period in seconds. This timeout is used immediately after start (or restart) of the deadline monitoring service. The timeout period of the successive periods is configured by ECUC_Com_00263.	
Multiplicity	0..1	
Type	EcucFloatParamDef	
Range	[0 .. 3600]	
Default Value		
Post-Build Variant Multiplicity	true	

Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComHandleId [ECUC_Com_00165]		
Parent Container	ComSignal		
Description	The numerical value used as the ID. This ID identifies signals and signal groups in the COM APIs using Com_SignalIdType or Com_SignalGroupIdType parameter respectively.		
Multiplicity	0..1		
Type	EcucIntegerParamDef (Symbolic Name generated for this parameter)		
Range	0 .. 65535		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	ComInitialValueOnly [ECUC_Com_00811]
Parent Container	ComSignal
Description	This parameter defines that the respective signal's initial value shall be put into the respective PDU but there will not be any update of the value through the RTE. Thus the Com implementation does not need to expect any API calls for this signal (group).
Multiplicity	0..1
Type	EcucBooleanParamDef
Default Value	false
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComInvalidNotification [ECUC_Com_00315]		
Parent Container	ComSignal		
Description	Only valid on receiver side: Name of Com_CbkInv callback function to be called. Name of the function which notifies the RTE about the reception of an invalidated signal/ signal group. Only applicable if ComDataInvalidAction is configured to NOTIFY.		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComNotification [ECUC_Com_00498]
Parent Container	ComSignal
Description	On sender side: Name of Com_CbkTxAck callback function to be called. On receiver side: Name of Com_CbkRxAck callback function to be called. If this parameter is omitted no notification shall take place.
Multiplicity	0..1
Type	EcucFunctionNameDef
Default Value	
Regular Expression	

Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComRxDataTimeoutAction [ECUC_Com_00412]		
Parent Container	ComSignal		
Description	This parameter defines the action performed upon expiration of the reception deadline monitoring timer.		
Multiplicity	0..1		
Type	EcucEnumerationParamDef		
Range	NONE	no replacement shall take place	
	REPLACE	signals shall be replaced by their ComSignalInitValue	
	SUBSTITUTE	signals shall be replaced by their ComTimeoutSubstitutionValue	
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComSignalDataInvalidValue [ECUC_Com_00391]		
Parent Container	ComSignal		
Description	Defines the data invalid value of the signal. In case the ComSignalType is UINT8, UINT16, UINT32, UINT64, SINT8, SINT16, SINT32, SINT64 the string shall be interpreted as defined in the chapter Integer Type in the AUTOSAR EcuC specification. In case the ComSignalType is FLOAT32, FLOAT64 the string shall be interpreted as defined in the chapter Float Type in the AUTOSAR EcuC specification. In case the ComSignalType is BOOLEAN the string shall be interpreted as defined in the chapter Boolean Type in the AUTOSAR EcuC specification. In case the ComSignal is a UINT8_N, UINT8_DYN the string shall be interpreted as a decimal representation of the characters separated by blanks, e.g. "97 98 100" means a string "abd", where the char "a" is in byte 0(lowest address), "b" is in byte 1, and "d" is in byte 2 and (highest address). For the ComSignalType UINT8_DYN the dynamic length shall be set to the number of configured characters. An empty string "" shall be interpreted as 0-sized dynamic signal.		
Multiplicity	0..1		
Type	EcucStringParamDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local dependency: In case of UINT8_N the length of ComSignalDataInvalidValue has to be the same as ComSignalLength.		

Name	ComSignalEndianness [ECUC_Com_00157]	
Parent Container	ComSignal	
Description	Defines the endianness of the signal's network representation.	
Multiplicity	1	
Type	EcucEnumerationParamDef	
Range	BIG_ENDIAN	
	LITTLE_ENDIAN	
	OPAQUE	
Post-Build Variant Value	true	

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComSignalInitValue [ECUC_Com_00170]		
Parent Container	ComSignal		
Description	Initial value for this signal. In case of UINT8_N the default value is a string of length ComSignalLength with all bytes set to 0x00. In case of UINT8_DYN the initial size shall be 0. In case the ComSignalType is UINT8, UINT16, UINT32, UINT64, SINT8, SINT16, SINT32, SINT64 the string shall be interpreted as defined in the chapter Integer Type in the AUTOSAR EcuC specification. In case the ComSignalType is FLOAT32, FLOAT64 the string shall be interpreted as defined in the chapter Float Type in the AUTOSAR EcuC specification. In case the ComSignalType is BOOLEAN the string shall be interpreted as defined in the chapter Boolean Type in the AUTOSAR EcuC specification. In case the ComSignal is a UINT8_N, UINT8_DYN the string shall be interpreted as a decimal representation of the characters separated by blanks, e.g. "97 98 100" means a string "abd", where the char "a" is in byte 0(lowest address), "b" is in byte 1, and "d" is in byte 2 and (highest address). For the ComSignalType UINT8_DYN the dynamic length shall be set to the number of configured characters. An empty string "" shall be interpreted as 0-sized dynamic signal.		
Multiplicity	0..1		
Type	EcucStringParamDef		
Default Value	0		
Regular Expression			
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local dependency: In case of UINT8_N the length of ComSignalInitValue has to be the same as ComSignalLength.		

Name	ComSignalLength [ECUC_Com_00437]		
Parent Container	ComSignal		
Description	Description: For ComSignalType UINT8_N this parameter specifies the length n in bytes. For ComSignalType UINT8_DYN it specifies the maximum length in bytes. For all other types this parameter shall be ignored. The supported maximum length is restricted by the used transportation system. For non TP-PDUs the maximum size of a PDU, and therefore also of any included signal, is limited by the concrete bus characteristic. For example, the limit is 8 bytes for CAN and LIN, 64 bytes for CAN FD and 254 for FlexRay.		
Multiplicity	0..1		
Type	EcucIntegerParamDef		
Range	0 .. 4294967295		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComSignalType [ECUC_Com_00127]	
Parent Container	ComSignal	
Description	The AUTOSAR type of the signal. Whether or not the signal is signed or unsigned can be found by examining the value of this attribute. This type could also be used to reserved appropriate storage in AUTOSAR COM.	
Multiplicity	1	
Type	EcucEnumerationParamDef	
Range	BOOLEAN	
	FLOAT32	
	FLOAT64	
	SINT16	
	SINT32	
	SINT64	
	SINT8	
	UINT16	
	UINT32	
	UINT64	
	UINT8	

	UINT8_DYN		
	UINT8_N		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComTimeout [ECUC_Com_00263]		
Parent Container	ComSignal		
Description	Defines the length of the deadline monitoring timeout period in seconds. The period for the first timeout period can be configured separately by ECUC_Com_00183.		
Multiplicity	0..1		
Type	EcucFloatParamDef		
Range	[0 .. 3600]		
Default Value			
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComTimeoutNotification [ECUC_Com_00552]
Parent Container	ComSignal
Description	On sender side: Name of Com_CbkTxTOut callback function to be called. On receiver side: Name of Com_CbkRxTOut callback function to be called.
Multiplicity	0..1
Type	EcucFunctionNameDef
Default Value	
Regular Expression	
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComTimeoutSubstitutionValue [ECUC_Com_10006]
Parent Container	ComSignal
Description	The signal substitution value will be used in case of a timeout and ComRxDataTimeoutAction is set to SUBSTITUTE. In case of UINT8_N the default value is a string of length ComSignalLength with all bytes set to 0x00. In case ofUINT8_DYN the initial size shall be 0. In case the ComSignalType is UINT8, UINT16, UINT32, UINT64, SINT8, SINT16, SINT32, SINT64 the string shall be interpreted as defined in the chapter Integer Type in the AUTOSAR EcuC specification. In case the ComSignalType is FLOAT32, FLOAT64 the string shall be interpreted as defined in the chapter Float Type in the AUTOSAR EcuC specification. In case the ComSignalType is BOOLEAN the string shall be interpreted as defined in the chapter Boolean Type in the AUTOSAR EcuC specification. In case the ComSignal is a UINT8_N, UINT8_DYN the string shall be interpreted as a decimal representation of the characters separated by blanks, e.g. "97 98 100" means a string "abd", where the char "a" is in byte 0(lowest address), "b" is in byte 1, and "d" is in byte 2 and (highest address). For the ComSignalType UINT8_DYN the dynamic length shall be set to the number of configured characters. An empty string "" shall be interpreted as 0-sized dynamic signal.
Multiplicity	0..1
Type	EcucStringParamDef
Default Value	
Regular Expression	
Post-Build Variant Multiplicity	true
Post-Build Variant Value	true

Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComTransferProperty [ECUC_Com_00232]		
Parent Container	ComSignal		
Description	Defines if a write access to this signal can trigger the transmission of the corresponding I-PDU. If the I-PDU is triggered, depends also on the transmission mode of the corresponding I-PDU.		
Multiplicity	0..1		
Type	EcucEnumerationParamDef		
Range	PENDING	A write access to this signal never triggers the transmission of the corresponding I-PDU.	
	TRIGGERED	Depending on the transmission mode, a write access to this signal can trigger the transmission of the corresponding I-PDU.	
	TRIGGERED_ON_CHANGE	Depending on the transmission mode, a write access to this signal can trigger the transmission of the corresponding I-PDU, but only in case the written value is different to the locally stored (last sent or initial value) in length or value.	
	TRIGGERED_ON_CHANGE_WITHOUT_REPETITION	Depending on the transmission mode, a write access to this signal can trigger the transmission of the corresponding I-PDU just once without a repetition, but only in case the written value is different to the locally stored (last sent or initial value) in length or value.	
	TRIGGERED_WITHOUT_REPETITION	Depending on the transmission mode, a write access to this signal can trigger the transmission of the corresponding I-PDU just once without a repetition.	
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComUpdateBitPosition [ECUC_Com_00257]		
Parent Container	ComSignal		
Description	Bit position of update-bit inside I-PDU. If this attribute is omitted then there is no update-bit. This setting must be consistently on sender and on receiver side. Range: 0..63 for CAN and LIN, 0..511 for CAN FD, 0..2031 for FlexRay, 0..4294967295 for TP.		
Multiplicity	0..1		
Type	EcucIntegerParamDef		
Range	0 .. 4294967295		
Default Value			
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComSystemTemplateSystemSignalRef [ECUC_Com_00002]		
Parent Container	ComSignal		
Description	Reference to the ISignalToIPduMapping that contains a reference to the ISignal (System Template) which this ComSignal (or ComGroupSignal) represents.		
Multiplicity	0..1		
Type	Foreign reference to I-SIGNAL-TO-I-PDU-MAPPING		
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: ECU		

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
ComFilter	0..1	This container contains the configuration parameters of the AUTOSAR COM module's Filters. Note: On sender side the container is used to specify the transmission mode conditions.

E.1.4 ComSignalGroup

SWS Item	[ECUC_Com_00345]		
Container Name	ComSignalGroup		
Description	Contains the configuration parameters of the AUTOSAR COM module's signal groups.		
Post-Build Variant Multiplicity	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Configuration Parameters			

Name	ComDataInvalidAction [ECUC_Com_00314]		
Parent Container	ComSignalGroup		
Description	This parameter defines the action performed upon reception of an invalid signal. Relating to signal groups the action in case if one of the included signals is an invalid signal. If Replace is used the ComSignalInitValue will be used for the replacement.		
Multiplicity	0..1		
Type	EcucEnumerationParamDef		
Range	NOTIFY		
	REPLACE	Literal for DataInvalidAction	
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComErrorNotification [ECUC_Com_00499]		
Parent Container	ComSignalGroup		
Description	Only valid on sender side: Name of Com_CbkTxErr callback function to be called. If this parameter is omitted no error notification shall take place.		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComFirstTimeout [ECUC_Com_00183]		
Parent Container	ComSignalGroup		
Description	Defines the length of the first deadline monitoring timeout period in seconds. This timeout is used immediately after start (or restart) of the deadline monitoring service. The timeout period of the successive periods is configured by ECUC_Com_00263.		
Multiplicity	0..1		
Type	EcucFloatParamDef		
Range	[0 .. 3600]		
Default Value			
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComHandleId [ECUC_Com_00165]		
Parent Container	ComSignalGroup		
Description	The numerical value used as the ID. This ID identifies signals and signal groups in the COM APIs using Com_SignalIdType or Com_SignalGroupIdType parameter respectively.		
Multiplicity	0..1		
Type	EcucIntegerParamDef (Symbolic Name generated for this parameter)		
Range	0 .. 65535		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	ComInitialValueOnly [ECUC_Com_00811]		
Parent Container	ComSignalGroup		
Description	This parameter defines that the respective signal's initial value shall be put into the respective PDU but there will not be any update of the value through the RTE. Thus the Com implementation does not need to expect any API calls for this signal (group).		
Multiplicity	0..1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComInvalidNotification [ECUC_Com_00315]		
Parent Container	ComSignalGroup		
Description	Only valid on receiver side: Name of Com_CbkInv callback function to be called. Name of the function which notifies the RTE about the reception of an invalidated signal/ signal group. Only applicable if ComDataInvalidAction is configured to NOTIFY.		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComNotification [ECUC_Com_00498]
Parent Container	ComSignalGroup
Description	On sender side: Name of Com_CbkTxAck callback function to be called. On receiver side: Name of Com_CbkRxAck callback function to be called. If this parameter is omitted no notification shall take place.
Multiplicity	0..1
Type	EcucFunctionNameDef
Default Value	
Regular Expression	
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComRxDataTimeoutAction [ECUC_Com_00412]		
Parent Container	ComSignalGroup		
Description	This parameter defines the action performed upon expiration of the reception deadline monitoring timer.		
Multiplicity	0..1		
Type	EcucEnumerationParamDef		
Range	NONE	no replacement shall take place	
	REPLACE	signals shall be replaced by their ComSignalInitValue	
	SUBSTITUTE	signals shall be replaced by their ComTimeoutSubstitutionValue	
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComSignalGroupArrayAccess [ECUC_Com_10003]
Parent Container	ComSignalGroup
Description	Defines whether the uint8-array based access shall be used for this ComSignalGroup.
Multiplicity	0..1
Type	EcucBooleanParamDef
Default Value	
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

Name	ComTimeout [ECUC_Com_00263]		
Parent Container	ComSignalGroup		
Description	Defines the length of the deadline monitoring timeout period in seconds. The period for the first timeout period can be configured separately by ECUC_Com_00183.		
Multiplicity	0..1		
Type	EcucFloatParamDef		
Range	[0 .. 3600]		
Default Value			
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComTimeoutNotification [ECUC_Com_00552]
Parent Container	ComSignalGroup
Description	On sender side: Name of Com_CbkTxTOut callback function to be called. On receiver side: Name of Com_CbkRxTOut callback function to be called.
Multiplicity	0..1
Type	EcucFunctionNameDef
Default Value	
Regular Expression	
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	ComTransferProperty [ECUC_Com_00232]		
Parent Container	ComSignalGroup		
Description	Defines if a write access to this signal can trigger the transmission of the corresponding I-PDU. If the I-PDU is triggered, depends also on the transmission mode of the corresponding I-PDU.		
Multiplicity	0..1		
Type	EcucEnumerationParamDef		
Range	PENDING	A write access to this signal never triggers the transmission of the corresponding I-PDU.	
	TRIGGERED	Depending on the transmission mode, a write access to this signal can trigger the transmission of the corresponding I-PDU.	
	TRIGGERED_ON_CHANGE	Depending on the transmission mode, a write access to this signal can trigger the transmission of the corresponding I-PDU, but only in case the written value is different to the locally stored (last sent or initial value) in length or value.	
	TRIGGERED_ON_CHANGE_WITHOUT_REPETITION	Depending on the transmission mode, a write access to this signal can trigger the transmission of the corresponding I-PDU just once without a repetition, but only in case the written value is different to the locally stored (last sent or initial value) in length or value.	
	TRIGGERED_WITHOUT_REPETITION	Depending on the transmission mode, a write access to this signal can trigger the transmission of the corresponding I-PDU just once without a repetition.	
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComUpdateBitPosition [ECUC_Com_00257]		
Parent Container	ComSignalGroup		
Description	Bit position of update-bit inside I-PDU. If this attribute is omitted then there is no update-bit. This setting must be consistently on sender and on receiver side. Range: 0..63 for CAN and LIN, 0..511 for CAN FD, 0..2031 for FlexRay, 0..4294967295 for TP.		
Multiplicity	0..1		
Type	EcucIntegerParamDef		
Range	0 .. 4294967295		
Default Value			
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: local		

Name	ComSystemTemplateSignalGroupRef [ECUC_Com_00001]		
Parent Container	ComSignalGroup		
Description	Reference to the ISignalToIPduMapping that contains a reference to the ISignalGroup (SystemTemplate) which this ComSignalGroup represents.		
Multiplicity	0..1		
Type	Foreign reference to I-SIGNAL-TO-I-PDU-MAPPING		
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Scope / Dependency	scope: ECU		

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
ComGroupSignal	0..*	This container contains the configuration parameters of group signals. I.e. signals that are included within a signal group.

E.2 LdCom

Module SWS Item	ECUC_LdCom_00001		
Module Name	LdCom		
Module Description	Configuration of the AUTOSAR LdCom module.		
Post-Build Variant Support	true		
Supported Config Variants	VARIANT-LINK-TIME, VARIANT-POST-BUILD, VARIANT-PRE-COMPILE		
Included Containers			
Container Name	**Multiplicity**	**Scope / Dependency**	
LdComConfig	1	This container contains the configuration parameters and sub containers of the AUTOSAR LdCom module.	
LdComGeneral	1	Contains the general configuration parameters of the LdCom module.	

E.2.1 LdComConfig

SWS Item	[ECUC_LdCom_00003]
Container Name	LdComConfig
Description	This container contains the configuration parameters and sub containers of the AUTOSAR LdCom module.
Configuration Parameters	

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
LdComIPdu	0..*	Contains the configuration parameters of the IPdu inside LdCom.

E.2.2 LdComIPdu

SWS Item	[ECUC_LdCom_00006]
Container Name	LdComIPdu
Description	Contains the configuration parameters of the IPdu inside LdCom.

Post-Build Variant Multiplicity	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Configuration Parameters			

Name	LdComApiType [ECUC_LdCom_00002]		
Parent Container	LdComIPdu		
Description	Defines if this I-PDU is a normal I-PDU that shall be sent unfragmented or if this is a large I-PDU that shall be sent via the Transport Protocol of the underlying bus. This setting is used by RTE to invoke the proper API.		
Multiplicity	1		
Type	EcucEnumerationParamDef		
Range	LDCOM_IF	sent or received via interface API.	
	LDCOM_TP	sent or received via transport protocol API.	
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	LdComHandleId [ECUC_LdCom_00005]		
Parent Container	LdComIPdu		
Description	This is the ID used by RTE to invoke LdCom. A corresponding shortName is created, which is used for the invocations of the RTE. The same ID is used for invocations by PduR.		
Multiplicity	1		
Type	EcucIntegerParamDef (Symbolic Name generated for this parameter)		
Range	0 .. 65535		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	LdComIPduDirection [ECUC_LdCom_00007]		
Parent Container	LdComIPdu		
Description	The direction defines if this IPdu, and therefore the contributing signal, shall be sent or received.		
Multiplicity	1		
Type	EcucEnumerationParamDef		
Range	LDCOM_RECEIVE		
	LDCOM_SEND		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: local		

Name	LdComRxCopyRxData [ECUC_LdCom_00013]		
Parent Container	LdComIPdu		
Description	Only on receiver side: Name of Rte_LdComCbkCopyRxData callback function to be called.		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	LdComRxIndication [ECUC_LdCom_00014]
Parent Container	LdComIPdu
Description	Only on receiver side: Name of Rte_LdComCbkRxIndication callback function to be called.
Multiplicity	0..1
Type	EcucFunctionNameDef
Default Value	
Regular Expression	

Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	LdComRxStartOfReception [ECUC_LdCom_00015]		
Parent Container	LdComIPdu		
Description	Only on receiver side: Name of Rte_LdComCbkStartOfReception callback function to be called.		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	LdComTpRxIndication [ECUC_LdCom_00016]
Parent Container	LdComIPdu
Description	Only on receiver side: Name of Rte_LdComCbkTpRxIndication callback function to be called.
Multiplicity	0..1
Type	EcucFunctionNameDef
Default Value	
Regular Expression	

Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	LdComTpTxConfirmation [ECUC_LdCom_00017]		
Parent Container	LdComIPdu		
Description	Only on sender side: Name of Rte_LdComCbkTpTxConfirmation callback function to be called.		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	LdComTxConfirmation [ECUC_LdCom_00021]
Parent Container	LdComIPdu
Description	Only on sender side: Name of Rte_LdComCbkTxConfirmation callback function to be called.
Multiplicity	0..1
Type	EcucFunctionNameDef
Default Value	
Regular Expression	

Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	LdComTxCopyTxData [ECUC_LdCom_00018]		
Parent Container	LdComIPdu		
Description	Only on sender side: Name of Rte_LdComCbkCopyTxData callback function to be called.		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	LdComTxTriggerTransmit [ECUC_LdCom_00019]
Parent Container	LdComIPdu
Description	Only on sender side: Name of Rte_LdComCbkTriggerTransmit callback function to be called. If defined TriggerTransmit has to be supported for this signal.
Multiplicity	0..1
Type	EcucFunctionNameDef
Default Value	
Regular Expression	

Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	LdComPduRef [ECUC_LdCom_00010]		
Parent Container	LdComIPdu		
Description	Reference to the global Pdu.		
Multiplicity	1		
Type	Reference to Pdu		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME, VARIANT-POST-BUILD
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	LdComSystemTemplateSignalRef [ECUC_LdCom_00011]		
Parent Container	LdComIPdu		
Description	Reference to the ISignalToIPduMapping that contains a reference to the ISignal (System Template).		
Multiplicity	0..1		
Type	Foreign reference to I-SIGNAL-TO-I-PDU-MAPPING		
Post-Build Variant Multiplicity	true		
Post-Build Variant Value	true		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	X	VARIANT-POST-BUILD

Scope / Dependency	scope: ECU

No Included Containers

E.3 EcuC

Module SWS Item	ECUC_EcuC_00008	
Module Name	EcuC	
Module Description	Virtual module to collect ECU Configuration specific / global configuration information.	
Post-Build Variant Support	true	
Supported Config Variants	VARIANT-POST-BUILD, VARIANT-PRE-COMPILE	
Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
EcucConfigSet	0..1	This container contains the configuration parameters and sub containers of the global PduCollection.
EcucHardware	0..1	Hardware definition of this Ecu.
EcucPartitionCollection	0..1	Collection of Partitions defined for this ECU.
EcucPostBuildVariants	0..1	Collection of toplevel PostBuildSelectable variants. The PredefinedVariants linked inside this container will determine how many PostBuildSelectableVariants exist. If this container exist the name pattern for initialization of BSW modules will be <Mip>_Config_<PredefinedVariant.shortName>. If this container does not exist the name pattern for initialization of BSW modlues will be <Mip>_Config.
EcucUnitGroupAssignment	0..1	Collection of UnitGroup references to support the generation of ASAM MCD file.
EcucVariationResolver	0..1	Collection of PredefinedVariant elements containing definition of values for SwSystemconst which shall be applied when resolving the variability during ECU Configuration.

E.3.1 EcucPartition

SWS Item	[ECUC_EcuC_00005]		
Container Name	EcucPartition		
Description	Definition of one Partition on this ECU. One Partition will be implemented using one Os-Application.		
Post-Build Variant Multiplicity	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE, VARIANT-POST-BUILD
	Link time	–	
	Post-build time	–	
Configuration Parameters			

Name	EcucPartitionBswModuleExecution [ECUC_EcuC_00037]		
Parent Container	EcucPartition		
Description	Denotes that this partition will execute BSW Modules. BSW Modules can only be executed in such partitions.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

Name	EcucPartitionQmBswModuleExecution [ECUC_EcuC_00069]		
Parent Container	EcucPartition		
Description	Denotes that this partition will execute QM BSW.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	true		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	PartitionCanBeRestarted [ECUC_EcuC_00006]		
Parent Container	EcucPartition		
Description	Specifies the requirement whether the Partition can be restarted. If set to true all software executing in this partition shall be capable of handling a restart.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

Name	EcucPartitionBswModuleDistinguishedPartition [ECUC_EcuC_00068]		
Parent Container	EcucPartition		
Description	This maps the abstract partition of the Bsw Module to a concrete Partition existing in the ECU.		
Multiplicity	0..*		
Type	Foreign reference to BSW-DISTINGUISHED-PARTITION		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

Name	EcucPartitionSoftwareComponentInstanceRef [ECUC_EcuC_00036]		
Parent Container	EcucPartition		
Description	References the SW Component instances from the Ecu Extract that shall be executed in this partition.		
Multiplicity	0..*		
Type	Instance reference to SW-COMPONENT-PROTOTYPE context: ROOT-SW-COMPOSITION-PROTOTYPE		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

No Included Containers

E.4 NvM

E.4.1 NvMBlockDescriptor

SWS Item	[ECUC_NvM_00061]
Container Name	NvMBlockDescriptor
Description	Container for a management structure to configure the composition of a given NVRAM Block Management Type. Its multiplicity describes the number of configured NVRAM blocks, one block is required to be configured. The NVRAM block descriptors are condensed in the NVRAM block descriptor table.
Configuration Parameters	

Name	NvMBlockCrcType [ECUC_NvM_00476]		
Parent Container	NvMBlockDescriptor		
Description	Defines CRC data width for the NVRAM block. Default: NVM_CRC16, i.e. CRC16 will be used if NVM_BLOCK_USE_CRC==true		
Multiplicity	0..1		
Type	EcucEnumerationParamDef		
Range	NVM_CRC16	(Default) CRC16 will be used if NVM_BLOCK_USE_CRC==true.	
	NVM_CRC32	CRC32 is selected for this NVRAM block if NVM_BLOCK_USE_CRC==true.	
	NVM_CRC8	CRC8 is selected for this NVRAM block if NVM_BLOCK_USE_CRC==true.	
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local dependency: NVM_BLOCK_USE_CRC, NVM_CALC_RAM_BLOCK_CRC		

Name	NvMBlockHeaderInclude [ECUC_NvM_00554]
Parent Container	NvMBlockDescriptor
Description	Defines the header file where the owner of the NVRAM block has the declarations of the permanent RAM data block, ROM data block (if configured) and the callback function prototype for each configured callback. If no permanent RAM block, ROM block or callback functions are configured then this configuration parameter shall be ignored.
Multiplicity	0..1
Type	EcucStringParamDef
Default Value	
Regular Expression	

Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMBlockJobPriority [ECUC_NvM_00477]		
Parent Container	NvMBlockDescriptor		
Description	Defines the job priority for a NVRAM block (0 = Immediate priority).		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 255		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMBlockManagementType [ECUC_NvM_00062]		
Parent Container	NvMBlockDescriptor		
Description	Defines the block management type for the NVRAM block.[NVM137]		
Multiplicity	1		
Type	EcucEnumerationParamDef		
Range	NVM_BLOCK_DATASET	NVRAM block is configured to be of dataset type.	
	NVM_BLOCK_NATIVE	NVRAM block is configured to be of native type.	
	NVM_BLOCK_REDUNDANT	NVRAM block is configured to be of redundant type.	
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMBlockUseAutoValidation [ECUC_NvM_00557]		
Parent Container	NvMBlockDescriptor		
Description	Defines whether the RAM Block shall be auto validated during shutdown phase. true: if auto validation mechanism is used, false: otherwise		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMBlockUseCrc [ECUC_NvM_00036]		
Parent Container	NvMBlockDescriptor		
Description	Defines CRC usage for the NVRAM block, i.e. memory space for CRC is reserved in RAM and NV memory. true: CRC will be used for this NVRAM block. false: CRC will not be used for this NVRAM block.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMBlockUseCRCCompMechanism [ECUC_NvM_00556]		
Parent Container	NvMBlockDescriptor		
Description	Defines whether the CRC of the RAM Block shall be compared during a write job with the CRC which was calculated during the last successful read or write job. true: if compare mechanism is used, false: otherwise		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	

Scope / Dependency	scope: local dependency: False if NvMBlockUseCrc = False

Name	NvMBlockUseSetRamBlockStatus [ECUC_NvM_00552]		
Parent Container	NvMBlockDescriptor		
Description	Defines if NvMSetRamBlockStatusApi shall be used for this block or not. Note: If NvMSetRamBlockStatusApi is disabled this configuration parameter shall be ignored. true: calling of NvMSetRamBlockStatus for this RAM block shall set the status of the RAM block. false: calling of NvMSetRamBlockStatus for this RAM block shall be ignored.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMBlockUseSyncMechanism [ECUC_NvM_00519]		
Parent Container	NvMBlockDescriptor		
Description	Defines whether an explicit synchronization mechanism with a RAM mirror and callback routines for transferring data to and from NvM module's RAM mirror is used for NV block. true if synchronization mechanism is used, false otherwise.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMBlockWriteProt [ECUC_NvM_00033]		
Parent Container	NvMBlockDescriptor		
Description	Defines an initial write protection of the NV block true: Initial block write protection is enabled. false: Initial block write protection is disabled.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMBswMBlockStatusInformation [ECUC_NvM_00551]		
Parent Container	NvMBlockDescriptor		
Description	This parameter specifies whether BswM is informed about the current status of the specified block. True: Call BswM_NvM_CurrentBlockMode on changes False: Don't inform BswM at all		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMCalcRamBlockCrc [ECUC_NvM_00119]
Parent Container	NvMBlockDescriptor
Description	Defines CRC (re)calculation for the permanent RAM block or NVRAM blocks which are configured to use explicit synchronization mechanism. true: CRC will be (re)calculated for this permanent RAM block. false: CRC will not be (re)calculated for this permanent RAM block.
Multiplicity	0..1
Type	EcucBooleanParamDef
Default Value	
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local dependency: NVM_BLOCK_USE_CRC		

Name	NvMInitBlockCallback [ECUC_NvM_00116]		
Parent Container	NvMBlockDescriptor		
Description	Entry address of a block specific callback routine which shall be called if no ROM data is available for initialization of the NVRAM block. If not configured, no specific callback routine shall be called for initialization of the NVRAM block with default data.		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMMaxNumOfReadRetries [ECUC_NvM_00533]		
Parent Container	NvMBlockDescriptor		
Description	Defines the maximum number of read retries.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 7		
Default Value	0		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	

Scope / Dependency	scope: local

Name	NvMMaxNumOfWriteRetries [ECUC_NvM_00499]		
Parent Container	NvMBlockDescriptor		
Description	Defines the maximum number of write retries for a NVRAM block with [ECUC_NvM_00061]. Regardless of configuration a consistency check (and maybe write retries) are always forced for each block which is processed by the request NvM_WriteAll and NvM_WriteBlock.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 7		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMNvBlockBaseNumber [ECUC_NvM_00478]		
Parent Container	NvMBlockDescriptor		
Description	Configuration parameter to perform the link between the NVM_NVRAM_BLOCK_IDENTIFIER used by the SW-Cs and the FEE_BLOCK_NUMBER expected by the memory abstraction modules. The parameter value equals the FEE_BLOCK_NUMBER or EA_BLOCK_NUMBER shifted to the right by NvMDatasetSelectionBits bits. (ref. to chapter 7.1.2.1). Calculation Formula: value = TargetBlockReference.[Ea/Fee]BlockConfiguration.[Ea/Fee]BlockNumber » NvMDatasetSelectionBits		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	1 .. 65534		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local dependency: FEE_BLOCK_NUMBER, EA_BLOCK_NUMBER		

Name	NvMNvBlockLength [ECUC_NvM_00479]		
Parent Container	NvMBlockDescriptor		
Description	Defines the NV block data length in bytes. Note: The implementer can add the attribute 'withAuto' to the parameter definition which indicates that the length can be calculated by the generator automatically (e.g. by using the sizeof operator). When 'withAuto' is set to 'true' for this parameter definition the 'isAutoValue' can be set to 'true'. If 'isAutoValue' is set to 'true' the actual value will not be considered during ECU Configuration but will be (re-)calculated by the code generator and stored in the value attribute afterwards.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	1 .. 65535		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMNvBlockNum [ECUC_NvM_00480]		
Parent Container	NvMBlockDescriptor		
Description	Defines the number of multiple NV blocks in a contiguous area according to the given block management type. 1-255 For NVRAM blocks to be configured of block management type NVM_BLOCK_DATASET. The actual range is limited according to SWS_NvM_00444. 1 For NVRAM blocks to be configured of block management type NVM_BLOCK_NATIVE 2 For NVRAM blocks to be configured of block management type NVM_BLOCK_REDUNDANT		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	1 .. 255		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local dependency: NVM_BLOCK_MANAGEMENT_TYPE		

Name	NvMNvramBlockIdentifier [ECUC_NvM_00481]		
Parent Container	NvMBlockDescriptor		
Description	Identification of a NVRAM block via a unique block identifier. Implementation Type: NvM_BlockIdType. min = 2 max = 2ˆ (16- NVM_DATASET_SELECTION_BITS)-1 Reserved NVRAM block IDs: 0 -> to derive multi block request results via NvM_GetErrorStatus 1 -> redundant NVRAM block which holds the configuration ID (generation tool should check that this block is correctly configured from type,CRC and size point of view)		
Multiplicity	1		
Type	EcucIntegerParamDef (Symbolic Name generated for this parameter)		
Range	2 .. 65535		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local dependency: NVM_DATASET_SELECTION_BITS		

Name	NvMNvramDeviceId [ECUC_NvM_00035]		
Parent Container	NvMBlockDescriptor		
Description	Defines the NVRAM device ID where the NVRAM block is located. Calculation Formula: value = TargetBlockReference.[Ea/Fee]BlockConfiguration.[Ea/Fee]DeviceIndex		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 1		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local dependency: EA_DEVICE_INDEX, FEE_DEVICE_INDEX		

Name	NvMRamBlockDataAddress [ECUC_NvM_00482]		
Parent Container	NvMBlockDescriptor		
Description	Defines the start address of the RAM block data. If this is not configured, no permanent RAM data block is available for the selected block management type.		
Multiplicity	0..1		
Type	EcucStringParamDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMReadRamBlockFromNvCallback [ECUC_NvM_00521]		
Parent Container	NvMBlockDescriptor		
Description	Entry address of a block specific callback routine which shall be called in order to let the application copy data from the NvM module's mirror to RAM block. Implementation type: Std_ReturnType E_OK: copy was successful E_NOT_OK: copy was not successful, callback routine to be called again		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMResistantToChangedSw [ECUC_NvM_00483]		
Parent Container	NvMBlockDescriptor		
Description	Defines whether a NVRAM block shall be treated resistant to configuration changes or not. If there is no default data available at configuration time then the application shall be responsible for providing the default initialization data. In this case the application has to use NvM_GetErrorStatus()to be able to distinguish between first initialization and corrupted data. true: NVRAM block is resistant to changed software. false: NVRAM block is not resistant to changed software.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMRomBlockDataAddress [ECUC_NvM_00484]		
Parent Container	NvMBlockDescriptor		
Description	Defines the start address of the ROM block data. If not configured, no ROM block is available for the selected block management type.		
Multiplicity	0..1		
Type	EcucStringParamDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMRomBlockNum [ECUC_NvM_00485]		
Parent Container	NvMBlockDescriptor		
Description	Defines the number of multiple ROM blocks in a contiguous area according to the given block management type. 0-254 For NVRAM blocks to be configured of block management type NVM_BLOCK_DATASET. The actual range is limited according to SWS_NvM_00444. 0-1 For NVRAM blocks to be configured of block management type NVM_BLOCK_NATIVE 0-1 For NVRAM blocks to be configured of block management type NVM_BLOCK_REDUNDANT		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 254		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local dependency: NVM_BLOCK_MANAGEMENT_TYPE, NVM_NV_BLOCK_NUM		

Name	NvMSelectBlockForFirstInitAll {NVM_SELECT_BLOCK_FOR_FIRST_INIT_ALL} [ECUC_NvM_00558]		
Parent Container	NvMBlockDescriptor		
Description	Defines whether a block will be processed or not by NvM_FirstInitAll. A block can be configured to be processed even if it doesn't have permanent RAM and/or explicit synchronization. TRUE: block will be processed by NvM_FirstInitAll FALSE: block will not be processed by NvM_FirstInitAll		
Multiplicity	0..1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMSelectBlockForReadAll [ECUC_NvM_00117]		
Parent Container	NvMBlockDescriptor		
Description	Defines whether a NVRAM block shall be processed during NvM_ReadAll or not. This configuration parameter has only influence on those NVRAM blocks which are configured to have a permanent RAM block or which are configured to use explicit synchronization mechanism. true: NVRAM block shall be processed by NvM_ReadAll false: NVRAM block shall not be processed by NvM_ReadAll		
Multiplicity	0..1		
Type	EcucBooleanParamDef		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local dependency: NVM_RAM_BLOCK_DATA_ADDRESS		

Name	NvMSelectBlockForWriteAll [ECUC_NvM_00549]
Parent Container	NvMBlockDescriptor
Description	Defines whether a NVRAM block shall be processed during NvM_WriteAll or not. This configuration parameter has only influence on those NVRAM blocks which are configured to have a permanent RAM block or which are configured to use explicit synchronization mechanism. true: NVRAM block shall be processed by NvM_WriteAll false: NVRAM block shall not be processed by NvM_WriteAll
Multiplicity	0..1
Type	EcucBooleanParamDef
Default Value	
Post-Build Variant Multiplicity	false

Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local dependency: NVM_RAM_BLOCK_DATA_ADDRESS		

Name	NvMSingleBlockCallback [ECUC_NvM_00506]		
Parent Container	NvMBlockDescriptor		
Description	Entry address of the block specific callback routine which shall be invoked on termination of each asynchronous single block request [NVM113].		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMStaticBlockIDCheck [ECUC_NvM_00532]
Parent Container	NvMBlockDescriptor
Description	Defines if the Static Block ID check is enabled. false: Static Block ID check is disabled. true: Static Block ID check is enabled.
Multiplicity	1
Type	EcucBooleanParamDef
Default Value	false
Post-Build Variant Value	false

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMWriteBlockOnce [ECUC_NvM_00072]		
Parent Container	NvMBlockDescriptor		
Description	Defines write protection after first write. The NVRAM manager sets the write protection bit either after the NV block was written the first time or if the block was already written and it is detected as valid and consistent during a read for it. [NVM276]. true: Defines write protection after first write is enabled. false: Defines write protection after first write is disabled.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMWriteRamBlockToNvCallback [ECUC_NvM_00520]		
Parent Container	NvMBlockDescriptor		
Description	Entry address of a block specific callback routine which shall be called in order to let the application copy data from RAM block to NvM module's mirror. Implementation type: Std_ReturnType E_OK: copy was successful E_NOT_OK: copy was not successful, callback routine to be called again		
Multiplicity	0..1		
Type	EcucFunctionNameDef		
Default Value			
Regular Expression			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	

Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMWriteVerification [ECUC_NvM_00534]		
Parent Container	NvMBlockDescriptor		
Description	Defines if Write Verification is enabled. false: Write verification is disabled. true: Write Verification is enabled.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Name	NvMWriteVerificationDataSize [ECUC_NvM_00538]		
Parent Container	NvMBlockDescriptor		
Description	Defines the number of bytes to compare in each step when comparing the content of a RAM Block and a block read back.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	1 .. 65535		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	VARIANT-PRE-COMPILE
	Link time	X	VARIANT-LINK-TIME
	Post-build time	–	
Scope / Dependency	scope: local		

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
NvMTargetBlockReference	1	This parameter is just a container for the parameters for EA and FEE

E.5 Os

E.5.1 OsAlarm

SWS Item	[ECUC_Os_00003]		
Container Name	OsAlarm		
Description	An OsAlarm may be used to asynchronously inform or activate a specific task. It is possible to start alarms automatically at system start-up depending on the application mode.		
Configuration Parameters			

Name	OsAlarmAccessingApplication [ECUC_Os_00004]		
Parent Container	OsAlarm		
Description	Reference to applications which have an access to this object.		
Multiplicity	0..*		
Type	Reference to OsApplication		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

Name	OsAlarmCounterRef [ECUC_Os_00005]		
Parent Container	OsAlarm		
Description	Reference to the assigned counter for that alarm		
Multiplicity	1		
Type	Reference to OsCounter		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
OsAlarmAction	1	This container defines which type of notification is used when the alarm expires.
OsAlarmAutostart	0..1	If present this container defines if an alarm is started automatically at system start-up depending on the application mode.

E.5.2 OsApplication

SWS Item	[ECUC_Os_00114]		
Container Name	OsApplication		
Description	An AUTOSAR OS must be capable of supporting a collection of OS objects (tasks, interrupts, alarms, hooks etc.) that form a cohesive functional unit. This collection of objects is termed an OS-Application. All objects which belong to the same OS-Application have access to each other. Access means to allow to use these objects within API services. Access by other applications can be granted separately.		
Configuration Parameters			

Name	OsTrusted [ECUC_Os_00115]		
Parent Container	OsApplication		
Description	Parameter to specify if an OS-Application is trusted or not. true: OS-Application is trusted false: OS-Application is not trusted (default)		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU dependency: Required for scalability class 3 and 4.		

Name	OsTrustedApplicationDelayTimingViolationCall [ECUC_Os_00395]		
Parent Container	OsApplication		
Description	Parameter to specify if a timing violation which occurs within an trusted OS-Application is raised immediately of if it is delayed until the current task returns to the calling OS-Application (return of CallTrustedFunction) true: violation / call to ProtectionHook() is delayed false: timing violation cause an immediate call to the ProtectionHook().		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	true		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	OsTrustedApplicationWithProtection [ECUC_Os_00394]		
Parent Container	OsApplication		
Description	Parameter to specify if a trusted OS-Application is executed with memory protection or not. true: OS-Application runs within a protected environment. This means that write access is limited. false: OS-Application has full write access (default)		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value	false		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	OsAppAlarmRef [ECUC_Os_00231]		
Parent Container	OsApplication		
Description	Specifies the OsAlarms that belong to the OsApplication.		
Multiplicity	0..*		
Type	Reference to OsAlarm		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	OsAppCounterRef [ECUC_Os_00234]
Parent Container	OsApplication
Description	References the OsCounters that belong to the OsApplication.
Multiplicity	0..*
Type	Reference to OsCounter
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	OsAppEcucPartitionRef [ECUC_Os_00392]		
Parent Container	OsApplication		
Description	Denotes which "EcucPartition" is implemented by this "OSApplication".		
Multiplicity	0..1		
Type	Reference to EcucPartition		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

Name	OsAppIsrRef [ECUC_Os_00221]		
Parent Container	OsApplication		
Description	references which OsIsrs belong to the OsApplication		
Multiplicity	0..*		
Type	Reference to OsIsr		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	OsApplicationCoreRef [ECUC_Os_00393]		
Parent Container	OsApplication		
Description	Reference to the Core Definition in the Ecuc Module where the CoreId is defined. This reference is used to describe to which Core the OsApplication is bound.		
Multiplicity	0..1		
Type	Reference to EcucCoreDefinition		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	OsAppScheduleTableRef [ECUC_Os_00230]		
Parent Container	OsApplication		
Description	References the OsScheduleTables that belong to the OsApplication.		
Multiplicity	0..*		
Type	Reference to OsScheduleTable		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	OsAppTaskRef [ECUC_Os_00116]
Parent Container	OsApplication
Description	references which OsTasks belong to the OsApplication
Multiplicity	0..*
Type	Reference to OsTask
Post-Build Variant Multiplicity	false
Post-Build Variant Value	false

Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	OsRestartTask [ECUC_Os_00120]		
Parent Container	OsApplication		
Description	Optionally one task of an OS-Application may be defined as Restart Task. Multiplicity = 1: Restart Task is activated by the Operating System if the protection hook requests it. Multiplicity = 0: No task is automatically started after a protection error happened.		
Multiplicity	0..1		
Type	Reference to OsTask		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU dependency: Required for scalability class 3 and 4.		

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
OsApplicationHooks	1	Container to structure the OS-Application-specific hooks
OsApplicationTrusted Function	0..*	Container to structure the configuration parameters of trusted functions

E.5.3 OsCounter

SWS Item	[ECUC_Os_00026]
Container Name	OsCounter
Description	Configuration information for the counters that belong to the OsApplication.

Configuration Parameters

Name	OsCounterMaxAllowedValue [ECUC_Os_00027]		
Parent Container	OsCounter		
Description	Maximum possible allowed value of the system counter in ticks.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	1 .. 18446744073709551615		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	OsCounterMinCycle [ECUC_Os_00028]		
Parent Container	OsCounter		
Description	The MINCYCLE attribute specifies the minimum allowed number of counter ticks for a cyclic alarm linked to the counter.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	1 .. 18446744073709551615		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	OsCounterTicksPerBase [ECUC_Os_00029]	
Parent Container	OsCounter	
Description	The TICKSPERBASE attribute specifies the number of ticks required to reach a counterspecific unit. The interpretation is implementation-specific.	
Multiplicity	1	
Type	EcucIntegerParamDef	
Range	1 .. 4294967295	
Default Value		
Post-Build Variant Value	false	

Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	OsCounterType [ECUC_Os_00255]	
Parent Container	OsCounter	
Description	This parameter contains the natural type or unit of the counter.	
Multiplicity	1	
Type	EcucEnumerationParamDef	
Range	HARDWARE	This counter is driven by some hardware e.g. a hardware timer unit.
	SOFTWARE	The counter is driven by some software which calls the IncrementCounter service.
Post-Build Variant Value	false	

Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	OsSecondsPerTick [ECUC_Os_00030]		
Parent Container	OsCounter		
Description	Time of one counter tick in seconds.		
Multiplicity	0..1		
Type	EcucFloatParamDef		
Range	[0 .. INF]		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	OsCounterAccessingApplication [ECUC_Os_00031]		
Parent Container	OsCounter		
Description	Reference to applications which have an access to this object.		
Multiplicity	0..*		
Type	Reference to OsApplication		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
OsDriver	0..1	This Container contains the information who will drive the counter. This configuration is only valid if the counter has OsCounterType set to HARDWARE. If the container does not exist (multiplicity=0) the timer is managed by the OS internally (OSINTERNAL). If the container exists the OS can use the GPT interface to manage the timer. The user have to supply the GPT channel. If the counter is driven by some other (external to the OS) source (like a TPU for example) this must be described as a vendor specific extension.
OsTimeConstant	0..*	Allows the user to define constants which can be e.g. used to compare time values with timer tick values. `A time value will be converted to a timer tick value during generation and can later on accessed via the OsConstName. The conversation is done by rounding time values to the nearest fitting tick value.`

E.5.4 OsEvent

SWS Item	[ECUC_Os_00033]
Container Name	OsEvent
Description	Representation of OS events in the configuration context. Adopted from the ISO 17356-6 specification.
Configuration Parameters	

Name	OsEventMask [ECUC_Os_00034]		
Parent Container	OsEvent		
Description	If event mask would be set to AUTO in OIL, this parameter should be omitted here.		
Multiplicity	0..1		
Type	EcucIntegerParamDef		
Range	0 .. 18446744073709551615		
Default Value			
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

No Included Containers

E.5.5 OsScheduleTable

SWS Item	[ECUC_Os_00141]
Container Name	OsScheduleTable
Description	An OsScheduleTable addresses the synchronization issue by providing an encapsulation of a statically defined set of alarms that cannot be modified at runtime.
Configuration Parameters	

Name	OsScheduleTableDuration [ECUC_Os_00053]		
Parent Container	OsScheduleTable		
Description	This parameter defines the modulus of the schedule table (in ticks).		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 18446744073709551615		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	

Scope / Dependency	scope: local

Name	OsScheduleTableRepeating [ECUC_Os_00144]		
Parent Container	OsScheduleTable		
Description	true: first expiry point on the schedule table shall be processed at final expiry point delay ticks after the final expiry point is processed. false: the schedule table processing stops when the final expiry point is processed.		
Multiplicity	1		
Type	EcucBooleanParamDef		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	OsScheduleTableCounterRef [ECUC_Os_00145]		
Parent Container	OsScheduleTable		
Description	This parameter contains a reference to the counter which drives the schedule table.		
Multiplicity	1		
Type	Reference to OsCounter		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	OsSchTblAccessingApplication [ECUC_Os_00054]		
Parent Container	OsScheduleTable		
Description	Reference to applications which have an access to this object.		
Multiplicity	0..*		
Type	Reference to OsApplication		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	

Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
OsScheduleTable Autostart	0..1	This container specifies if and how the schedule table is started on startup of the Operating System. The options to start a schedule table correspond to the API calls to start schedule tables during runtime.
OsScheduleTableExpiry Point	1..*	The point on a Schedule Table at which the OS activates tasks and/or sets events
OsScheduleTableSync	0..1	This container specifies the synchronization parameters of the schedule table.

E.5.6 OsScheduleTableExpiryPoint

SWS Item	[ECUC_Os_00143]
Container Name	OsScheduleTableExpiryPoint
Description	The point on a Schedule Table at which the OS activates tasks and/or sets events
Configuration Parameters	

Name	OsScheduleTblExpPointOffset [ECUC_Os_00062]		
Parent Container	OsScheduleTableExpiryPoint		
Description	The offset from zero (in ticks) at which the expiry point is to be processed.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 18446744073709551615		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency			

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
OsScheduleTableEvent Setting	0..*	Event that is triggered by that schedule table.
OsScheduleTableTask Activation	0..*	Task that is triggered by that schedule table.

OsScheduleTbl AdjustableExpPoint	0..1	Adjustable expiry point

E.5.7 OsTask

SWS Item	[ECUC_Os_00073]
Container Name	OsTask
Description	This container represents an ISO 17356 task.
Configuration Parameters	

Name	OsTaskActivation [ECUC_Os_00074]		
Parent Container	OsTask		
Description	This attribute defines the maximum number of queued activation requests for the task. A value equal to "1" means that at any time only a single activation is permitted for this task. Note that the value must be a natural number starting at 1.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	1 .. 4294967295		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	OsTaskPriority [ECUC_Os_00075]		
Parent Container	OsTask		
Description	The priority of a task is defined by the value of this attribute. This value has to be understood as a relative value, i.e. the values show only the relative ordering of the tasks. ISO 17356-3 defines the lowest priority as zero (0); larger values correspond to higher priorities.		
Multiplicity	1		
Type	EcucIntegerParamDef		
Range	0 .. 4294967295		
Default Value			
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	OsTaskSchedule [ECUC_Os_00076]		
Parent Container	OsTask		
Description	The OsTaskSchedule attribute defines the preemptability of the task. If this attribute is set to NON, no internal resources may be assigned to this task.		
Multiplicity	1		
Type	EcucEnumerationParamDef		
Range	FULL	Task is preemptable.	
	NON	Task is not preemptable.	
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	OsMemoryMappingCodeLocationRef [ECUC_Os_00402]		
Parent Container	OsTask		
Description	Reference to the memory mapping containing details about the section where the code is placed.		
Multiplicity	0..1		
Type	Foreign reference to SW-ADDR-METHOD		
Post-Build Variant Value	false		
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: ECU		

Name	OsTaskAccessingApplication [ECUC_Os_00077]		
Parent Container	OsTask		
Description	Reference to applications which have an access to this object.		
Multiplicity	0..*		
Type	Reference to OsApplication		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	

Scope / Dependency	scope: local

Name	OsTaskEventRef [ECUC_Os_00078]		
Parent Container	OsTask		
Description	This reference defines the list of events the extended task may react on.		
Multiplicity	0..*		
Type	Reference to OsEvent		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Name	OsTaskResourceRef [ECUC_Os_00079]		
Parent Container	OsTask		
Description	This reference defines a list of resources accessed by this task.		
Multiplicity	0..*		
Type	Reference to OsResource		
Post-Build Variant Multiplicity	false		
Post-Build Variant Value	false		
Multiplicity Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Value Configuration Class	**Pre-compile time**	X	All Variants
	Link time	–	
	Post-build time	–	
Scope / Dependency	scope: local		

Included Containers		
Container Name	**Multiplicity**	**Scope / Dependency**
OsTaskAutostart	0..1	This container determines whether the task is activated during the system start-up procedure or not for some specific application modes. If the task shall be activated during the system start-up, this container is present and holds the references to the application modes in which the task is auto-started.
OsTaskTimingProtection	0..1	This container contains all parameters regarding timing protection of the task.

F Examples

This chapter contains more detailed information for examples which were shown inside the preceding chapters of the specification.

F.1 ModeDeclarationGroupMapping

The example for **Mapping of ModeDeclarations** in chapter 4.4.10 is based on the following ARXML:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<AUTOSAR xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="
    http://autosar.org/schema/r4.0" xsi:schemaLocation="http://autosar.
    org/schema/r4.0 AUTOSAR_4-2-1.xsd">
  <AR-PACKAGES>
    <AR-PACKAGE>
      <SHORT-NAME>Demo</SHORT-NAME>
      <DESC>
        <L-2 L="EN">Example about Connection of Mode Managers and Mode
            Users with different number of ModeDeclarations</L-2>
      </DESC>
      <CATEGORY>EXAMPLE</CATEGORY>
      <AR-PACKAGES>
        <AR-PACKAGE>
          <SHORT-NAME>SwComponentTypes</SHORT-NAME>
          <ELEMENTS>
            <APPLICATION-SW-COMPONENT-TYPE>
              <SHORT-NAME>ModeManager</SHORT-NAME>
              <PORTS>
                <P-PORT-PROTOTYPE>
                  <SHORT-NAME>EcuState</SHORT-NAME>
                  <PROVIDED-COM-SPECS>
                    <MODE-SWITCH-SENDER-COM-SPEC>
                      <ENHANCED-MODE-API>true</ENHANCED-MODE-API>
                      <MODE-GROUP-REF DEST="MODE-DECLARATION-GROUP-
                          PROTOTYPE">/Demo/PortInterfaces/
                          EcuStatesExtended/EcuStatesExtended</MODE-
                          GROUP-REF>
                      <QUEUE-LENGTH>1</QUEUE-LENGTH>
                    </MODE-SWITCH-SENDER-COM-SPEC>
                  </PROVIDED-COM-SPECS>
                  <PROVIDED-INTERFACE-TREF DEST="MODE-SWITCH-INTERFACE"
                      >/Demo/PortInterfaces/EcuStatesExtended</PROVIDED
                      -INTERFACE-TREF>
                </P-PORT-PROTOTYPE>
              </PORTS>
            </APPLICATION-SW-COMPONENT-TYPE>
            <APPLICATION-SW-COMPONENT-TYPE>
              <SHORT-NAME>ModeUser</SHORT-NAME>
              <PORTS>
                <R-PORT-PROTOTYPE>
                  <SHORT-NAME>EcuState</SHORT-NAME>
                  <REQUIRED-COM-SPECS>
```

```xml
                <MODE-SWITCH-RECEIVER-COM-SPEC>
                  <ENHANCED-MODE-API>1</ENHANCED-MODE-API>
                  <SUPPORTS-ASYNCHRONOUS-MODE-SWITCH>false</
                     SUPPORTS-ASYNCHRONOUS-MODE-SWITCH>
                </MODE-SWITCH-RECEIVER-COM-SPEC>
              </REQUIRED-COM-SPECS>
              <REQUIRED-INTERFACE-TREF DEST="MODE-SWITCH-INTERFACE"
                 >/Demo/PortInterfaces/EcuStatesBasic</REQUIRED-
                 INTERFACE-TREF>
            </R-PORT-PROTOTYPE>
          </PORTS>
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        <COMPOSITION-SW-COMPONENT-TYPE>
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          <COMPONENTS>
            <SW-COMPONENT-PROTOTYPE>
              <SHORT-NAME>ModeManager</SHORT-NAME>
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                 /SwComponentTypes/ModeManager</TYPE-TREF>
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            <SW-COMPONENT-PROTOTYPE>
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              <TYPE-TREF DEST="APPLICATION-SW-COMPONENT-TYPE">/Demo
                 /SwComponentTypes/ModeUser</TYPE-TREF>
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                 SHORT-NAME>
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                 PortInterfaceMappingSets/
                 ModeSwitchInterfaceMapping/
                 EcuStatesExtended_2_EcuStatesBasic</MAPPING-REF>
              <PROVIDER-IREF>
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                   CONTEXT-COMPONENT-REF>
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                   SwComponentTypes/ModeManager/EcuState</TARGET-P
                   -PORT-REF>
              </PROVIDER-IREF>
              <REQUESTER-IREF>
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                   ">/Demo/SwComponentTypes/DemoEcu/ModeUser</
                   CONTEXT-COMPONENT-REF>
                <TARGET-R-PORT-REF DEST="R-PORT-PROTOTYPE">/Demo/
                   SwComponentTypes/ModeUser/EcuState</TARGET-R-
                   PORT-REF>
              </REQUESTER-IREF>
            </ASSEMBLY-SW-CONNECTOR>
          </CONNECTORS>
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```

```
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            <SW-CALIBRATION-ACCESS>READ-ONLY</SW-CALIBRATION-ACCESS
                >
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          </MODE-GROUP>
        </MODE-SWITCH-INTERFACE>
        <MODE-SWITCH-INTERFACE>
          <SHORT-NAME>EcuStatesExtended</SHORT-NAME>
          <MODE-GROUP>
            <SHORT-NAME>EcuStatesExtended</SHORT-NAME>
            <SW-CALIBRATION-ACCESS>READ-ONLY</SW-CALIBRATION-ACCESS
                >
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      <ELEMENTS>
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          <CATEGORY>EXPLICIT_ORDER</CATEGORY>
          <INITIAL-MODE-REF DEST="MODE-DECLARATION">/Demo/
              ModeDeclarationGroups/EcuStatesBasic/STARTUP</INITIAL
              -MODE-REF>

          <MODE-DECLARATIONS>
            <MODE-DECLARATION>
              <SHORT-NAME>STARTUP</SHORT-NAME>
              <DESC>
                <L-2 L="EN">Startup phase of the Ecu</L-2>
              </DESC>
              <VALUE>1</VALUE>
            </MODE-DECLARATION>
            <MODE-DECLARATION>
              <SHORT-NAME>RUN</SHORT-NAME>
              <DESC>
                <L-2 L="EN">Run phase of the Ecu</L-2>
              </DESC>
              <VALUE>2</VALUE>
            </MODE-DECLARATION>
            <MODE-DECLARATION>
              <SHORT-NAME>POST_RUN</SHORT-NAME>
              <DESC>
                <L-2 L="EN">post run phase of the Ecu</L-2>
              </DESC>
              <VALUE>3</VALUE>
            </MODE-DECLARATION>
```

```
        <MODE-DECLARATION>
          <SHORT-NAME>SHUTDOWN</SHORT-NAME>
          <DESC>
            <L-2 L="EN">shutdown phase of the Ecu</L-2>
          </DESC>
          <VALUE>4</VALUE>
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      <MODE-TRANSITION>
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            ModeDeclarationGroups/EcuStatesBasic/RUN</ENTERED-
            MODE-REF>
        <EXITED-MODE-REF DEST="MODE-DECLARATION">/Demo/
            ModeDeclarationGroups/EcuStatesBasic/STARTUP</
            EXITED-MODE-REF>
      </MODE-TRANSITION>
      <MODE-TRANSITION>
        <SHORT-NAME>STARTUP_POST_RUN</SHORT-NAME>
        <ENTERED-MODE-REF DEST="MODE-DECLARATION">/Demo/
            ModeDeclarationGroups/EcuStatesBasic/POST_RUN</
            ENTERED-MODE-REF>
        <EXITED-MODE-REF DEST="MODE-DECLARATION">/Demo/
            ModeDeclarationGroups/EcuStatesBasic/STARTUP</
            EXITED-MODE-REF>
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      <MODE-TRANSITION>
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            ModeDeclarationGroups/EcuStatesBasic/POST_RUN</
            ENTERED-MODE-REF>
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            ModeDeclarationGroups/EcuStatesBasic/RUN</EXITED-
            MODE-REF>
      </MODE-TRANSITION>
      <MODE-TRANSITION>
        <SHORT-NAME>POST_RUN_SHUTDOWN</SHORT-NAME>
        <ENTERED-MODE-REF DEST="MODE-DECLARATION">/Demo/
            ModeDeclarationGroups/EcuStatesBasic/SHUTDOWN</
            ENTERED-MODE-REF>
        <EXITED-MODE-REF DEST="MODE-DECLARATION">/Demo/
            ModeDeclarationGroups/EcuStatesBasic/POST_RUN</
            EXITED-MODE-REF>
      </MODE-TRANSITION>
      </MODE-TRANSITIONS>
      <ON-TRANSITION-VALUE>0</ON-TRANSITION-VALUE>
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    <MODE-DECLARATION-GROUP>
      <SHORT-NAME>EcuStatesExtended</SHORT-NAME>
      <CATEGORY>ALPHABETIC_ORDER</CATEGORY>
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          ModeDeclarationGroups/EcuStatesExtended/StartUp</
          INITIAL-MODE-REF>
      <MODE-DECLARATIONS>
        <MODE-DECLARATION>
```

```
            <SHORT-NAME>StartUp</SHORT-NAME>
            <DESC>
              <L-2 L="EN">Start up phase of the Ecu</L-2>
            </DESC>
          </MODE-DECLARATION>
          <MODE-DECLARATION>
            <SHORT-NAME>Run</SHORT-NAME>
            <DESC>
              <L-2 L="EN">Run phase of the Ecu</L-2>
            </DESC>
          </MODE-DECLARATION>
          <MODE-DECLARATION>
            <SHORT-NAME>PostRun1</SHORT-NAME>
            <DESC>
              <L-2 L="EN">First post run phase of the Ecu</L-2>
            </DESC>
          </MODE-DECLARATION>
          <MODE-DECLARATION>
            <SHORT-NAME>PostRun2</SHORT-NAME>
            <DESC>
              <L-2 L="EN">Second post run phase of the Ecu</L-2>
            </DESC>
          </MODE-DECLARATION>
          <MODE-DECLARATION>
            <SHORT-NAME>ShutDown</SHORT-NAME>
            <DESC>
              <L-2 L="EN">Shut down phase of the Ecu</L-2>
            </DESC>
          </MODE-DECLARATION>
          <MODE-DECLARATION>
            <SHORT-NAME>Sleep</SHORT-NAME>
            <DESC>
              <L-2 L="EN">Sleep mode of the Ecu with reduced
                  functionality</L-2>
            </DESC>
          </MODE-DECLARATION>
          <MODE-DECLARATION>
            <SHORT-NAME>Hibernate</SHORT-NAME>
            <DESC>
              <L-2 L="EN">Hibernate mode of the Ecu with extreme
                  reduced functionality</L-2>
            </DESC>
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      </MODE-DECLARATION-GROUP>
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  </AR-PACKAGE>
  <AR-PACKAGE>
    <SHORT-NAME>PortInterfaceMappingSets</SHORT-NAME>
    <ELEMENTS>
      <MODE-DECLARATION-MAPPING-SET>
        <SHORT-NAME>EcuStateMapping</SHORT-NAME>
        <MODE-DECLARATION-MAPPINGS>
          <MODE-DECLARATION-MAPPING>
            <SHORT-NAME>StartUp_2_STARTUP_</SHORT-NAME>
            <FIRST-MODE-REFS>
```

```
        <FIRST-MODE-REF DEST="MODE-DECLARATION">/Demo/
          ModeDeclarationGroups/EcuStatesExtended/StartUp
          </FIRST-MODE-REF>
      </FIRST-MODE-REFS>
      <SECOND-MODE-REF DEST="MODE-DECLARATION">/Demo/
        ModeDeclarationGroups/EcuStatesBasic/STARTUP</
        SECOND-MODE-REF>
    </MODE-DECLARATION-MAPPING>
    <MODE-DECLARATION-MAPPING>
      <SHORT-NAME>Run_2_RUN</SHORT-NAME>
      <FIRST-MODE-REFS>
        <FIRST-MODE-REF DEST="MODE-DECLARATION">/Demo/
          ModeDeclarationGroups/EcuStatesExtended/Run</
          FIRST-MODE-REF>
      </FIRST-MODE-REFS>
      <SECOND-MODE-REF DEST="MODE-DECLARATION">/Demo/
        ModeDeclarationGroups/EcuStatesBasic/RUN</SECOND-
        MODE-REF>
    </MODE-DECLARATION-MAPPING>
    <MODE-DECLARATION-MAPPING>
      <SHORT-NAME>PostRunX_2_POST_RUN</SHORT-NAME>
      <FIRST-MODE-REFS>
        <FIRST-MODE-REF DEST="MODE-DECLARATION">/Demo/
          ModeDeclarationGroups/EcuStatesExtended/
          PostRun1</FIRST-MODE-REF>
        <FIRST-MODE-REF DEST="MODE-DECLARATION">/Demo/
          ModeDeclarationGroups/EcuStatesExtended/
          PostRun2</FIRST-MODE-REF>
      </FIRST-MODE-REFS>
      <SECOND-MODE-REF DEST="MODE-DECLARATION">/Demo/
        ModeDeclarationGroups/EcuStatesBasic/POST_RUN</
        SECOND-MODE-REF>
    </MODE-DECLARATION-MAPPING>
    <MODE-DECLARATION-MAPPING>
      <SHORT-NAME>ShutDown_2_SHUTDOWN</SHORT-NAME>
      <FIRST-MODE-REFS>
        <FIRST-MODE-REF DEST="MODE-DECLARATION">/Demo/
          ModeDeclarationGroups/EcuStatesExtended/
          ShutDown</FIRST-MODE-REF>
      </FIRST-MODE-REFS>
      <SECOND-MODE-REF DEST="MODE-DECLARATION">/Demo/
        ModeDeclarationGroups/EcuStatesBasic/SHUTDOWN</
        SECOND-MODE-REF>
    </MODE-DECLARATION-MAPPING>
    <MODE-DECLARATION-MAPPING>
      <SHORT-NAME>Sleep_Hibernate_2_SHUTDOWN</SHORT-NAME>
      <FIRST-MODE-REFS>
        <FIRST-MODE-REF DEST="MODE-DECLARATION">/Demo/
          ModeDeclarationGroups/EcuStatesExtended/Sleep</
          FIRST-MODE-REF>
        <FIRST-MODE-REF DEST="MODE-DECLARATION">/Demo/
          ModeDeclarationGroups/EcuStatesExtended/
          Hibernate</FIRST-MODE-REF>
      </FIRST-MODE-REFS>
```

```
                  <SECOND-MODE-REF DEST="MODE-DECLARATION">/Demo/
                     ModeDeclarationGroups/EcuStatesBasic/SHUTDOWN</
                     SECOND-MODE-REF>
                </MODE-DECLARATION-MAPPING>
              </MODE-DECLARATION-MAPPINGS>
            </MODE-DECLARATION-MAPPING-SET>
            <PORT-INTERFACE-MAPPING-SET>
              <SHORT-NAME>ModeSwitchInterfaceMapping</SHORT-NAME>
              <PORT-INTERFACE-MAPPINGS>
                <MODE-INTERFACE-MAPPING>
                  <SHORT-NAME>EcuStatesExtended_2_EcuStatesBasic</SHORT
                     -NAME>
                  <MODE-MAPPING>
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                       PROTOTYPE">/Demo/PortInterfaces/
                       EcuStatesExtended/EcuStatesExtended</FIRST-MODE
                       -GROUP-REF>
                    <MODE-DECLARATION-MAPPING-SET-REF DEST="MODE-
                       DECLARATION-MAPPING-SET">/Demo/
                       PortInterfaceMappingSets/EcuStateMapping</MODE-
                       DECLARATION-MAPPING-SET-REF>
                    <SECOND-MODE-GROUP-REF DEST="MODE-DECLARATION-GROUP
                       -PROTOTYPE">/Demo/PortInterfaces/EcuStatesBasic
                       /EcuStatesBasic</SECOND-MODE-GROUP-REF>
                  </MODE-MAPPING>
                </MODE-INTERFACE-MAPPING>
              </PORT-INTERFACE-MAPPINGS>
            </PORT-INTERFACE-MAPPING-SET>
          </ELEMENTS>
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      </AR-PACKAGES>
    </AR-PACKAGE>
  </AR-PACKAGES>
</AUTOSAR>
```

F.2 Stability need for received data

The example for **Stability need for received data** in example 4.7 is based on the following ARXML:

```
<?xml version="1.0" encoding="UTF-8"?>
<AUTOSAR xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="
   http://autosar.org/schema/r4.0" xsi:schemaLocation="http://autosar.
   org/schema/r4.0 AUTOSAR_4-2-1.xsd">
  <AR-PACKAGES>
    <AR-PACKAGE>
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      <CATEGORY>EXAMPLE</CATEGORY>
      <AR-PACKAGES>
        <AR-PACKAGE>
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          <ELEMENTS>
            <COMPOSITION-SW-COMPONENT-TYPE>
```

```
<SHORT-NAME>COMP_1</SHORT-NAME>
<DESC><L-2 L="EN">Stability need for received data (see
    SWS RTE)</L-2></DESC>
<CONSISTENCY-NEEDSS>
<CONSISTENCY-NEEDS>
  <SHORT-NAME>CN_BC</SHORT-NAME>
  <DPG-DOES-NOT-REQUIRE-COHERENCYS>
  <DATA-PROTOTYPE-GROUP>
    <SHORT-NAME>CN_BC_DG1</SHORT-NAME>
    <IMPLICIT-DATA-ACCESS-IREFS>
    <IMPLICIT-DATA-ACCESS-IREF>
    <CONTEXT-SW-COMPONENT-PROTOTYPE-REF DEST="SW-
        COMPONENT-PROTOTYPE">/Demo/SwComponentTypes/
        COMP_1/ASWC_B</CONTEXT-SW-COMPONENT-PROTOTYPE-REF
        >
    <CONTEXT-PORT-PROTOTYPE-REF DEST="R-PORT-PROTOTYPE">/
        Demo/SwComponentTypes/ASWC_B/A</CONTEXT-PORT-
        PROTOTYPE-REF>
    <TARGET-VARIABLE-DATA-PROTOTYPE-REF DEST="VARIABLE-
        DATA-PROTOTYPE">/Demo/PortInterfaces/A/A</TARGET-
        VARIABLE-DATA-PROTOTYPE-REF>
    </IMPLICIT-DATA-ACCESS-IREF>

    <IMPLICIT-DATA-ACCESS-IREF>
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        COMPONENT-PROTOTYPE">/Demo/SwComponentTypes/
        COMP_1/ASWC_C</CONTEXT-SW-COMPONENT-PROTOTYPE-REF
        >
    <CONTEXT-PORT-PROTOTYPE-REF DEST="R-PORT-PROTOTYPE">/
        Demo/SwComponentTypes/ASWC_C/A</CONTEXT-PORT-
        PROTOTYPE-REF>
    <TARGET-VARIABLE-DATA-PROTOTYPE-REF DEST="VARIABLE-
        DATA-PROTOTYPE">/Demo/PortInterfaces/A/A</TARGET-
        VARIABLE-DATA-PROTOTYPE-REF>
    </IMPLICIT-DATA-ACCESS-IREF>

    <IMPLICIT-DATA-ACCESS-IREF>
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        COMPONENT-PROTOTYPE">/Demo/SwComponentTypes/
        COMP_1/ASWC_B</CONTEXT-SW-COMPONENT-PROTOTYPE-REF
        >
    <CONTEXT-PORT-PROTOTYPE-REF DEST="R-PORT-PROTOTYPE">/
        Demo/SwComponentTypes/ASWC_B/B</CONTEXT-PORT-
        PROTOTYPE-REF>
    <TARGET-VARIABLE-DATA-PROTOTYPE-REF DEST="VARIABLE-
        DATA-PROTOTYPE">/Demo/PortInterfaces/B/B</TARGET-
        VARIABLE-DATA-PROTOTYPE-REF>
    </IMPLICIT-DATA-ACCESS-IREF>


    <IMPLICIT-DATA-ACCESS-IREF>
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        COMPONENT-PROTOTYPE">/Demo/SwComponentTypes/
        COMP_1/ASWC_C</CONTEXT-SW-COMPONENT-PROTOTYPE-REF
        >
```

```
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           Demo/SwComponentTypes/ASWC_C/B</CONTEXT-PORT-
           PROTOTYPE-REF>
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           DATA-PROTOTYPE">/Demo/PortInterfaces/B/B</TARGET-
           VARIABLE-DATA-PROTOTYPE-REF>
        </IMPLICIT-DATA-ACCESS-IREF>

        </IMPLICIT-DATA-ACCESS-IREFS>
      </DATA-PROTOTYPE-GROUP>
      </DPG-DOES-NOT-REQUIRE-COHERENCYS>
      <REG-REQUIRES-STABILITYS>
      <RUNNABLE-ENTITY-GROUP>
        <SHORT-NAME>CN_BC_RG1</SHORT-NAME>
        <RUNNABLE-ENTITY-IREFS>
        <RUNNABLE-ENTITY-IREF>
        <CONTEXT-SW-COMPONENT-PROTOTYPE-REF DEST="SW-
           COMPONENT-PROTOTYPE">/Demo/SwComponentTypes/
           COMP_1/ASWC_B</CONTEXT-SW-COMPONENT-PROTOTYPE-REF
           >
        <TARGET-RUNNABLE-ENTITY-REF DEST="RUNNABLE-ENTITY">/
           Demo/SwComponentTypes/ASWC_B/IB_ASWC_B/
           ASWC_B_RUN1</TARGET-RUNNABLE-ENTITY-REF>
        </RUNNABLE-ENTITY-IREF>
        <RUNNABLE-ENTITY-IREF>
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           COMP_1/ASWC_C</CONTEXT-SW-COMPONENT-PROTOTYPE-REF
           >
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           Demo/SwComponentTypes/ASWC_C/IB_ASWC_C/
           ASWC_C_RUN1</TARGET-RUNNABLE-ENTITY-REF>
        </RUNNABLE-ENTITY-IREF>
        </RUNNABLE-ENTITY-IREFS>
      </RUNNABLE-ENTITY-GROUP>
      </REG-REQUIRES-STABILITYS>
    </CONSISTENCY-NEEDS>
    </CONSISTENCY-NEEDSS>
    <COMPONENTS>
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           /SwComponentTypes/ASWC_A</TYPE-TREF>
      </SW-COMPONENT-PROTOTYPE>
      <SW-COMPONENT-PROTOTYPE>
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           /SwComponentTypes/ASWC_B</TYPE-TREF>
      </SW-COMPONENT-PROTOTYPE>
      <SW-COMPONENT-PROTOTYPE>
        <SHORT-NAME>ASWC_C</SHORT-NAME>
        <TYPE-TREF DEST="APPLICATION-SW-COMPONENT-TYPE">/Demo
           /SwComponentTypes/ASWC_C</TYPE-TREF>
      </SW-COMPONENT-PROTOTYPE>
    </COMPONENTS>
  </COMPOSITION-SW-COMPONENT-TYPE>
```

```
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          INTERFACE">/Demo/PortInterfaces/A</PROVIDED-
          INTERFACE-TREF>
    </P-PORT-PROTOTYPE>
    <P-PORT-PROTOTYPE>
      <SHORT-NAME>B</SHORT-NAME>
      <PROVIDED-INTERFACE-TREF DEST="SENDER-RECEIVER-
          INTERFACE">/Demo/PortInterfaces/B</PROVIDED-
          INTERFACE-TREF>
    </P-PORT-PROTOTYPE>
  </PORTS>
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    <SWC-INTERNAL-BEHAVIOR>
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      <RUNNABLES>
        <RUNNABLE-ENTITY>
          <SHORT-NAME>ASWC_A_RUN1</SHORT-NAME>
          <DATA-WRITE-ACCESSS>
            <VARIABLE-ACCESS>
              <SHORT-NAME>DWP_ASWC_A_RUN1_A_A</SHORT-NAME>
              <ACCESSED-VARIABLE>
                <AUTOSAR-VARIABLE-IREF>
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                      PROTOTYPE">/Demo/SwComponentTypes/
                      ASWC_A/A</PORT-PROTOTYPE-REF>
                  <TARGET-DATA-PROTOTYPE-REF DEST="VARIABLE
                      -DATA-PROTOTYPE">/Demo/PortInterfaces
                      /A/A</TARGET-DATA-PROTOTYPE-REF>
                </AUTOSAR-VARIABLE-IREF>
              </ACCESSED-VARIABLE>
            </VARIABLE-ACCESS>
            <VARIABLE-ACCESS>
              <SHORT-NAME>DWP_ASWC_A_RUN1_B_B</SHORT-NAME>
              <ACCESSED-VARIABLE>
                <AUTOSAR-VARIABLE-IREF>
                  <PORT-PROTOTYPE-REF DEST="P-PORT-
                      PROTOTYPE">/Demo/SwComponentTypes/
                      ASWC_A/B</PORT-PROTOTYPE-REF>
                  <TARGET-DATA-PROTOTYPE-REF DEST="VARIABLE
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                      /B/B</TARGET-DATA-PROTOTYPE-REF>
                </AUTOSAR-VARIABLE-IREF>
              </ACCESSED-VARIABLE>
            </VARIABLE-ACCESS>
          </DATA-WRITE-ACCESSS>
        </RUNNABLE-ENTITY>
      </RUNNABLES>
    </SWC-INTERNAL-BEHAVIOR>
  </INTERNAL-BEHAVIORS>
</APPLICATION-SW-COMPONENT-TYPE>
<APPLICATION-SW-COMPONENT-TYPE>
```

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    <PORTS>
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            INTERFACE">/Demo/PortInterfaces/A</REQUIRED-
            INTERFACE-TREF>
      </R-PORT-PROTOTYPE>
      <R-PORT-PROTOTYPE>
        <SHORT-NAME>B</SHORT-NAME>
        <REQUIRED-INTERFACE-TREF DEST="SENDER-RECEIVER-
            INTERFACE">/Demo/PortInterfaces/B</REQUIRED-
            INTERFACE-TREF>
      </R-PORT-PROTOTYPE>
    </PORTS>
    <INTERNAL-BEHAVIORS>
      <SWC-INTERNAL-BEHAVIOR>
        <SHORT-NAME>IB_ASWC_B</SHORT-NAME>
        <RUNNABLES>
          <RUNNABLE-ENTITY>
            <SHORT-NAME>ASWC_B_RUN1</SHORT-NAME>
            <DATA-READ-ACCESSS>
              <VARIABLE-ACCESS>
                <SHORT-NAME>DWP_ASWC_B_RUN1_A_A</SHORT-NAME>
                <ACCESSED-VARIABLE>
                  <AUTOSAR-VARIABLE-IREF>
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                        PROTOTYPE">/Demo/SwComponentTypes/
                        ASWC_B/A</PORT-PROTOTYPE-REF>
                    <TARGET-DATA-PROTOTYPE-REF DEST="VARIABLE
                        -DATA-PROTOTYPE">/Demo/PortInterfaces
                        /A/A</TARGET-DATA-PROTOTYPE-REF>
                  </AUTOSAR-VARIABLE-IREF>
                </ACCESSED-VARIABLE>
              </VARIABLE-ACCESS>
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                <SHORT-NAME>DWP_ASWC_B_RUN1_B_B</SHORT-NAME>
                <ACCESSED-VARIABLE>
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                        ASWC_B/B</PORT-PROTOTYPE-REF>
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                        /B/B</TARGET-DATA-PROTOTYPE-REF>
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                </ACCESSED-VARIABLE>
              </VARIABLE-ACCESS>
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        </RUNNABLES>
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                INTERFACE">/Demo/PortInterfaces/A</REQUIRED-
                INTERFACE-TREF>
          </R-PORT-PROTOTYPE>
          <R-PORT-PROTOTYPE>
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                INTERFACE-TREF>
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        </PORTS>
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            <RUNNABLES>
              <RUNNABLE-ENTITY>
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                <DATA-READ-ACCESSS>
                  <VARIABLE-ACCESS>
                    <SHORT-NAME>DWP_ASWC_C_RUN1_A_A</SHORT-NAME>
                    <ACCESSED-VARIABLE>
                      <AUTOSAR-VARIABLE-IREF>
                        <PORT-PROTOTYPE-REF DEST="R-PORT-
                            PROTOTYPE">/Demo/SwComponentTypes/
                            ASWC_C/A</PORT-PROTOTYPE-REF>
                        <TARGET-DATA-PROTOTYPE-REF DEST="VARIABLE
                            -DATA-PROTOTYPE">/Demo/PortInterfaces
                            /A/A</TARGET-DATA-PROTOTYPE-REF>
                      </AUTOSAR-VARIABLE-IREF>
                    </ACCESSED-VARIABLE>
                  </VARIABLE-ACCESS>
                  <VARIABLE-ACCESS>
                    <SHORT-NAME>DWP_ASWC_C_RUN1_B_B</SHORT-NAME>
                    <ACCESSED-VARIABLE>
                      <AUTOSAR-VARIABLE-IREF>
                        <PORT-PROTOTYPE-REF DEST="R-PORT-
                            PROTOTYPE">/Demo/SwComponentTypes/
                            ASWC_C/B</PORT-PROTOTYPE-REF>
                        <TARGET-DATA-PROTOTYPE-REF DEST="VARIABLE
                            -DATA-PROTOTYPE">/Demo/PortInterfaces
                            /B/B</TARGET-DATA-PROTOTYPE-REF>
                      </AUTOSAR-VARIABLE-IREF>
                    </ACCESSED-VARIABLE>
                  </VARIABLE-ACCESS>
                </DATA-READ-ACCESSS>
              </RUNNABLE-ENTITY>
            </RUNNABLES>
          </SWC-INTERNAL-BEHAVIOR>
        </INTERNAL-BEHAVIORS>
      </APPLICATION-SW-COMPONENT-TYPE>
    </ELEMENTS>
  </AR-PACKAGE>
  <AR-PACKAGE>
```

```
            <SHORT-NAME>PortInterfaces</SHORT-NAME>
            <ELEMENTS>
              <SENDER-RECEIVER-INTERFACE>
                <SHORT-NAME>A</SHORT-NAME>
                <DATA-ELEMENTS>
                  <VARIABLE-DATA-PROTOTYPE>
                    <SHORT-NAME>A</SHORT-NAME>
                  </VARIABLE-DATA-PROTOTYPE>
                </DATA-ELEMENTS>
              </SENDER-RECEIVER-INTERFACE>
              <SENDER-RECEIVER-INTERFACE>
                <SHORT-NAME>B</SHORT-NAME>
                <DATA-ELEMENTS>
                  <VARIABLE-DATA-PROTOTYPE>
                    <SHORT-NAME>B</SHORT-NAME>
                  </VARIABLE-DATA-PROTOTYPE>
                </DATA-ELEMENTS>
              </SENDER-RECEIVER-INTERFACE>
            </ELEMENTS>
          </AR-PACKAGE>
        </AR-PACKAGES>
      </AR-PACKAGE>
    </AR-PACKAGES>
  </AUTOSAR>
```

F.3 CompuMethod with bitfield texttable conversion

The following CompuMethod of category BITFIELD_TEXTTABLE

Listing F.1: example for bit field text table CompuMethod

```
<COMPU-METHOD>
  <SHORT-NAME>Texttable</SHORT-NAME>
  <CATEGORY>BITFIELD_TEXTTABLE</CATEGORY>
  <COMPU-INTERNAL-TO-PHYS>
    <COMPU-SCALES>
      <!-- problem -->
      <COMPU-SCALE>
        <SHORT-LABEL>problem</SHORT-LABEL>
        <SYMBOL>problem_flat_tire</SYMBOL>
        <MASK>0b11110000</MASK>
        <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b00000000</LOWER-LIMIT>
        <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b00000000</UPPER-LIMIT>
        <COMPU-CONST>
          <VT>flat tire</VT>
        </COMPU-CONST>
      </COMPU-SCALE>
      <COMPU-SCALE>
        <SHORT-LABEL>problem</SHORT-LABEL>
        <SYMBOL>problem_low_pressure</SYMBOL>
        <MASK>0b11110000</MASK>
        <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b00010000</LOWER-LIMIT>
        <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b00010000</UPPER-LIMIT>
        <COMPU-CONST>
```

```
            <VT>low pressure</VT>
          </COMPU-CONST>
        </COMPU-SCALE>
        <COMPU-SCALE>
          <SHORT-LABEL>problem</SHORT-LABEL>
          <SYMBOL>problem_unbalanced</SYMBOL>
          <MASK>0b11110000</MASK>
          <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b00100000</LOWER-LIMIT>
          <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b00100000</UPPER-LIMIT>
          <COMPU-CONST>
            <VT>unbalanced</VT>
          </COMPU-CONST>
        </COMPU-SCALE>
        <COMPU-SCALE>
          <SHORT-LABEL>problem</SHORT-LABEL>
          <SYMBOL>problem_unknown</SYMBOL>
          <MASK>0b11110000</MASK>
          <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b00110000</LOWER-LIMIT>
          <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b00110000</UPPER-LIMIT>
          <COMPU-CONST>
            <VT>unknown</VT>
          </COMPU-CONST>
        </COMPU-SCALE>
        <COMPU-SCALE>
          <SHORT-LABEL>problem</SHORT-LABEL>
          <SYMBOL>problem_invalid</SYMBOL>
          <MASK>0b11110000</MASK>
          <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b11110000</LOWER-LIMIT>
          <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b11110000</UPPER-LIMIT>
          <COMPU-CONST>
            <VT>invalid</VT>
          </COMPU-CONST>
        </COMPU-SCALE>
        <!-- rear right -->
        <COMPU-SCALE>
          <SHORT-LABEL>rearRight</SHORT-LABEL>
          <SYMBOL>rearRight_no</SYMBOL>
          <MASK>0b11001000</MASK>
          <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b00000000</LOWER-LIMIT>
          <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b00000000</UPPER-LIMIT>
          <COMPU-CONST>
            <VT>no</VT>
          </COMPU-CONST>
        </COMPU-SCALE>
        <COMPU-SCALE>
          <SHORT-LABEL>rearRight</SHORT-LABEL>
          <SYMBOL>rearRight_yes</SYMBOL>
          <MASK>0b11001000</MASK>
          <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b00001000</LOWER-LIMIT>
          <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b00001000</UPPER-LIMIT>
          <COMPU-CONST>
            <VT>yes</VT>
          </COMPU-CONST>
        </COMPU-SCALE>
        <!-- rear left -->
        <COMPU-SCALE>
```

```
        <SHORT-LABEL>rearLeft</SHORT-LABEL>
        <SYMBOL>rearLeft_no</SYMBOL>
        <MASK>0b11000100</MASK>
        <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b00000000</LOWER-LIMIT>
        <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b00000000</UPPER-LIMIT>
        <COMPU-CONST>
          <VT>no</VT>
        </COMPU-CONST>
      </COMPU-SCALE>
      <COMPU-SCALE>
        <SHORT-LABEL>rearLeft</SHORT-LABEL>
        <SYMBOL>rearLeft_yes</SYMBOL>
        <MASK>0b11000100</MASK>
        <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b00000100</LOWER-LIMIT>
        <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b00000100</UPPER-LIMIT>
        <COMPU-CONST>
          <VT>yes</VT>
        </COMPU-CONST>
      </COMPU-SCALE>
      <!-- front right -->
      <COMPU-SCALE>
        <SHORT-LABEL>frontRight</SHORT-LABEL>
        <SYMBOL>frontRight_no</SYMBOL>
        <MASK>0b11000010</MASK>
        <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b00000000</LOWER-LIMIT>
        <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b00000000</UPPER-LIMIT>
        <COMPU-CONST>
          <VT>no</VT>
        </COMPU-CONST>
      </COMPU-SCALE>
      <COMPU-SCALE>
        <SHORT-LABEL>frontRight</SHORT-LABEL>
        <SYMBOL>frontRight_yes</SYMBOL>
        <MASK>0b11000010</MASK>
        <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b00000010</LOWER-LIMIT>
        <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b00000010</UPPER-LIMIT>
        <COMPU-CONST>
          <VT>yes</VT>
        </COMPU-CONST>
      </COMPU-SCALE>
      <!-- front left -->
      <COMPU-SCALE>
        <SHORT-LABEL>frontLeft</SHORT-LABEL>
        <SYMBOL>frontLeft_no</SYMBOL>
        <MASK>0b11000001</MASK>
        <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b00000000</LOWER-LIMIT>
        <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b00000000</UPPER-LIMIT>
        <COMPU-CONST>
          <VT>no</VT>
        </COMPU-CONST>
      </COMPU-SCALE>
      <COMPU-SCALE>
        <SHORT-LABEL>frontLeft</SHORT-LABEL>
        <SYMBOL>frontLeft_yes</SYMBOL>
        <MASK>0b11000001</MASK>
        <LOWER-LIMIT INTERVAL-TYPE="CLOSED">0b00000001</LOWER-LIMIT>
```

```
          <UPPER-LIMIT INTERVAL-TYPE="CLOSED">0b00000001</UPPER-LIMIT>
          <COMPU-CONST>
            <VT>yes</VT>
          </COMPU-CONST>
        </COMPU-SCALE>
      </COMPU-SCALES>
    </COMPU-INTERNAL-TO-PHYS>
</COMPU-METHOD>
```

results in this definitions:

Listing F.2: literals for bit field text table `CompuMethod`

```
/* [SWS_Rte_07410] unique "shortLabel" / "mask" pair "problem" / 0
   b11110000 */
#ifndef problem_BflMask
#define problem_BflMask 240U
#endif /* problem_BflMask */

/* [SWS_Rte_07411] unique "shortLabel" / "mask" pair "problem" / 0
   b11110000  with a single contiguous bit field*/
#ifndef problem_BflPn
#define problem_BflPn 4U
#endif /* problem_BflPn */

/* [SWS_Rte_07412] unique "shortLabel" / "mask" pair "problem" / 0
   b11110000  with a single contiguous bit field*/
#ifndef problem_BflLn
#define problem_BflLn 4U
#endif /* problem_BflLn */

/* [SWS_Rte_03810] CompuScale with point range "0b00000000", symbol
   attribute "problem_flat_tire"*/
#ifndef problem_flat_tire
#define problem_flat_tire 0U
#endif /* problem_flat_tire */

/* [SWS_Rte_03810] CompuScale with point range "0b00010000", symbol
   attribute "problem_low_pressure"*/
#ifndef problem_low_pressure
#define problem_low_pressure 16U
#endif /* problem_low_pressure */

/* [SWS_Rte_03810] CompuScale with point range "0b00100000", symbol
   attribute "problem_unbalanced"*/
#ifndef problem_unbalanced
#define problem_unbalanced 32U
#endif /* problem_unbalanced */

/* [SWS_Rte_03810] CompuScale with point range "0b00110000", symbol
   attribute "problem_unknown"*/
#ifndef problem_unknown
#define problem_unknown 48U
#endif /* problem_unknown */

```

```
/* [SWS_Rte_03810] CompuScale with point range "0b11110000", symbol
    attribute "problem_invalid"*/
#ifndef problem_invalid
#define problem_invalid 240U
#endif /* problem_invalid */

/* [SWS_Rte_07410] unique "shortLabel" / "mask" pair "rearRight" / 0
    b11001000 */
#ifndef rearRight_BflMask
#define rearRight_BflMask 200U
#endif /* rearRight_BflMask */

/* [SWS_Rte_07411] unique "shortLabel" / "mask" pair "rearRight" / 0
    b11001000  but not a single contiguous bit field*/

/* [SWS_Rte_07412] unique "shortLabel" / "mask" pair "rearRight" / 0
    b11001000  bot not a single contiguous bit field*/

/* [SWS_Rte_03810] CompuScale with point range "0b00000000", symbol
    attribute "rearRight_no"*/
#ifndef rearRight_no
#define rearRight_no 0U
#endif /* rearRight_no */

/* [SWS_Rte_03810] CompuScale with point range "0b00001000", symbol
    attribute "rearRight_yes"*/
#ifndef rearRight_yes
#define rearRight_yes 8U
#endif /* rearRight_yes */

/* [SWS_Rte_07410] unique "shortLabel" / "mask" pair "rearLeft" / 0
    b11000100 */
#ifndef rearLeft_BflMask
#define rearLeft_BflMask 200U
#endif /* rearLeft_BflMask */

/* [SWS_Rte_07411] unique "shortLabel" / "mask" pair "rearLeft" / 0
    b11000100  but not a single contiguous bit field*/

/* [SWS_Rte_07412] unique "shortLabel" / "mask" pair "rearLeft" / 0
    b11000100  bot not a single contiguous bit field*/

/* [SWS_Rte_03810] CompuScale with point range "0b00000000", symbol
    attribute "rearLeft_no"*/
#ifndef rearLeft_no
#define rearLeft_no 0U
#endif /* rearLeft_no */

/* [SWS_Rte_03810] CompuScale with point range "0b00000100", symbol
    attribute "rearLeft_yes"*/
#ifndef rearLeft_yes
#define rearLeft_yes 4U
#endif /* rearLeft_yes */

/* [SWS_Rte_07410] unique "shortLabel" / "mask" pair "frontRight" / 0
    b11000010 */
```

```
#ifndef frontRight_BflMask
#define frontRight_BflMask 194U
#endif /* frontRight_BflMask */

/* [SWS_Rte_07411] unique "shortLabel" / "mask" pair "frontRight" / 0 b11000010  but not a single contiguous bit field*/

/* [SWS_Rte_07412] unique "shortLabel" / "mask" pair "frontRight" / 0 b11000010  bot not a single contiguous bit field*/

/* [SWS_Rte_03810] CompuScale with point range "0b00000000", symbol attribute "frontRight_no"*/
#ifndef frontRight_no
#define frontRight_no 0U
#endif /* frontRight_no */

/* [SWS_Rte_03810] CompuScale with point range "0b00000010", symbol attribute "frontRight_yes"*/
#ifndef frontRight_yes
#define frontRight_yes 2U
#endif /* frontRight_yes */

/* [SWS_Rte_07410] unique "shortLabel" / "mask" pair "frontLeft" / 0 b11000001 */
#ifndef frontLeft_BflMask
#define frontLeft_BflMask 193U
#endif /* frontLeft_BflMask */

/* [SWS_Rte_07411] unique "shortLabel" / "mask" pair "frontLeft" / 0 b11000001  but not a single contiguous bit field*/

/* [SWS_Rte_07412] unique "shortLabel" / "mask" pair "frontLeft" / 0 b11000001  bot not a single contiguous bit field*/

/* [SWS_Rte_03810] CompuScale with point range "0b00000000", symbol attribute "frontLeft_no"*/
#ifndef frontLeft_no
#define frontLeft_no 0U
#endif /* frontLeft_no */

/* [SWS_Rte_03810] CompuScale with point range "0b00000001", symbol attribute "frontLeft_yes"*/
#ifndef frontLeft_yes
#define frontLeft_yes 1U
#endif /* frontLeft_yes */
```

F.4 Structure type with self-reference

The example **Structure type with self-reference** in the following ARXML shows a structure type which contains as an element a pointer witch can point to objects being of the type of the structure. Those types are usually needed for linked lists.

```
<?xml version="1.0" encoding="UTF-8"?>
```

```
<AUTOSAR xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="
    http://autosar.org/schema/r4.0" xsi:schemaLocation="http://autosar.
    org/schema/r4.0 AUTOSAR_4-2-1.xsd">
  <AR-PACKAGES>
    <AR-PACKAGE>
      <SHORT-NAME>Demo</SHORT-NAME>
      <DESC>
        <L-2 L="EN">Example about structure with a reference to its own
            type</L-2>
      </DESC>
      <CATEGORY>EXAMPLE</CATEGORY>
      <AR-PACKAGES>
        <AR-PACKAGE>
          <SHORT-NAME>ImplementationDataTypes</SHORT-NAME>
          <ELEMENTS>
            <IMPLEMENTATION-DATA-TYPE>
              <SHORT-NAME>DataSet</SHORT-NAME>
              <CATEGORY>STRUCTURE</CATEGORY>
              <SUB-ELEMENTS>
                <IMPLEMENTATION-DATA-TYPE-ELEMENT>
                  <SHORT-NAME>data1</SHORT-NAME>
                  <CATEGORY>TYPE_REFERENCE</CATEGORY>
                  <SW-DATA-DEF-PROPS>
                    <SW-DATA-DEF-PROPS-VARIANTS>
                      <SW-DATA-DEF-PROPS-CONDITIONAL>
                        <IMPLEMENTATION-DATA-TYPE-REF DEST="
                            IMPLEMENTATION-DATA-TYPE">/AUTOSAR_Platform
                            /ImplementationDataTypes/uint32</
                            IMPLEMENTATION-DATA-TYPE-REF>
                      </SW-DATA-DEF-PROPS-CONDITIONAL>
                    </SW-DATA-DEF-PROPS-VARIANTS>
                  </SW-DATA-DEF-PROPS>
                </IMPLEMENTATION-DATA-TYPE-ELEMENT>
                <IMPLEMENTATION-DATA-TYPE-ELEMENT>
                  <SHORT-NAME>data2</SHORT-NAME>
                  <CATEGORY>TYPE_REFERENCE</CATEGORY>
                  <SW-DATA-DEF-PROPS>
                    <SW-DATA-DEF-PROPS-VARIANTS>
                      <SW-DATA-DEF-PROPS-CONDITIONAL>
                        <IMPLEMENTATION-DATA-TYPE-REF DEST="
                            IMPLEMENTATION-DATA-TYPE">/AUTOSAR_Platform
                            /ImplementationDataTypes/uint8</
                            IMPLEMENTATION-DATA-TYPE-REF>
                      </SW-DATA-DEF-PROPS-CONDITIONAL>
                    </SW-DATA-DEF-PROPS-VARIANTS>
                  </SW-DATA-DEF-PROPS>
                </IMPLEMENTATION-DATA-TYPE-ELEMENT>
                <IMPLEMENTATION-DATA-TYPE-ELEMENT>
                  <SHORT-NAME>dataSetPtr</SHORT-NAME>
                  <CATEGORY>DATA_REFERENCE</CATEGORY>
                  <SW-DATA-DEF-PROPS>
                    <SW-DATA-DEF-PROPS-VARIANTS>
                      <SW-DATA-DEF-PROPS-CONDITIONAL>
                        <SW-POINTER-TARGET-PROPS>
                          <TARGET-CATEGORY>TYPE_REFERENCE</TARGET-
                              CATEGORY>
```

```
                    <SW-DATA-DEF-PROPS>
                      <SW-DATA-DEF-PROPS-VARIANTS>
                        <SW-DATA-DEF-PROPS-CONDITIONAL>
                          <IMPLEMENTATION-DATA-TYPE-REF DEST="
                              IMPLEMENTATION-DATA-TYPE">/Demo/
                              ImplementationDataTypes/DataSet</
                              IMPLEMENTATION-DATA-TYPE-REF>
                        </SW-DATA-DEF-PROPS-CONDITIONAL>
                      </SW-DATA-DEF-PROPS-VARIANTS>
                    </SW-DATA-DEF-PROPS>
                  </SW-POINTER-TARGET-PROPS>
                </SW-DATA-DEF-PROPS-CONDITIONAL>
              </SW-DATA-DEF-PROPS-VARIANTS>
            </SW-DATA-DEF-PROPS>
          </IMPLEMENTATION-DATA-TYPE-ELEMENT>
          <IMPLEMENTATION-DATA-TYPE-ELEMENT>
            <SHORT-NAME>substruct</SHORT-NAME>
            <CATEGORY>STRUCTURE</CATEGORY>
            <SUB-ELEMENTS>
              <IMPLEMENTATION-DATA-TYPE-ELEMENT>
                <SHORT-NAME>sub1</SHORT-NAME>
                <CATEGORY>TYPE_REFERENCE</CATEGORY>
                <SW-DATA-DEF-PROPS>
                  <SW-DATA-DEF-PROPS-VARIANTS>
                    <SW-DATA-DEF-PROPS-CONDITIONAL>
                      <IMPLEMENTATION-DATA-TYPE-REF DEST="
                          IMPLEMENTATION-DATA-TYPE">/
                          AUTOSAR_Platform/
                          ImplementationDataTypes/uint8</
                          IMPLEMENTATION-DATA-TYPE-REF>
                    </SW-DATA-DEF-PROPS-CONDITIONAL>
                  </SW-DATA-DEF-PROPS-VARIANTS>
                </SW-DATA-DEF-PROPS>
              </IMPLEMENTATION-DATA-TYPE-ELEMENT>
              <IMPLEMENTATION-DATA-TYPE-ELEMENT>
                <SHORT-NAME>sub2</SHORT-NAME>
                <CATEGORY>TYPE_REFERENCE</CATEGORY>
                <SW-DATA-DEF-PROPS>
                  <SW-DATA-DEF-PROPS-VARIANTS>
                    <SW-DATA-DEF-PROPS-CONDITIONAL>
                      <IMPLEMENTATION-DATA-TYPE-REF DEST="
                          IMPLEMENTATION-DATA-TYPE">/
                          AUTOSAR_Platform/
                          ImplementationDataTypes/uint8</
                          IMPLEMENTATION-DATA-TYPE-REF>
                    </SW-DATA-DEF-PROPS-CONDITIONAL>
                  </SW-DATA-DEF-PROPS-VARIANTS>
                </SW-DATA-DEF-PROPS>
              </IMPLEMENTATION-DATA-TYPE-ELEMENT>
            </SUB-ELEMENTS>
          </IMPLEMENTATION-DATA-TYPE-ELEMENT>
        </SUB-ELEMENTS>
        <TYPE-EMITTER>RTE</TYPE-EMITTER>
      </IMPLEMENTATION-DATA-TYPE>
    </ELEMENTS>
  </AR-PACKAGE>
```

```
        </AR-PACKAGES>
      </AR-PACKAGE>
    </AR-PACKAGES>
  </AUTOSAR>
```

This results according [SWS_Rte_07114] and [SWS_Rte_06812] in following code in the `Rte_Type.h` file.

Listing F.3: Structure type with self-reference

```c
/* typedef is created as forward declaration according SWS_Rte_06812 */
typedef struct Rte_struct_DataSet DataSet;

/* declaration of the structure according SWS_Rte_07114 */
struct Rte_struct_DataSet
{
    uint32 data1;
    uint8 data2;
    DataSet * dataSetPtr;
    struct
    {
        uint8 sub1;
        uint8 sub2;
    } substruct;
};
```

F.5 Multiple calibration parameters instances

The example **Multiple calibration parameters instances** in the following `ARXML` shows the example of multiple calibration data instances as explained in section 4.2.8.3.7.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<AUTOSAR xmlns="http://autosar.org/schema/r4.0" xmlns:xsi="http://www.
    w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://autosar.
    org/schema/r4.0 AUTOSAR_4-2-1.xsd">
  <ADMIN-DATA>
    <LANGUAGE>EN</LANGUAGE>
    <DOC-REVISIONS>
      <DOC-REVISION>
        <REVISION-LABEL>0.1.0</REVISION-LABEL>
        <DATE>2014-07-31</DATE>
      </DOC-REVISION>
    </DOC-REVISIONS>
  </ADMIN-DATA>
  <AR-PACKAGES>
    <AR-PACKAGE>
      <SHORT-NAME>Demo</SHORT-NAME>
      <AR-PACKAGES>
        <AR-PACKAGE>
          <SHORT-NAME>PortInterfaces</SHORT-NAME>
          <ELEMENTS>
            <PARAMETER-INTERFACE>
```

```xml
        <SHORT-NAME>EP</SHORT-NAME>
        <PARAMETERS>
          <PARAMETER-DATA-PROTOTYPE>
            <SHORT-NAME>Prm1</SHORT-NAME>
            <SW-DATA-DEF-PROPS>
              <SW-DATA-DEF-PROPS-VARIANTS>
                <SW-DATA-DEF-PROPS-CONDITIONAL>
                  <SW-ADDR-METHOD-REF DEST="SW-ADDR-METHOD">/
                      AUTOSAR_MemMap/SwAddrMethods/CALIB_QM</SW-
                      ADDR-METHOD-REF>
                  <SW-CALIBRATION-ACCESS>READ-WRITE</SW-
                      CALIBRATION-ACCESS>
                  <SW-IMPL-POLICY>STANDARD</SW-IMPL-POLICY>
                </SW-DATA-DEF-PROPS-CONDITIONAL>
              </SW-DATA-DEF-PROPS-VARIANTS>
            </SW-DATA-DEF-PROPS>
            <TYPE-TREF DEST="APPLICATION-PRIMITIVE-DATA-TYPE">/
                AUTOSAR_AISpecification/ApplicationDataTypes/Flg1
                </TYPE-TREF>
          </PARAMETER-DATA-PROTOTYPE>
        </PARAMETERS>
      </PARAMETER-INTERFACE>
    </ELEMENTS>
  </AR-PACKAGE>
  <AR-PACKAGE>
    <SHORT-NAME>SwComponentTypes</SHORT-NAME>
    <ELEMENTS>
      <PARAMETER-SW-COMPONENT-TYPE>
        <SHORT-NAME>PSWC</SHORT-NAME>
        <PORTS>
          <P-PORT-PROTOTYPE>
            <SHORT-NAME>EP</SHORT-NAME>
            <PROVIDED-COM-SPECS>
              <PARAMETER-PROVIDE-COM-SPEC>
                <INIT-VALUE>
                  <APPLICATION-VALUE-SPECIFICATION>
                    <SW-VALUE-CONT>
                      <UNIT-REF DEST="UNIT">/AUTOSAR/
                          AISpecification/Units/NoUnit</UNIT-REF>
                      <SW-VALUES-PHYS>
                        <VT>Rst</VT>
                      </SW-VALUES-PHYS>
                    </SW-VALUE-CONT>
                  </APPLICATION-VALUE-SPECIFICATION>
                </INIT-VALUE>
                <PARAMETER-REF DEST="PARAMETER-DATA-PROTOTYPE">/
                    Demo/PortInterfaces/EP/Prm1</PARAMETER-REF>
              </PARAMETER-PROVIDE-COM-SPEC>
            </PROVIDED-COM-SPECS>
            <PROVIDED-INTERFACE-TREF DEST="PARAMETER-INTERFACE">/
                Demo/PortInterfaces/EP</PROVIDED-INTERFACE-TREF>
          </P-PORT-PROTOTYPE>
        </PORTS>
      </PARAMETER-SW-COMPONENT-TYPE>
      <APPLICATION-SW-COMPONENT-TYPE>
        <SHORT-NAME>ASWC</SHORT-NAME>
```

```
<PORTS>
  <R-PORT-PROTOTYPE>
    <SHORT-NAME>EP</SHORT-NAME>
    <REQUIRED-INTERFACE-TREF DEST="PARAMETER-INTERFACE">/
       Demo/PortInterfaces/EP</REQUIRED-INTERFACE-TREF>
  </R-PORT-PROTOTYPE>
</PORTS>
<INTERNAL-BEHAVIORS>
  <SWC-INTERNAL-BEHAVIOR>
    <SHORT-NAME>ASWC</SHORT-NAME>
    <PER-INSTANCE-PARAMETERS>
      <PARAMETER-DATA-PROTOTYPE>
        <SHORT-NAME>PIP</SHORT-NAME>
        <SW-DATA-DEF-PROPS>
          <SW-DATA-DEF-PROPS-VARIANTS>
            <SW-DATA-DEF-PROPS-CONDITIONAL>
              <SW-ADDR-METHOD-REF DEST="SW-ADDR-METHOD">/
                 AUTOSAR_MemMap/SwAddrMethods/CALIB_QM</
                 SW-ADDR-METHOD-REF>
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G Changes History

G.1 Changes in Rel. 4.0 Rev. 2 compared to Rel. 4.0 Rev. 1

G.1.1 Deleted SWS Items

The following SWS Items were removed in Rel. 4.0 Rev. 2: rte_sws_1254, rte_sws_3552, rte_sws_3557, rte_sws_3559, rte_sws_3563, rte_sws_3564, rte_sws_3568, rte_sws_3588, rte_sws_3593, rte_sws_3743, rte_sws_5512.

G.1.2 Changed SWS Items

The following SWS Items were changed in Rel. 4.0 Rev. 2: [SWS_Rte_01086], [SWS_Rte_01111], [SWS_Rte_01113], [SWS_Rte_01114], [SWS_Rte_01118], [SWS_Rte_01156], [SWS_Rte_01355], [SWS_Rte_02517], [SWS_Rte_02527], [SWS_Rte_02528], [SWS_Rte_02613], [SWS_Rte_02615], [SWS_Rte_02679], [SWS_Rte_02728], [SWS_Rte_02730], [SWS_Rte_02747], [SWS_Rte_02752], [SWS_Rte_02753], [SWS_Rte_03001], [SWS_Rte_03560], [SWS_Rte_03562], [SWS_Rte_03567], [SWS_Rte_03598], [SWS_Rte_03599], [SWS_Rte_03774], [SWS_Rte_03827], [SWS_Rte_03837], [SWS_Rte_03930], [SWS_Rte_03953], [SWS_Rte_03954], [SWS_Rte_03955], [SWS_Rte_03956], [SWS_Rte_03957], [SWS_Rte_05021], [SWS_Rte_05156], SWS_Rte_05506, [SWS_Rte_05509], [SWS_Rte_06010], [SWS_Rte_06633], [SWS_Rte_07020], [SWS_Rte_07021], [SWS_Rte_07041], [SWS_Rte_07184], [SWS_Rte_07187], [SWS_Rte_07195], [SWS_Rte_07262], [SWS_Rte_07280], [SWS_Rte_07282], [SWS_Rte_07293], [SWS_Rte_07294], [SWS_Rte_07375], [SWS_Rte_07376], [SWS_Rte_07409], [SWS_Rte_07586], [SWS_Rte_07589], [SWS_Rte_07632], [SWS_Rte_07636], [SWS_Rte_07637], [SWS_Rte_07667], [SWS_Rte_07680], [SWS_Rte_07683], rte_sws_ext_3811.

G.1.3 Added SWS Items

The following SWS Items were added in Rel. 4.0 Rev. 2: [SWS_Rte_02761], rte_sws_3850, rte_sws_3851, [SWS_Rte_03852], [SWS_Rte_03853], [SWS_Rte_07045], [SWS_Rte_07046], [SWS_Rte_07047], [SWS_Rte_07048], [SWS_Rte_07049], [SWS_Rte_07050], [SWS_Rte_07051], [SWS_Rte_07052], [SWS_Rte_07053], [SWS_Rte_07054], [SWS_Rte_07055], [SWS_Rte_07056], [SWS_Rte_07057], [SWS_Rte_07058], [SWS_Rte_07059], [SWS_Rte_07060], [SWS_Rte_07061], [SWS_Rte_07062], [SWS_Rte_07063], [SWS_Rte_07064], [SWS_Rte_07065], [SWS_Rte_07066], [SWS_Rte_07067], [SWS_Rte_07068], [SWS_Rte_07069], [SWS_Rte_07070], [SWS_Rte_07071], [SWS_Rte_07072], [SWS_Rte_07073], [SWS_Rte_07074], [SWS_Rte_07075], [SWS_Rte_07076], [SWS_Rte_07077], [SWS_Rte_07078], [SWS_Rte_07079], [SWS_Rte_07080], [SWS_Rte_07081], [SWS_Rte_08000], [SWS_Rte_08001], [SWS_Rte_08002], [SWS_Rte_08300], [SWS_Rte_08301], [SWS_Rte_08302].

G.2 Changes in Rel. 4.0 Rev. 3 compared to Rel. 4.0 Rev. 2

G.2.1 Deleted SWS Items

The following SWS Items were removed in Rel. 4.0 Rev. 3: rte_sws_3838, rte_sws_3844, rte_sws_3850, rte_sws_5171, rte_sws_7106, rte_sws_7108, rte_sws_7164, rte_sws_7165, rte_sws_7168, rte_sws_7176, rte_sws_7674.

G.2.2 Changed SWS Items

The following SWS Items were changed in Rel. 4.0 Rev. 3: [SWS_Rte_01018], [SWS_Rte_01019], [SWS_Rte_01020], [SWS_Rte_01156], [SWS_Rte_01171], [SWS_Rte_01238], [SWS_Rte_01239], [SWS_Rte_01248], [SWS_Rte_01249], [SWS_Rte_01300], [SWS_Rte_02500], [SWS_Rte_02568], [SWS_Rte_02576], [SWS_Rte_02627], [SWS_Rte_02628], [SWS_Rte_02629], [SWS_Rte_02631], [SWS_Rte_02648], [SWS_Rte_02659], [SWS_Rte_02662], [SWS_Rte_02664], [SWS_Rte_02675], [SWS_Rte_02732], [SWS_Rte_03526], [SWS_Rte_03714], [SWS_Rte_03731], [SWS_Rte_03782], [SWS_Rte_03793], [SWS_Rte_03809], [SWS_Rte_03810], [SWS_Rte_03813], [SWS_Rte_03827], [SWS_Rte_03828], [SWS_Rte_03829], [SWS_Rte_03831], [SWS_Rte_03832], [SWS_Rte_03833], [SWS_Rte_03837], [SWS_Rte_03839], [SWS_Rte_03840], [SWS_Rte_03841], [SWS_Rte_03842], [SWS_Rte_03843], [SWS_Rte_03845], [SWS_Rte_03846], [SWS_Rte_03847], [SWS_Rte_03848], [SWS_Rte_03849], [SWS_Rte_03851], [SWS_Rte_03907], [SWS_Rte_03949], [SWS_Rte_04526], [SWS_Rte_05051], [SWS_Rte_05052], SWS_Rte_05059, [SWS_Rte_05062], [SWS_Rte_05078], [SWS_Rte_05127], [SWS_Rte_05128], [SWS_Rte_06513], [SWS_Rte_06515], [SWS_Rte_06518], [SWS_Rte_06519], [SWS_Rte_06520], [SWS_Rte_06530], [SWS_Rte_06532], [SWS_Rte_06535], [SWS_Rte_06536], [SWS_Rte_07022], [SWS_Rte_07030], [SWS_Rte_07036], [SWS_Rte_07037], [SWS_Rte_07038], [SWS_Rte_07047], [SWS_Rte_07048], [SWS_Rte_07069], [SWS_Rte_07104], [SWS_Rte_07109], [SWS_Rte_07110], [SWS_Rte_07111], [SWS_Rte_07113], [SWS_Rte_07114], [SWS_Rte_07116], [SWS_Rte_07133], [SWS_Rte_07136], [SWS_Rte_07144], [SWS_Rte_07148], [SWS_Rte_07149], [SWS_Rte_07157], [SWS_Rte_07162], [SWS_Rte_07163], [SWS_Rte_07166], [SWS_Rte_07175], [SWS_Rte_07182], [SWS_Rte_07185], [SWS_Rte_07190], [SWS_Rte_07194], [SWS_Rte_07195], [SWS_Rte_07200], [SWS_Rte_07203], [SWS_Rte_07214], [SWS_Rte_07224], [SWS_Rte_07250], [SWS_Rte_07253], [SWS_Rte_07255], [SWS_Rte_07260], [SWS_Rte_07261], [SWS_Rte_07263], [SWS_Rte_07266], [SWS_Rte_07282], [SWS_Rte_07292], [SWS_Rte_07293], [SWS_Rte_07294], [SWS_Rte_07295], [SWS_Rte_07310], [SWS_Rte_07315], [SWS_Rte_07381], [SWS_Rte_07382], [SWS_Rte_07383], [SWS_Rte_07501], [SWS_Rte_07503], [SWS_Rte_07504], [SWS_Rte_07543], [SWS_Rte_07544], [SWS_Rte_07552], [SWS_Rte_07554], [SWS_Rte_07555], [SWS_Rte_07556], [SWS_Rte_07670], [SWS_Rte_07682], [SWS_Rte_08300].

G.2.3 Added SWS Items

The following SWS Items were added in Rel. 4.0 Rev. 3: [SWS_Rte_03854], [SWS_Rte_03855], [SWS_Rte_03856], [SWS_Rte_03857], [SWS_Rte_03858], [SWS_Rte_03859], [SWS_Rte_03860], [SWS_Rte_03861], [SWS_Rte_06700], [SWS_Rte_06701], [SWS_Rte_06702], [SWS_Rte_06703], [SWS_Rte_06704], [SWS_Rte_06705], [SWS_Rte_06706], [SWS_Rte_06707], [SWS_Rte_06708], [SWS_Rte_06709], [SWS_Rte_06710], [SWS_Rte_06711], [SWS_Rte_06712], [SWS_Rte_06713], [SWS_Rte_06714], [SWS_Rte_06715], [SWS_Rte_06716], [SWS_Rte_06717], [SWS_Rte_06718], [SWS_Rte_06719], [SWS_Rte_06720], [SWS_Rte_06721], [SWS_Rte_06722], [SWS_Rte_06723], [SWS_Rte_06724], [SWS_Rte_06725], [SWS_Rte_06726], [SWS_Rte_07082], [SWS_Rte_07083], [SWS_Rte_07084], [SWS_Rte_07085], [SWS_Rte_07086], [SWS_Rte_07087], [SWS_Rte_07088], [SWS_Rte_07089], [SWS_Rte_07090], [SWS_Rte_07091], [SWS_Rte_07092], [SWS_Rte_07093], [SWS_Rte_07094], [SWS_Rte_07095], [SWS_Rte_07096], [SWS_Rte_07097], [SWS_Rte_07099], [SWS_Rte_07593], [SWS_Rte_07594], [SWS_Rte_07595], [SWS_Rte_07596], [SWS_Rte_07692], [SWS_Rte_07693], [SWS_Rte_07694], [SWS_Rte_07920], [SWS_Rte_07921], [SWS_Rte_07922], [SWS_Rte_07923], [SWS_Rte_07924], [SWS_Rte_08004], [SWS_Rte_08005], [SWS_Rte_08007], [SWS_Rte_08008], [SWS_Rte_08009], [SWS_Rte_08016], [SWS_Rte_08017], [SWS_Rte_08018], [SWS_Rte_08020], [SWS_Rte_08021], [SWS_Rte_08022], [SWS_Rte_08023], [SWS_Rte_08024], [SWS_Rte_08025], [SWS_Rte_08026], [SWS_Rte_08027], [SWS_Rte_08028], [SWS_Rte_08029], [SWS_Rte_08030], [SWS_Rte_08031], [SWS_Rte_08032], [SWS_Rte_08033], [SWS_Rte_08034], [SWS_Rte_08035], [SWS_Rte_08036], [SWS_Rte_08037], [SWS_Rte_08038], [SWS_Rte_08039], [SWS_Rte_08040], [SWS_Rte_08041], [SWS_Rte_08042], [SWS_Rte_08043], [SWS_Rte_08044], [SWS_Rte_08045], [SWS_Rte_08303], [SWS_Rte_08304], [SWS_Rte_08305], [SWS_Rte_08306], [SWS_Rte_08307], [SWS_Rte_08308], [SWS_Rte_08400], [SWS_Rte_08401], [SWS_Rte_08402], [SWS_Rte_08403], [SWS_Rte_08404], [SWS_Rte_08500], [SWS_Rte_08501], SWS_Rte_08503, [SWS_Rte_08504], [SWS_Rte_08505], [SWS_Rte_08506], [SWS_Rte_08507], [SWS_Rte_08509], [SWS_Rte_08510], rte_sws_ext_7597, rte_sws_ext_7598, rte_sws_ext_8502, rte_sws_ext_8508.

G.3 Changes in Rel. 4.1 Rev. 1 compared to Rel. 4.0 Rev. 3

G.3.1 Renamed SWS Items

The external requirements are redefined as AUTOSAR constraints.

rte_sws_ext_3811	[constr_9004]	Usage of WaitPoints is restricted depending on *ExclusiveAreaImplMechanism*
rte_sws_ext_7598	[SWS_Rte_CONSTR_09005]	The references RteSwcTriggerSourceRef has to be consistent with the RteSoftwareComponentInstanceRef
rte_sws_ext_7597	[SWS_Rte_CONSTR_09006]	The references RteBswTriggerSourceRef has to be consistent with the RteBswImplementationRef
rte_sws_ext_7547	[SWS_Rte_CONSTR_09007]	*issuedTrigger* and *BswTriggerDirectImplementation* are mutually exclusive
rte_sws_ext_7040	[SWS_Rte_CONSTR_09008]	The same Trigger in a *Trigger Sink* must not be connected to multiple *Trigger Source*s
rte_sws_ext_7550	[SWS_Rte_CONSTR_09009]	Synchronized Trigger shall not be referenced by more than one type of access method
rte_sws_ext_7521	[SWS_Rte_CONSTR_09010]	Worst case execution time shall be less than the GCD
rte_sws_ext_7351	[SWS_Rte_CONSTR_09011]	NvMBlockDescriptor related to a RAM Block of a NvBlockSwComponentType shall use NvMBlockUseSyncMechanism
rte_sws_ext_7816	[SWS_Rte_CONSTR_09012]	Category 1 interrupts shall not access the RTE
rte_sws_ext_2542	[SWS_Rte_CONSTR_09013]	Exactly one mode or one mode transition shall be active
rte_sws_ext_7565	[SWS_Rte_CONSTR_09014]	*ModeSwitchPoint*(s) and *managedModeGroup*(s) are mutually exclusive for synchronized *ModeDeclarationGroupPrototype*s
rte_sws_ext_7818	[SWS_Rte_CONSTR_09015]	Rte_Write API may only be used by the runnable that describe its usage
rte_sws_ext_7819	[SWS_Rte_CONSTR_09016]	Rte_Send API may only be used by the runnable that describes its usage
rte_sws_ext_2681	[SWS_Rte_CONSTR_09017]	Rte_Switch API may only be used by the runnable that describes its usage
rte_sws_ext_2682	[SWS_Rte_CONSTR_09018]	Rte_Invalidate API may only be used by the runnable that describe its usage
rte_sws_ext_2687	[SWS_Rte_CONSTR_09019]	Rte_Feedback API may only be used by the runnable that describe its usage
rte_sws_ext_2726	[SWS_Rte_CONSTR_09020]	Rte_SwitchAck API may only be used by the runnable that describe its usage
rte_sws_ext_2683	[SWS_Rte_CONSTR_09021]	Rte_Read API may only be used by the runnable that describe its usage
rte_sws_ext_7397	[SWS_Rte_CONSTR_09022]	Rte_DRead API may only be used by the runnable that describe its usage
rte_sws_ext_2684	[SWS_Rte_CONSTR_09023]	Rte_Receive API may only be used by the runnable that describe its usage
rte_sws_ext_2685	[SWS_Rte_CONSTR_09024]	Rte_Call API may only be used by the runnable that describe its usage
rte_sws_ext_2686	[SWS_Rte_CONSTR_09025]	Blocking Rte_Result API may only be used by the runnable that describe the WaitPoint
rte_sws_ext_7679	[SWS_Rte_CONSTR_09026]	Rte_IWriteRef may not return values written in previous executions

rte_sws_ext_2601	[SWS_Rte_CONSTR_09027]	Rte_IStatus API shall only be used by a RunnableEntity describing an access to the data or which is triggered by an error event related to this data
rte_sws_ext_7171	[SWS_Rte_CONSTR_09028]	Rte_Enter and Rte_Exit API may only be used by runnables describing its usage
rte_sws_ext_7172	[SWS_Rte_CONSTR_09029]	Nested call of Rte_Enter and Rte_Exit is restricted
rte_sws_ext_7568	[SWS_Rte_CONSTR_09030]	Rte_Mode API may only be used by the runnable that describe its usage
rte_sws_ext_8502	[SWS_Rte_CONSTR_09031]	Rte_Mode API may only be used by the runnable that describe its usage
rte_sws_ext_7202	[SWS_Rte_CONSTR_09032]	Rte_Trigger API may only be used by the runnable that describe its usage
rte_sws_ext_7205	[SWS_Rte_CONSTR_09033]	Rte_IrTrigger API may only be used by the runnable that describe its usage
rte_sws_ext_7603	[SWS_Rte_CONSTR_09034]	Rte_IsUpdated API may only be used by the runnable that describe the access to the corresponding data
rte_sws_ext_2582	[SWS_Rte_CONSTR_09035]	Rte_Start shall be called only once
rte_sws_ext_7577	[SWS_Rte_CONSTR_09036]	Rte_Start API may only be used after call of SchM_Init
rte_sws_ext_2714	[SWS_Rte_CONSTR_09037]	Rte_Start API shall be called on every core
rte_sws_ext_2583	[SWS_Rte_CONSTR_09038]	Rte_Stop shall be called before BSW shutdown
rte_sws_ext_7332	[SWS_Rte_CONSTR_09039]	Rte_PartitionTerminated shall be called only once
rte_sws_ext_7618	[SWS_Rte_CONSTR_09040]	Rte_PartitionRestarting shall be called only once
rte_sws_ext_7337	[SWS_Rte_CONSTR_09041]	Rte_RestartPartition shall be called from RestartTask
rte_sws_ext_1190	[SWS_Rte_CONSTR_09042]	Array Implementation Data Types needs at least one element
rte_sws_ext_1192	[SWS_Rte_CONSTR_09043]	Structure Implementation Data Types needs at least one element
rte_sws_ext_7147	[constr_9044]	*Union Implementation Data Type* shall include at least two elements
rte_sws_ext_2704	[SWS_Rte_CONSTR_09045]	The upper two bits of the of the server return value are reserved
rte_sws_ext_7285	[SWS_Rte_CONSTR_09046]	SchM_Enter and SchM_Exit API may only be used by BswModuleEntitys describing its usage
rte_sws_ext_7529	[SWS_Rte_CONSTR_09047]	Nested call of SchM_Enter and SchM_Exit API is restricted
rte_sws_ext_7189	[SWS_Rte_CONSTR_09048]	SchM_Exit API may only be used by BswModuleEntitys that describe its usage
rte_sws_ext_7257	[SWS_Rte_CONSTR_09049]	SchM_Switch API may only be used by BswModuleEntitys that describe its usage
rte_sws_ext_7587	[SWS_Rte_CONSTR_09050]	SchM_Mode API may only be used by BswModuleEntitys that describe its usage
rte_sws_ext_8508	[SWS_Rte_CONSTR_09051]	SchM_Mode API may only be used by BswModuleEntitys that describe its usage
rte_sws_ext_7567	[SWS_Rte_CONSTR_09052]	SchM_SwitchAck API may only be used by BswModuleEntitys that describe its usage
rte_sws_ext_7265	[SWS_Rte_CONSTR_09053]	SchM_Trigger API may only be used by the BswModuleEntitys that describe its usage

rte_sws_ext_7268	[SWS_Rte_CONSTR_09054]	SchM_ActMainFunction API may only be used by the BswModuleEntitys that describe its usage
rte_sws_ext_7272	[SWS_Rte_CONSTR_09055]	SchM_Init shall be called only once
rte_sws_ext_7576	[SWS_Rte_CONSTR_09056]	SchM_Deinit API may only be used after the was RTE finalized
rte_sws_ext_7276	[SWS_Rte_CONSTR_09057]	SchM_Deinit shall be called before shut down of BSW
rte_sws_ext_7287	[SWS_Rte_CONSTR_09058]	BswSchedulableEntity is not allowed to have service arguments or return value
rte_sws_ext_7512	[SWS_Rte_CONSTR_09059]	Usage of *Basic Software Scheduler* API prerequisites the include of the *Module Interlink Header File*

Table G.1: external requirements converted to constraints

rte_sws_7649	[SWS_Rte_CONSTR_09000]	Rte_IFeedback API may only be used by the RunnableEntitys that describe its usage

Table G.2: requirements converted to constraints

G.3.2 Added constraints

The following constraints were added in Rel. 4.1 Rev. 1: [SWS_Rte_CONSTR_03510], [SWS_Rte_CONSTR_09060], [SWS_Rte_CONSTR_09061], [SWS_Rte_CONSTR_09062], [SWS_Rte_CONSTR_09063], [SWS_Rte_CONSTR_09064]

G.3.3 Deleted SWS Items

The following SWS items were removed in Rel. 4.1 Rev. 1: SWS_Rte_02652, SWS_Rte_02731, SWS_Rte_03555, SWS_Rte_03569, SWS_Rte_03581, SWS_Rte_03747, SWS_Rte_03803, SWS_Rte_05020, SWS_Rte_05033, SWS_Rte_05054, SWS_Rte_05055, SWS_Rte_05056, SWS_Rte_05057, SWS_Rte_05058, SWS_Rte_05059, SWS_Rte_05066, SWS_Rte_05067, SWS_Rte_05110, SWS_Rte_05163, SWS_Rte_06028, SWS_Rte_07296, SWS_Rte_07649, SWS_Rte_07656, SWS_Rte_07657, SWS_Rte_07658, SWS_Rte_07665, SWS_Rte_07687, SWS_Rte_07688, SWS_Rte_07690, SWS_Rte_07691, SWS_Rte_08503.

G.3.4 Changed SWS Items

The following SWS items were changed in Rel. 4.1 Rev. 1: [SWS_Rte_01003], [SWS_Rte_01019], [SWS_Rte_01058], [SWS_Rte_01060], [SWS_Rte_01061], [SWS_Rte_01064], [SWS_Rte_01065], [SWS_Rte_01071], [SWS_Rte_01072], [SWS_Rte_01083], [SWS_Rte_01091], [SWS_Rte_01092], [SWS_Rte_01102], [SWS_Rte_01111], [SWS_Rte_01118], [SWS_Rte_01120], [SWS_Rte_01123], [SWS_Rte_01126], [SWS_Rte_01150], [SWS_Rte_01206], [SWS_Rte_01252], [SWS_Rte_01284], [SWS_Rte_01285], [SWS_Rte_01286], [SWS_Rte_01317], [SWS_Rte_01354], [SWS_Rte_01358], [SWS_Rte_01360], [SWS_Rte_01368], [SWS_Rte_02516], [SWS_Rte_02530], [SWS_Rte_02544], [SWS_Rte_02571], [SWS_Rte_02579], [SWS_Rte_02594], [SWS_Rte_02599], [SWS_Rte_02600], [SWS_Rte_02610], [SWS_Rte_02611], [SWS_Rte_02612], [SWS_Rte_02613], [SWS_Rte_02614], [SWS_Rte_02615], [SWS_Rte_02619], [SWS_Rte_02623], [SWS_Rte_02628], [SWS_Rte_02631], [SWS_Rte_02649], [SWS_Rte_02651], [SWS_Rte_02679], [SWS_Rte_02702], [SWS_Rte_02707], [SWS_Rte_02709], [SWS_Rte_02712], [SWS_Rte_02713], [SWS_Rte_02725], [SWS_Rte_02736], [SWS_Rte_02739], [SWS_Rte_02747], [SWS_Rte_02757], [SWS_Rte_02759], [SWS_Rte_02760], [SWS_Rte_03001], [SWS_Rte_03002], [SWS_Rte_03004], [SWS_Rte_03005], [SWS_Rte_03012], [SWS_Rte_03503], [SWS_Rte_03504], [SWS_Rte_03526], [SWS_Rte_03527], [SWS_Rte_03550], [SWS_Rte_03553], [SWS_Rte_03560], [SWS_Rte_03565], [SWS_Rte_03589], [SWS_Rte_03595], [SWS_Rte_03598], [SWS_Rte_03602], [SWS_Rte_03603], [SWS_Rte_03714], [SWS_Rte_03741], [SWS_Rte_03744], [SWS_Rte_03755], [SWS_Rte_03760], [SWS_Rte_03764], [SWS_Rte_03770], [SWS_Rte_03775], [SWS_Rte_03776], [SWS_Rte_03788], [SWS_Rte_03800], [SWS_Rte_03809], [SWS_Rte_03827], [SWS_Rte_03828], [SWS_Rte_03843], [SWS_Rte_03849], [SWS_Rte_03857], [SWS_Rte_03927], [SWS_Rte_03928], [SWS_Rte_03952], [SWS_Rte_03955], [SWS_Rte_03970], [SWS_Rte_04508], [SWS_Rte_04515], [SWS_Rte_04516], [SWS_Rte_04518], [SWS_Rte_05021], [SWS_Rte_05026], [SWS_Rte_05048], [SWS_Rte_05052], [SWS_Rte_05065], [SWS_Rte_05084], [SWS_Rte_05085], [SWS_Rte_05090], [SWS_Rte_05111], [SWS_Rte_05131], [SWS_Rte_05145], [SWS_Rte_05146], [SWS_Rte_05147], [SWS_Rte_05164], [SWS_Rte_05189], SWS_Rte_05506, [SWS_Rte_05509], [SWS_Rte_06532], [SWS_Rte_06533], [SWS_Rte_06713], [SWS_Rte_06714], [SWS_Rte_06715], [SWS_Rte_06718], [SWS_Rte_07006], [SWS_Rte_07008], [SWS_Rte_07031], [SWS_Rte_07047], [SWS_Rte_07048], [SWS_Rte_07054], [SWS_Rte_07056], [SWS_Rte_07059], [SWS_Rte_07075], [SWS_Rte_07092], [SWS_Rte_07093], [SWS_Rte_07099], [SWS_Rte_07101], [SWS_Rte_07122], [SWS_Rte_07135], [SWS_Rte_07140], [SWS_Rte_07152], [SWS_Rte_07170], [SWS_Rte_07175], [SWS_Rte_07178], [SWS_Rte_07187], [SWS_Rte_07194], [SWS_Rte_07195], [SWS_Rte_07200], [SWS_Rte_07203], [SWS_Rte_07251], [SWS_Rte_07254], [SWS_Rte_07270], [SWS_Rte_07282], [SWS_Rte_07283], [SWS_Rte_07289], [SWS_Rte_07290], [SWS_Rte_07293], [SWS_Rte_07294], [SWS_Rte_07346], [SWS_Rte_07367], [SWS_Rte_07384], [SWS_Rte_07385], [SWS_Rte_07387], [SWS_Rte_07390], [SWS_Rte_07394], [SWS_Rte_07396], [SWS_Rte_07530], [SWS_Rte_07559], [SWS_Rte_07562], [SWS_Rte_07563], [SWS_Rte_07575], [SWS_Rte_07586], [SWS_Rte_07590], [SWS_Rte_07621], [SWS_Rte_07647], [SWS_Rte_07648], [SWS_Rte_07654], [SWS_Rte_07655], [SWS_Rte_07675], [SWS_Rte_07680], [SWS_Rte_08001], [SWS_Rte_08002], [SWS_Rte_08016], [SWS_Rte_08039], [SWS_Rte_08301], [SWS_Rte_08500], [SWS_Rte_08505].

G.3.5 Added SWS Items

The following SWS items were added in Rel. 4.1 Rev. 1: [SWS_Rte_03862], [SWS_Rte_06727], [SWS_Rte_06728], [SWS_Rte_06729], [SWS_Rte_06730], [SWS_Rte_06731], [SWS_Rte_06732], [SWS_Rte_06733], [SWS_Rte_06734], [SWS_Rte_06735], [SWS_Rte_06736], [SWS_Rte_06737], [SWS_Rte_06738], [SWS_Rte_06739], [SWS_Rte_06740], [SWS_Rte_06741], [SWS_Rte_06742], [SWS_Rte_06743], [SWS_Rte_06744], [SWS_Rte_06745], [SWS_Rte_06746], [SWS_Rte_06747], [SWS_Rte_06748], [SWS_Rte_06749], [SWS_Rte_06750], [SWS_Rte_06751], [SWS_Rte_06752], [SWS_Rte_06753], [SWS_Rte_06754], [SWS_Rte_06755], [SWS_Rte_06756], [SWS_Rte_06757], [SWS_Rte_06758], [SWS_Rte_06759], [SWS_Rte_06760], [SWS_Rte_06761], [SWS_Rte_06762], [SWS_Rte_06764], [SWS_Rte_06765], [SWS_Rte_06766], [SWS_Rte_06767], [SWS_Rte_06768], [SWS_Rte_06769], [SWS_Rte_06770], [SWS_Rte_06771], [SWS_Rte_06772], [SWS_Rte_06773], [SWS_Rte_06774], [SWS_Rte_06775], [SWS_Rte_06776], [SWS_Rte_06777], [SWS_Rte_06778], [SWS_Rte_06779], [SWS_Rte_06780], [SWS_Rte_06781], [SWS_Rte_06782], [SWS_Rte_06783], [SWS_Rte_06784], [SWS_Rte_06785], [SWS_Rte_06786], [SWS_Rte_06787], [SWS_Rte_06788], [SWS_Rte_06789], [SWS_Rte_06791], [SWS_Rte_06792], [SWS_Rte_06793], [SWS_Rte_06794], [SWS_Rte_06795], [SWS_Rte_06796], [SWS_Rte_06797], [SWS_Rte_07828], [SWS_Rte_07829], [SWS_Rte_07830], [SWS_Rte_07831], [SWS_Rte_07832], [SWS_Rte_07833], [SWS_Rte_07834], [SWS_Rte_07835], [SWS_Rte_07836], [SWS_Rte_07837], [SWS_Rte_07838], [SWS_Rte_07839], [SWS_Rte_07840], [SWS_Rte_07841], [SWS_Rte_07925], [SWS_Rte_07926], [SWS_Rte_07927], [SWS_Rte_08046], [SWS_Rte_08047], [SWS_Rte_08048], [SWS_Rte_08049], [SWS_Rte_08050], [SWS_Rte_08051], [SWS_Rte_08052], [SWS_Rte_08053], [SWS_Rte_08054], [SWS_Rte_08055], [SWS_Rte_08056], [SWS_Rte_08057], [SWS_Rte_08058], [SWS_Rte_08059], [SWS_Rte_08060], [SWS_Rte_08061], [SWS_Rte_08062], [SWS_Rte_08063], [SWS_Rte_08064], [SWS_Rte_08065], [SWS_Rte_08066], [SWS_Rte_08067], [SWS_Rte_08068], [SWS_Rte_08069], [SWS_Rte_08070], [SWS_Rte_08071], [SWS_Rte_08072], [SWS_Rte_08073], [SWS_Rte_08309], [SWS_Rte_08310], [SWS_Rte_08311], [SWS_Rte_08405], [SWS_Rte_08406], [SWS_Rte_08407], [SWS_Rte_08408], [SWS_Rte_08409], [SWS_Rte_08410], [SWS_Rte_08411], [SWS_Rte_08412], [SWS_Rte_08511], [SWS_Rte_08512], [SWS_Rte_08513], [SWS_Rte_08514], [SWS_Rte_08600], [SWS_Rte_08601], [SWS_Rte_08700], [SWS_Rte_08701], [SWS_Rte_08702], [SWS_Rte_08703], [SWS_Rte_08704], [SWS_Rte_08705], [SWS_Rte_08706], [SWS_Rte_08707], [SWS_Rte_08708], [SWS_Rte_08709], [SWS_Rte_08710], [SWS_Rte_08711], [SWS_Rte_08712], [SWS_Rte_08713], [SWS_Rte_08725], [SWS_Rte_08726], [SWS_Rte_08727], [SWS_Rte_08728], [SWS_Rte_08729], [SWS_Rte_08730], [SWS_Rte_08731], [SWS_Rte_08732], [SWS_Rte_08733], [SWS_Rte_08734], [SWS_Rte_08735], [SWS_Rte_08736], [SWS_Rte_08737], [SWS_Rte_08738], [SWS_Rte_08739], [SWS_Rte_08740], [SWS_Rte_08741], [SWS_Rte_08742], [SWS_Rte_08743], [SWS_Rte_08744], [SWS_Rte_08745], [SWS_Rte_08746], [SWS_Rte_08747], [SWS_Rte_08748], [SWS_Rte_08749], [SWS_Rte_08750], [SWS_Rte_08751], [SWS_Rte_08752], [SWS_Rte_08753], [SWS_Rte_08754], [SWS_Rte_08755], [SWS_Rte_08756], [SWS_Rte_08757], [SWS_Rte_08758], [SWS_Rte_08759], [SWS_Rte_08761], [SWS_Rte_08762], [SWS_Rte_08763], [SWS_Rte_08764], [SWS_Rte_08765], [SWS_Rte_08766].

G.4 Changes in Rel. 4.1 Rev. 2 compared to Rel. 4.1 Rev. 1

G.4.1 Added Traceables in 4.1.2

[SWS_Rte_01371] [SWS_Rte_01372] [SWS_Rte_07410] [SWS_Rte_07411] [SWS_Rte_07412] [SWS_Rte_07842] [SWS_Rte_07843] [SWS_Rte_07844] [SWS_Rte_07928] [SWS_Rte_08074] [SWS_Rte_08075] [SWS_Rte_08076] [SWS_Rte_08312] [SWS_Rte_08313] [SWS_Rte_08314] [SWS_Rte_08315] [SWS_Rte_08316] [SWS_Rte_08317] [SWS_Rte_08413] [SWS_Rte_08414] [SWS_Rte_08415] [SWS_Rte_08416] [SWS_Rte_08767] [SWS_Rte_08768] [SWS_Rte_08769] [SWS_Rte_08770] [SWS_Rte_08771] [SWS_Rte_08772] [SWS_Rte_08773] [SWS_Rte_08774] [SWS_Rte_08775] [SWS_Rte_08776] [SWS_Rte_08800] [SWS_Rte_08801]

G.4.2 Changed Traceables in 4.1.2

[SWS_Rte_01003] [SWS_Rte_01296] [SWS_Rte_01297] [SWS_Rte_01358] [SWS_Rte_01360] [SWS_Rte_01368] [SWS_Rte_02549] [SWS_Rte_02600] [SWS_Rte_02678] [SWS_Rte_03012] [SWS_Rte_03526] [SWS_Rte_03527] [SWS_Rte_03571] [SWS_Rte_03755] [SWS_Rte_03788] [SWS_Rte_03809] [SWS_Rte_03810] [SWS_Rte_03813] [SWS_Rte_03832] [SWS_Rte_03843] [SWS_Rte_03849] [SWS_Rte_03851] [SWS_Rte_03862] [SWS_Rte_03970] [SWS_Rte_04508] [SWS_Rte_05052] [SWS_Rte_05088] [SWS_Rte_05089] [SWS_Rte_05090] [SWS_Rte_05097] [SWS_Rte_05129] [SWS_Rte_05147] [SWS_Rte_05177] [SWS_Rte_05184] [SWS_Rte_05191] [SWS_Rte_05503] [SWS_Rte_06727] [SWS_Rte_06731] [SWS_Rte_06732] [SWS_Rte_06737] [SWS_Rte_06738] [SWS_Rte_06780] [SWS_Rte_07006] [SWS_Rte_07027] [SWS_Rte_07085] [SWS_Rte_07101] [SWS_Rte_07135] [SWS_Rte_07170] [SWS_Rte_07175] [SWS_Rte_07188] [SWS_Rte_07196] [SWS_Rte_07260] [SWS_Rte_07261] [SWS_Rte_07385] [SWS_Rte_07538] [SWS_Rte_07620] [SWS_Rte_07621] [SWS_Rte_07654] [SWS_Rte_07662] [SWS_Rte_07694] [SWS_Rte_07831] [SWS_Rte_07832] [SWS_Rte_07927] [SWS_Rte_08017] [SWS_Rte_08018] [SWS_Rte_08020] [SWS_Rte_08021] [SWS_Rte_08022] [SWS_Rte_08023] [SWS_Rte_08043] [SWS_Rte_08044] [SWS_Rte_08045]

[SWS_Rte_08064] [SWS_Rte_08072] [SWS_Rte_08403] [SWS_Rte_08404] [SWS_Rte_08407] [SWS_Rte_08501] [SWS_Rte_08507] [SWS_Rte_08513] [SWS_Rte_08514] [SWS_Rte_08733] [SWS_Rte_08743]

G.4.3 Deleted Traceables in 4.1.2

[SWS_Rte_02673] [SWS_Rte_05001] [SWS_Rte_05506]

G.4.4 Added Constraints in 4.1.2

Id	Heading
[constr_9080]	The *shortNames* of *PortInterfaces* shall be unique within a software component if it supports multiple instantiation or `indirectAPI` attribute is set to 'true'
[constr_9081]	Mapping to partition vs the value of VariableAccess.scope

Table G.3: Added Constraints in 4.1.2

G.4.5 Changed Constraints in 4.1.2

Id	Heading
[constr_9020]	The blocking `Rte_SwitchAck` API may only be used by the runnable that describes its usage.

Table G.4: Changed Constraints in 4.1.2

G.4.6 Deleted Constraints in 4.1.2

none

G.5 Changes in Rel. 4.1 Rev. 3 compared to Rel. 4.1 Rev. 2

G.5.1 Added Traceables in 4.1.3

[SWS_Rte_01373] [SWS_Rte_01374] [SWS_Rte_01375] [SWS_Rte_06030] [SWS_Rte_06031] [SWS_Rte_06032] [SWS_Rte_06551] [SWS_Rte_06552] [SWS_Rte_06553] [SWS_Rte_06790] [SWS_Rte_06798] [SWS_Rte_06799] [SWS_Rte_06800] [SWS_Rte_06801] [SWS_Rte_06802] [SWS_Rte_06803] [SWS_Rte_06804] [SWS_Rte_06805] [SWS_Rte_06806] [SWS_Rte_06807] [SWS_Rte_06808] [SWS_Rte_06809] [SWS_Rte_06810] [SWS_Rte_07845] [SWS_Rte_07846] [SWS_Rte_07847] [SWS_Rte_07848] [SWS_Rte_07849] [SWS_Rte_07850] [SWS_Rte_07851] [SWS_Rte_08077] [SWS_Rte_08078] [SWS_Rte_08079] [SWS_Rte_08318] [SWS_Rte_08319] [SWS_Rte_08320] [SWS_Rte_08321] [SWS_Rte_08322] [SWS_Rte_08777] [SWS_Rte_08778]

[SWS_Rte_08779] [SWS_Rte_08780] [SWS_Rte_08781] [SWS_Rte_08782] [SWS_Rte_08783] [SWS_Rte_08784] [SWS_Rte_08785] [SWS_Rte_08786]

G.5.2 Changed Traceables in 4.1.3

[SWS_Rte_01071] [SWS_Rte_01072] [SWS_Rte_01083] [SWS_Rte_01091] [SWS_Rte_01092] [SWS_Rte_01102] [SWS_Rte_01111] [SWS_Rte_01118] [SWS_Rte_01120] [SWS_Rte_01123] [SWS_Rte_01206] [SWS_Rte_01252] [SWS_Rte_01354] [SWS_Rte_02568] [SWS_Rte_02599] [SWS_Rte_02614] [SWS_Rte_02619] [SWS_Rte_02628] [SWS_Rte_02631] [SWS_Rte_02659] [SWS_Rte_02667] [SWS_Rte_02725] [SWS_Rte_02740] [SWS_Rte_02741] [SWS_Rte_02743] [SWS_Rte_02744] [SWS_Rte_02745] [SWS_Rte_03527] [SWS_Rte_03550] [SWS_Rte_03553] [SWS_Rte_03560] [SWS_Rte_03565] [SWS_Rte_03741] [SWS_Rte_03744] [SWS_Rte_03800] [SWS_Rte_03813] [SWS_Rte_03832] [SWS_Rte_03858] [SWS_Rte_03859] [SWS_Rte_03928] [SWS_Rte_05129] [SWS_Rte_05501] [SWS_Rte_05509] [SWS_Rte_06536] [SWS_Rte_07026] [SWS_Rte_07038] [SWS_Rte_07039] [SWS_Rte_07057] [SWS_Rte_07195] [SWS_Rte_07200] [SWS_Rte_07203] [SWS_Rte_07214] [SWS_Rte_07216] [SWS_Rte_07223] [SWS_Rte_07224] [SWS_Rte_07367] [SWS_Rte_07394] [SWS_Rte_07554] [SWS_Rte_07640] [SWS_Rte_07680] [SWS_Rte_07928] [SWS_Rte_08066] [SWS_Rte_08314] [SWS_Rte_08315] [SWS_Rte_08316] [SWS_Rte_08800]

G.5.3 Deleted Traceables in 4.1.3

[SWS_Rte_03012] [SWS_Rte_03790] [SWS_Rte_04525] [SWS_Rte_05116] [SWS_Rte_05134]

G.5.4 Added Constraints in 4.1.3

Id	Heading
[constr_9082]	RtePositionInTask and RteBswPositionInTask values shall be unique in a particular context

Table G.5: Added Constraints in 4.1.3

G.5.5 Changed Constraints in 4.1.3

none

G.5.6 Deleted Constraints in 4.1.3

Id	Heading
[constr_9004]	Usage of WaitPoints is restricted depending on *ExclusiveAreaImplMechanism*

Table G.6: Deleted Constraints in 4.1.3

G.6 Changes in Rel. 4.2 Rev. 1 compared to Rel. 4.1 Rev. 3

G.6.1 Added Traceables in 4.2.1

[SWS_Rte_01376]	[SWS_Rte_01377]	[SWS_Rte_01378]	[SWS_Rte_01379]
[SWS_Rte_01380]	[SWS_Rte_01381]	[SWS_Rte_01382]	[SWS_Rte_01383]
[SWS_Rte_01384]	[SWS_Rte_01385]	[SWS_Rte_01386]	[SWS_Rte_01387]
[SWS_Rte_01388]	[SWS_Rte_01389]	[SWS_Rte_01390]	[SWS_Rte_01391]
[SWS_Rte_01392]	[SWS_Rte_01393]	[SWS_Rte_01394]	[SWS_Rte_01395]
[SWS_Rte_01396]	[SWS_Rte_01397]	[SWS_Rte_01398]	[SWS_Rte_01399]
[SWS_Rte_01400]	[SWS_Rte_01401]	[SWS_Rte_01402]	[SWS_Rte_01403]
[SWS_Rte_01404]	[SWS_Rte_01405]	[SWS_Rte_01406]	[SWS_Rte_01407]
[SWS_Rte_01408]	[SWS_Rte_01409]	[SWS_Rte_01410]	[SWS_Rte_01411]
[SWS_Rte_01412]	[SWS_Rte_01413]	[SWS_Rte_02307]	[SWS_Rte_02308]
[SWS_Rte_02309]	[SWS_Rte_03863]	[SWS_Rte_03864]	[SWS_Rte_03865]
[SWS_Rte_03983]	[SWS_Rte_03984]	[SWS_Rte_03985]	[SWS_Rte_03986]
[SWS_Rte_03987]	[SWS_Rte_03988]	[SWS_Rte_03989]	[SWS_Rte_03990]
[SWS_Rte_03991]	[SWS_Rte_03992]	[SWS_Rte_03993]	[SWS_Rte_03994]
[SWS_Rte_03995]	[SWS_Rte_03996]	[SWS_Rte_03997]	[SWS_Rte_06811]
[SWS_Rte_06812]	[SWS_Rte_06813]	[SWS_Rte_06814]	[SWS_Rte_06815]
[SWS_Rte_06816]	[SWS_Rte_06817]	[SWS_Rte_06818]	[SWS_Rte_06819]
[SWS_Rte_06820]	[SWS_Rte_06821]	[SWS_Rte_06822]	[SWS_Rte_06823]
[SWS_Rte_06824]	[SWS_Rte_06825]	[SWS_Rte_06826]	[SWS_Rte_06827]
[SWS_Rte_06828]	[SWS_Rte_06829]	[SWS_Rte_06830]	[SWS_Rte_07413]
[SWS_Rte_08080]	[SWS_Rte_08081]	[SWS_Rte_08082]	[SWS_Rte_08083]
[SWS_Rte_08084]	[SWS_Rte_08085]	[SWS_Rte_08086]	[SWS_Rte_08087]
[SWS_Rte_08088]	[SWS_Rte_08089]	[SWS_Rte_08090]	[SWS_Rte_08091]
[SWS_Rte_08092]	[SWS_Rte_08093]	[SWS_Rte_08094]	[SWS_Rte_08095]
[SWS_Rte_08096]	[SWS_Rte_08097]	[SWS_Rte_08098]	[SWS_Rte_08099]
[SWS_Rte_08100]	[SWS_Rte_08101]	[SWS_Rte_08102]	[SWS_Rte_08103]
[SWS_Rte_08515]	[SWS_Rte_08516]	[SWS_Rte_08517]	[SWS_Rte_08518]
[SWS_Rte_08519]	[SWS_Rte_08520]	[SWS_Rte_08521]	[SWS_Rte_08522]
[SWS_Rte_08523]	[SWS_Rte_08524]	[SWS_Rte_08525]	[SWS_Rte_08526]
[SWS_Rte_08527]	[SWS_Rte_08528]	[SWS_Rte_08529]	[SWS_Rte_08530]
[SWS_Rte_08531]	[SWS_Rte_08532]	[SWS_Rte_08533]	[SWS_Rte_08534]
[SWS_Rte_08535]	[SWS_Rte_08536]	[SWS_Rte_08537]	[SWS_Rte_08538]
[SWS_Rte_08539]	[SWS_Rte_08540]	[SWS_Rte_08541]	[SWS_Rte_08542]
[SWS_Rte_08543]	[SWS_Rte_08544]	[SWS_Rte_08545]	[SWS_Rte_08546]
[SWS_Rte_08547]	[SWS_Rte_08548]	[SWS_Rte_08549]	[SWS_Rte_08550]
[SWS_Rte_08551]	[SWS_Rte_08552]	[SWS_Rte_08553]	[SWS_Rte_08554]
[SWS_Rte_08555]	[SWS_Rte_08556]	[SWS_Rte_08557]	[SWS_Rte_08558]

[SWS_Rte_08559] [SWS_Rte_08560] [SWS_Rte_08561] [SWS_Rte_08562]
[SWS_Rte_08563] [SWS_Rte_08564] [SWS_Rte_08565] [SWS_Rte_08566]
[SWS_Rte_08567] [SWS_Rte_08568] [SWS_Rte_08569] [SWS_Rte_08570]
[SWS_Rte_08571] [SWS_Rte_08572] [SWS_Rte_08573] [SWS_Rte_08574]
[SWS_Rte_08575] [SWS_Rte_08576] [SWS_Rte_08577] [SWS_Rte_08578]
[SWS_Rte_08579] [SWS_Rte_08580] [SWS_Rte_08581] [SWS_Rte_08582]
[SWS_Rte_08583] [SWS_Rte_08584] [SWS_Rte_08585] [SWS_Rte_08586]
[SWS_Rte_08587] [SWS_Rte_08588] [SWS_Rte_08589] [SWS_Rte_08590]
[SWS_Rte_08591] [SWS_Rte_08787] [SWS_Rte_08788] [SWS_Rte_08789]
[SWS_Rte_08790] [SWS_Rte_08791] [SWS_Rte_08792] [SWS_Rte_08793]
[SWS_Rte_08794] [SWS_Rte_08795] [SWS_Rte_08796] [SWS_Rte_08797]
[SWS_Rte_08798] [SWS_Rte_08799]

G.6.2 Changed Traceables in 4.2.1

[SWS_Rte_01071] [SWS_Rte_01072] [SWS_Rte_01091] [SWS_Rte_01092]
[SWS_Rte_01102] [SWS_Rte_01111] [SWS_Rte_01118] [SWS_Rte_01119]
[SWS_Rte_01166] [SWS_Rte_01206] [SWS_Rte_01238] [SWS_Rte_01239]
[SWS_Rte_01252] [SWS_Rte_01282] [SWS_Rte_01299] [SWS_Rte_01300]
[SWS_Rte_02599] [SWS_Rte_02600] [SWS_Rte_02607] [SWS_Rte_02608]
[SWS_Rte_02648] [SWS_Rte_02651] [SWS_Rte_02662] [SWS_Rte_02663]
[SWS_Rte_02665] [SWS_Rte_02710] [SWS_Rte_03530] [SWS_Rte_03531]
[SWS_Rte_03532] [SWS_Rte_03594] [SWS_Rte_03600] [SWS_Rte_03754]
[SWS_Rte_03758] [SWS_Rte_03759] [SWS_Rte_03770] [SWS_Rte_03795]
[SWS_Rte_03801] [SWS_Rte_03830] [SWS_Rte_03833] [SWS_Rte_03927]
[SWS_Rte_03928] [SWS_Rte_03929] [SWS_Rte_03952] [SWS_Rte_04505]
[SWS_Rte_04526] [SWS_Rte_04527] [SWS_Rte_05021] [SWS_Rte_05024]
[SWS_Rte_05025] [SWS_Rte_05026] [SWS_Rte_05049] [SWS_Rte_05062]
[SWS_Rte_05081] [SWS_Rte_05088] [SWS_Rte_05126] [SWS_Rte_05127]
[SWS_Rte_05128] [SWS_Rte_06002] [SWS_Rte_06023] [SWS_Rte_06613]
[SWS_Rte_06630] [SWS_Rte_06631] [SWS_Rte_06632] [SWS_Rte_06633]
[SWS_Rte_06634] [SWS_Rte_06635] [SWS_Rte_06637] [SWS_Rte_06734]
[SWS_Rte_06735] [SWS_Rte_06772] [SWS_Rte_06773] [SWS_Rte_06774]
[SWS_Rte_06804] [SWS_Rte_06805] [SWS_Rte_06806] [SWS_Rte_06807]
[SWS_Rte_07032] [SWS_Rte_07114] [SWS_Rte_07144] [SWS_Rte_07163]
[SWS_Rte_07173] [SWS_Rte_07195] [SWS_Rte_07214] [SWS_Rte_07282]
[SWS_Rte_07317] [SWS_Rte_07355] [SWS_Rte_07356] [SWS_Rte_07394]
[SWS_Rte_07554] [SWS_Rte_07670] [SWS_Rte_07675] [SWS_Rte_07676]
[SWS_Rte_07682] [SWS_Rte_07683] [SWS_Rte_07684] [SWS_Rte_07685]
[SWS_Rte_07693] [SWS_Rte_07810] [SWS_Rte_07813] [SWS_Rte_07814]
[SWS_Rte_07846] [SWS_Rte_07847] [SWS_Rte_07848] [SWS_Rte_07849]
[SWS_Rte_07920] [SWS_Rte_07927] [SWS_Rte_07928] [SWS_Rte_08016]
[SWS_Rte_08022] [SWS_Rte_08023] [SWS_Rte_08038] [SWS_Rte_08045]
[SWS_Rte_08061] [SWS_Rte_08062] [SWS_Rte_08074] [SWS_Rte_08075]
[SWS_Rte_08076] [SWS_Rte_08301] [SWS_Rte_08310] [SWS_Rte_08414]

[SWS_Rte_08415] [SWS_Rte_08711] [SWS_Rte_08712] [SWS_Rte_08713] [SWS_Rte_08725] [SWS_Rte_08726] [SWS_Rte_08727] [SWS_Rte_08728] [SWS_Rte_08729] [SWS_Rte_08800]

G.6.3 Deleted Traceables in 4.2.1

[SWS_Rte_02724] [SWS_Rte_04506] [SWS_Rte_04507] [SWS_Rte_07136] [SWS_Rte_08702] [SWS_Rte_08704] [SWS_Rte_08706] [SWS_Rte_08708] [SWS_Rte_08710] [SWS_Rte_08730] [SWS_Rte_08761] [SWS_Rte_08762]

G.6.4 Added Constraints in 4.2.1

Id	Heading
[constr_9083]	`Rte_IRead` API may only be used by the runnable that describe its usage
[constr_9084]	`Rte_IWrite` API may only be used by the runnable that describe its usage
[constr_9085]	`Rte_IWriteRef` API may only be used by the runnable that describe its usage
[constr_9086]	`Rte_IInvalidate` API may only be used by the runnable that is describing an write access to the data
[constr_9087]	`Rte_IrvIRead` API may only be used by the runnable that describe its usage
[constr_9088]	`Rte_IrvIWrite` API may only be used by the runnable that describe its usage
[constr_9089]	`Rte_IrvRead` API may only be used by the runnable that describe its usage
[constr_9090]	`Rte_IrvWrite` API may only be used by the runnable that describe its usage
[constr_9091]	`RteSwNvRamMappingRef` and `RteSwNvBlockDescriptorRef` are excluding each other

Table G.7: Added Constraints in 4.2.1

G.6.5 Changed Constraints in 4.2.1

Id	Heading
[constr_9011]	`NvMBlockDescriptor` related to a `RAM Block` of a `NvBlockSwComponentType` shall use `NvmBlockUseSyncMechanism`
[constr_9027]	`Rte_IStatus` API shall only be used by a `RunnableEntity` describing an read access to the related data

Table G.8: Changed Constraints in 4.2.1

G.6.6 Deleted Constraints in 4.2.1

Id	Heading
[constr_9044]	*Union Implementation Data Type* shall include at least two elements
[constr_9065]	Signature of Serializer
[constr_9066]	A BswModuleEntry representing a serializer shall comply to a serializer's signature
[constr_9068]	Return value for successful serialization
[constr_9069]	Return value for a serialization error
[constr_9071]	Signature of Deserializer

[constr_9072]	A BswModuleEntry representing a deserializer shall comply to a deserializer's signature
[constr_9073]	Return value for successful deserialization
[constr_9074]	Return value for a deserialization error

Table G.9: Deleted Constraints in 4.2.1

G.7 Changes in Rel. 4.2 Rev. 2 compared to Rel. 4.2 Rev. 1

G.7.1 Added Traceables in 4.2.2

[SWS_Rte_03866] [SWS_Rte_03998] [SWS_Rte_05300] [SWS_Rte_05301] [SWS_Rte_06200] [SWS_Rte_06201] [SWS_Rte_06203] [SWS_Rte_06204] [SWS_Rte_06205] [SWS_Rte_06206] [SWS_Rte_06207] [SWS_Rte_06208] [SWS_Rte_06209] [SWS_Rte_06831] [SWS_Rte_07414] [SWS_Rte_07415] [SWS_Rte_07416] [SWS_Rte_07417] [SWS_Rte_07418] [SWS_Rte_07419] [SWS_Rte_07420] [SWS_Rte_08104] [SWS_Rte_08105] [SWS_Rte_08106] [SWS_Rte_08107] [SWS_Rte_08108] [SWS_Rte_08109] [SWS_Rte_08110] [SWS_Rte_08417] [SWS_Rte_08418] [SWS_Rte_08419] [SWS_Rte_08592] [SWS_Rte_08593] [SWS_Rte_08594] [SWS_Rte_08595] [SWS_Rte_08596] [SWS_Rte_08597] [SWS_Rte_08598] [SWS_Rte_08599]

G.7.2 Changed Traceables in 4.2.2

[SWS_Rte_01156] [SWS_Rte_01366] [SWS_Rte_01403] [SWS_Rte_02250] [SWS_Rte_02254] [SWS_Rte_02572] [SWS_Rte_02604] [SWS_Rte_02703] [SWS_Rte_03724] [SWS_Rte_03793] [SWS_Rte_03832] [SWS_Rte_05094] [SWS_Rte_05095] [SWS_Rte_05096] [SWS_Rte_05097] [SWS_Rte_05098] [SWS_Rte_05105] [SWS_Rte_05500] [SWS_Rte_06545] [SWS_Rte_06611] [SWS_Rte_06630] [SWS_Rte_06631] [SWS_Rte_06799] [SWS_Rte_06811] [SWS_Rte_06818] [SWS_Rte_06829] [SWS_Rte_07038] [SWS_Rte_07089] [SWS_Rte_07200] [SWS_Rte_07207] [SWS_Rte_07310] [SWS_Rte_07315] [SWS_Rte_07408] [SWS_Rte_07409] [SWS_Rte_07413] [SWS_Rte_07623] [SWS_Rte_07627] [SWS_Rte_07676] [SWS_Rte_07686] [SWS_Rte_07817] [SWS_Rte_08064] [SWS_Rte_08409] [SWS_Rte_08411] [SWS_Rte_08412] [SWS_Rte_08515] [SWS_Rte_08516] [SWS_Rte_08518] [SWS_Rte_08523] [SWS_Rte_08526] [SWS_Rte_08533] [SWS_Rte_08558] [SWS_Rte_08711] [SWS_Rte_08712] [SWS_Rte_08732] [SWS_Rte_08794] [SWS_Rte_08795] [SWS_Rte_08800]

G.7.3 Deleted Traceables in 4.2.2

[SWS_Rte_01231] [SWS_Rte_01276] [SWS_Rte_02251] [SWS_Rte_05022] [SWS_Rte_05063] [SWS_Rte_08713]

G.7.4 Added Constraints in 4.2.2

Id	Heading
[constr_9092]	Rte_IrvIWriteRef API may only be used by the runnable that describe its usage
[constr_9093]	Rte_IrvIWriteRef may not return values written in previous executions

Table G.10: Added Constraints in 4.2.2

G.7.5 Changed Constraints in 4.2.2

none

G.7.6 Deleted Constraints in 4.2.2

none

G.8 Changes in Rel. 4.3 Rev. 0 compared to Rel. 4.2 Rev. 2

G.8.1 Added Traceables in 4.3.0

[SWS_Rte_03867] [SWS_Rte_03868] [SWS_Rte_03999] [SWS_Rte_04528] [SWS_Rte_04529] [SWS_Rte_04530] [SWS_Rte_04531] [SWS_Rte_04532] [SWS_Rte_04533] [SWS_Rte_04534] [SWS_Rte_04535] [SWS_Rte_04536] [SWS_Rte_04537] [SWS_Rte_04538] [SWS_Rte_04539] [SWS_Rte_04540] [SWS_Rte_04541] [SWS_Rte_04542] [SWS_Rte_04543] [SWS_Rte_04544] [SWS_Rte_04545] [SWS_Rte_04546] [SWS_Rte_04547] [SWS_Rte_04548] [SWS_Rte_04549] [SWS_Rte_04550] [SWS_Rte_04551] [SWS_Rte_06033] [SWS_Rte_06034] [SWS_Rte_06035] [SWS_Rte_06036] [SWS_Rte_06037] [SWS_Rte_06038] [SWS_Rte_06039] [SWS_Rte_06040] [SWS_Rte_06041] [SWS_Rte_06042] [SWS_Rte_06043] [SWS_Rte_06044] [SWS_Rte_06045] [SWS_Rte_06046] [SWS_Rte_06047] [SWS_Rte_06048] [SWS_Rte_06049] [SWS_Rte_06050] [SWS_Rte_06051] [SWS_Rte_06052] [SWS_Rte_06053] [SWS_Rte_06054] [SWS_Rte_06055] [SWS_Rte_06056] [SWS_Rte_06057] [SWS_Rte_06058] [SWS_Rte_06059] [SWS_Rte_06060] [SWS_Rte_06061] [SWS_Rte_06064] [SWS_Rte_06065] [SWS_Rte_06066] [SWS_Rte_06067] [SWS_Rte_06068] [SWS_Rte_06069] [SWS_Rte_06073] [SWS_Rte_06074] [SWS_Rte_06075] [SWS_Rte_06076] [SWS_Rte_06077] [SWS_Rte_06079] [SWS_Rte_06080] [SWS_Rte_06081] [SWS_Rte_06082] [SWS_Rte_06083] [SWS_Rte_06084] [SWS_Rte_06085] [SWS_Rte_06086] [SWS_Rte_06087] [SWS_Rte_06088] [SWS_Rte_06089] [SWS_Rte_06090] [SWS_Rte_06091] [SWS_Rte_06092] [SWS_Rte_06093] [SWS_Rte_06094] [SWS_Rte_06095] [SWS_Rte_06096] [SWS_Rte_06097] [SWS_Rte_06098] [SWS_Rte_06099] [SWS_Rte_06100] [SWS_Rte_06101] [SWS_Rte_06102] [SWS_Rte_06103] [SWS_Rte_06104] [SWS_Rte_06105] [SWS_Rte_06106] [SWS_Rte_06107]

[SWS_Rte_06108] [SWS_Rte_06109] [SWS_Rte_06110] [SWS_Rte_06111] [SWS_Rte_06112] [SWS_Rte_06113] [SWS_Rte_06114] [SWS_Rte_06115] [SWS_Rte_06120] [SWS_Rte_06210] [SWS_Rte_06211] [SWS_Rte_06212] [SWS_Rte_08111] [SWS_Rte_08420] [SWS_Rte_08421] [SWS_Rte_08422] [SWS_Rte_08423] [SWS_Rte_08424] [SWS_Rte_08603] [SWS_Rte_08604] [SWS_Rte_08605]

G.8.2 Changed Traceables in 4.3.0

[SWS_Rte_01072] [SWS_Rte_01092] [SWS_Rte_01120] [SWS_Rte_01123] [SWS_Rte_01150] [SWS_Rte_01168] [SWS_Rte_01238] [SWS_Rte_01239] [SWS_Rte_01240] [SWS_Rte_01241] [SWS_Rte_01319] [SWS_Rte_01342] [SWS_Rte_01354] [SWS_Rte_01408] [SWS_Rte_01411] [SWS_Rte_02579] [SWS_Rte_02599] [SWS_Rte_02614] [SWS_Rte_02619] [SWS_Rte_02653] [SWS_Rte_02679] [SWS_Rte_03602] [SWS_Rte_03603] [SWS_Rte_03712] [SWS_Rte_03714] [SWS_Rte_03731] [SWS_Rte_03739] [SWS_Rte_03741] [SWS_Rte_03744] [SWS_Rte_03799] [SWS_Rte_03810] [SWS_Rte_03827] [SWS_Rte_03828] [SWS_Rte_03832] [SWS_Rte_03984] [SWS_Rte_04504] [SWS_Rte_05509] [SWS_Rte_06533] [SWS_Rte_06612] [SWS_Rte_06620] [SWS_Rte_06638] [SWS_Rte_06768] [SWS_Rte_06769] [SWS_Rte_06770] [SWS_Rte_06813] [SWS_Rte_07053] [SWS_Rte_07100] [SWS_Rte_07138] [SWS_Rte_07170] [SWS_Rte_07250] [SWS_Rte_07253] [SWS_Rte_07270] [SWS_Rte_07386] [SWS_Rte_07411] [SWS_Rte_07556] [SWS_Rte_07574] [SWS_Rte_07675] [SWS_Rte_07683] [SWS_Rte_07810] [SWS_Rte_07811] [SWS_Rte_07928] [SWS_Rte_08080] [SWS_Rte_08081] [SWS_Rte_08090] [SWS_Rte_08312] [SWS_Rte_08517] [SWS_Rte_08524] [SWS_Rte_08538] [SWS_Rte_08541] [SWS_Rte_08700] [SWS_Rte_08733] [SWS_Rte_08736] [SWS_Rte_08740] [SWS_Rte_08743] [SWS_Rte_08744] [SWS_Rte_08795] [SWS_Rte_08801]

G.8.3 Deleted Traceables in 4.3.0

[SWS_Rte_02627] [SWS_Rte_03503] [SWS_Rte_03773] [SWS_Rte_05094] [SWS_Rte_05095] [SWS_Rte_05096] [SWS_Rte_05097] [SWS_Rte_05098] [SWS_Rte_05103] [SWS_Rte_05104] [SWS_Rte_05105] [SWS_Rte_06544] [SWS_Rte_06545] [SWS_Rte_06630] [SWS_Rte_07283] [SWS_Rte_07292] [SWS_Rte_07357] [SWS_Rte_07813] [SWS_Rte_07814] [SWS_Rte_08106] [SWS_Rte_08701] [SWS_Rte_08759] [SWS_Rte_08781]

G.8.4 Renamed Constraints in 4.3.0

constr_9081	[SWS_Rte_CONSTR_09081]	Mapping to partition vs the value of VariableAccess.scope

constr_9010	[SWS_Rte_CONSTR_09010]	Worst case execution time shall be less than the GCD
constr_9012	[SWS_Rte_CONSTR_09012]	Category 1 interrupts shall not access the RTE.
constr_9011	[SWS_Rte_CONSTR_09011]	NvMBlockDescriptor related to a RAM Block of a NvBlockSwComponentType shall use NvMBlockDescriptor.NvmBlockUseSyncMechanism
constr_9001	[SWS_Rte_CONSTR_09001]	Whole DataPrototypeGroup in role ConsistencyNeeds.dpgRequiresCoherency shall be propagated coherently
constr_9002	[SWS_Rte_CONSTR_09002]	The whole DataPrototypeGroup shall be read stable for the whole RunnableEntityGroup in the role ConsistencyNeeds.regRequiresStability
constr_9013	[SWS_Rte_CONSTR_09013]	Exactly one mode or one mode transition shall be active
constr_9014	[SWS_Rte_CONSTR_09014]	ModeSwitchPoint(s) and managedModeGroup(s) are mutually exclusive for synchronized ModeDeclarationGroupPrototypes
constr_9007	[SWS_Rte_CONSTR_09007]	issuedTrigger and BswTriggerDirectImplementation are mutually exclusive
constr_9008	[SWS_Rte_CONSTR_09008]	The same Trigger in a trigger sink must not be connected to multiple trigger sources
constr_9009	[SWS_Rte_CONSTR_09009]	Synchronized Trigger shall not be referenced by more than one type of access method
constr_9042	[SWS_Rte_CONSTR_09042]	Array Implementation Data Type needs at least one element
constr_9043	[SWS_Rte_CONSTR_09043]	Structure Implementation Data Type needs at least one element
constr_9080	[SWS_Rte_CONSTR_09080]	The shortNames of PortInterfaces shall be unique within a software component if it supports multiple instantiation or PortAPIOption.indirectAPI attribute is set to 'true'
constr_9015	[SWS_Rte_CONSTR_09015]	Rte_Write API may only be used by the runnable that describe its usage
constr_9016	[SWS_Rte_CONSTR_09016]	Rte_Send API may only be used by the runnable that describes its usage
constr_9017	[SWS_Rte_CONSTR_09017]	Rte_Switch API may only be used by the runnable that describes its usage
constr_9018	[SWS_Rte_CONSTR_09018]	Rte_Invalidate API may only be used by the runnable that describe its usage
constr_9019	[SWS_Rte_CONSTR_09019]	Rte_Feedback API may only be used by the runnable that describe its usage
constr_9020	[SWS_Rte_CONSTR_09020]	The blocking Rte_SwitchAck API may only be used by the runnable that describes its usage.
constr_9021	[SWS_Rte_CONSTR_09021]	Rte_Read API may only be used by the runnable that describe its usage
constr_9022	[SWS_Rte_CONSTR_09022]	Rte_DRead API may only be used by the runnable that describe its usage
constr_9023	[SWS_Rte_CONSTR_09023]	Rte_Receive API may only be used by the runnable that describe its usage
constr_9024	[SWS_Rte_CONSTR_09024]	Rte_Call API may only be used by the runnable that describe its usage
constr_9025	[SWS_Rte_CONSTR_09025]	Blocking Rte_Result API may only be used by the runnable that describe the WaitPoint
constr_9083	[SWS_Rte_CONSTR_09083]	Rte_IRead API may only be used by the runnable that describe its usage

constr_9084	[SWS_Rte_CONSTR_09084]	Rte_IWrite API may only be used by the runnable that describe its usage
constr_9085	[SWS_Rte_CONSTR_09085]	Rte_IWriteRef API may only be used by the runnable that describe its usage
constr_9026	[SWS_Rte_CONSTR_09026]	Rte_IWriteRef may not return values written in previous executions
constr_9086	[SWS_Rte_CONSTR_09086]	Rte_IInvalidate API may only be used by the runnable that is describing an write access to the data
constr_9027	[SWS_Rte_CONSTR_09027]	Rte_IStatus API shall only be used by a RunnableEntity describing an read access to the related data
constr_9087	[SWS_Rte_CONSTR_09087]	Rte_IrvIRead API may only be used by the runnable that describe its usage
constr_9088	[SWS_Rte_CONSTR_09088]	Rte_IrvIWrite API may only be used by the runnable that describe its usage
constr_9092	[SWS_Rte_CONSTR_09092]	Rte_IrvIWriteRef API may only be used by the runnable that describe its usage
constr_9093	[SWS_Rte_CONSTR_09093]	Rte_IrvIWriteRef may not return values written in previous executions
constr_9089	[SWS_Rte_CONSTR_09089]	Rte_IrvRead API may only be used by the runnable that describe its usage
constr_9090	[SWS_Rte_CONSTR_09090]	Rte_IrvWrite API may only be used by the runnable that describe its usage
constr_9028	[SWS_Rte_CONSTR_09028]	Rte_Enter and Rte_Exit API may only be used by runnables describing its usage
constr_9029	[SWS_Rte_CONSTR_09029]	Nested call of Rte_Enter and Rte_Exit is restricted
constr_9030	[SWS_Rte_CONSTR_09030]	Rte_Mode API may only be used by the runnable that describe its usage
constr_9031	[SWS_Rte_CONSTR_09031]	Rte_Mode API may only be used by the runnable that describe its usage
constr_9032	[SWS_Rte_CONSTR_09032]	Rte_Trigger API may only be used by the runnable that describe its usage
constr_9033	[SWS_Rte_CONSTR_09033]	Rte_IrTrigger API may only be used by the runnable that describe its usage
constr_9000	[SWS_Rte_CONSTR_09000]	Rte_IFeedback API may only be used by the RunnableEntitys that describe its usage
constr_9034	[SWS_Rte_CONSTR_09034]	Rte_IsUpdated API may only be used by the runnable that describe the access to the corresponding data
constr_9045	[SWS_Rte_CONSTR_09045]	The upper two bits of the of the server return value are reserved
constr_9035	[SWS_Rte_CONSTR_09035]	Rte_Start shall be called only once
constr_9036	[SWS_Rte_CONSTR_09036]	Rte_Start API may only be used after call of SchM_Init
constr_9037	[SWS_Rte_CONSTR_09037]	Rte_Start API shall be called on every core
constr_9038	[SWS_Rte_CONSTR_09038]	Rte_Stop shall be called before BSW shutdown
constr_9039	[SWS_Rte_CONSTR_09039]	Rte_PartitionTerminated shall be called only once
constr_9040	[SWS_Rte_CONSTR_09040]	Rte_PartitionRestarting shall be called only onc
constr_9041	[SWS_Rte_CONSTR_09041]	Rte_RestartPartition shall be called from RestartTask
constr_9060	[SWS_Rte_CONSTR_09060]	Rte_Init API may only be used after call of Rte_Start

constr_9061	[SWS_Rte_CONSTR_09061]	Rte_StartTiming API may only be used after call of Rte_Start
constr_9059	[SWS_Rte_CONSTR_09059]	Usage of Basic Software Scheduler API prerequisites the include of the Module Interlink Header File
constr_9046	[SWS_Rte_CONSTR_09046]	SchM_Enter and SchM_Exit API may only be used by BswModuleEntitys describing its usage
constr_9047	[SWS_Rte_CONSTR_09047]	Nested call of SchM_Enter and SchM_Exit API is restricted
constr_9048	[SWS_Rte_CONSTR_09048]	SchM_Exit API may only be used by BswModuleEntitys that describe its usage
constr_9079	[SWS_Rte_CONSTR_09079]	SchM_Call API may only be used by the BswModuleEntity that describe its usage
constr_9076	[SWS_Rte_CONSTR_09076]	SchM_Result API may only be used by the BswModuleEntity that describe its usage
constr_9077	[SWS_Rte_CONSTR_09077]	SchM_Send API may only be used by the BswModuleEntity that describes its usage
constr_9078	[SWS_Rte_CONSTR_09078]	SchM_Receive API may only be used by the BswModuleEntity that describes its usage
constr_9049	[SWS_Rte_CONSTR_09049]	SchM_Switch API may only be used by BswModuleEntitys that describe its usage
constr_9050	[SWS_Rte_CONSTR_09050]	SchM_Mode API may only be used by BswModuleEntitys that describe its usage
constr_9051	[SWS_Rte_CONSTR_09051]	SchM_Mode API may only be used by BswModuleEntitys that describe its usage
constr_9052	[SWS_Rte_CONSTR_09052]	SchM_SwitchAck API may only be used by BswModuleEntitys that describe its usage
constr_9053	[SWS_Rte_CONSTR_09053]	SchM_Trigger API may only be used by the BswModuleEntitys that describe its usage
constr_9054	[SWS_Rte_CONSTR_09054]	SchM_ActMainFunction API may only be used by the BswModuleEntitys that describe its usage
constr_9058	[SWS_Rte_CONSTR_09058]	BswSchedulableEntity is not allowed to have service arguments or return value
constr_9055	[SWS_Rte_CONSTR_09055]	SchM_Init, SchM_Start, SchM_StartTiming shall be called only once
constr_9057	[SWS_Rte_CONSTR_09057]	SchM_Deinit shall be called before shut down of BSW
constr_9056	[SWS_Rte_CONSTR_09056]	SchM_Deinit API may only be used after the was RTE finalized
constr_9082	[SWS_Rte_CONSTR_09082]	RteEventToTaskMapping.RtePositionInTask and RteBswEventToTaskMapping.RteBswPositionInTask values shall be unique in a particular context
constr_3510	[SWS_Rte_CONSTR_03510]	Exclude usage of RteExclusiveAreaImplMechanism.OS_SPINLOCK in RteExclusiveAreaImplementation
constr_9091	[SWS_Rte_CONSTR_09091]	RteNvRamAllocation.RteSwNvRamMappingRef and RteNvRamAllocation.RteSwNvBlockDescriptorRef are excluding each other
constr_9005	[SWS_Rte_CONSTR_09005]	The references RteInternalTriggerConfig.RteSwcTriggerSourceRef has to be consistent with the RteSwComponentInstance.RteSoftwareComponentInstanceRef

constr_9006	[SWS_Rte_CONSTR_09006]	The references RteBswInternalTriggerConfig.RteBswTriggerSourceRef has to be consistent with the RteBswModuleInstance.RteBswImplementationRef
constr_9063	[SWS_Rte_CONSTR_09063]	Restricted kinds of RTEEvents which may mapped to RteInitializationRunnableBatch containers
constr_9064	[SWS_Rte_CONSTR_09064]	A single RteInitializationRunnableBatch container may not handle RTEEvents of different partitions
constr_9062	[SWS_Rte_CONSTR_09062]	Entire mapping of on-entry Runnable Entities for ModeDeclarationGroup.initialMode to RteInitializationRunnableBatch containers

Table G.11: Renamed Constraints in 4.3.0

G.8.5 Added Constraints in 4.3.0

none

G.8.6 Changed Constraints in 4.3.0

none

G.8.7 Deleted Constraints in 4.3.0

none

G.9 Changes in Rel. 4.3 Rev. 1 compared to Rel. 4.3 Rev. 0

G.9.1 Added Traceables in 4.3.1

[SWS_Rte_02310] [SWS_Rte_02311] [SWS_Rte_03608] [SWS_Rte_03609] [SWS_Rte_03610] [SWS_Rte_03869] [SWS_Rte_04552] [SWS_Rte_04553] [SWS_Rte_04554] [SWS_Rte_04555] [SWS_Rte_04556] [SWS_Rte_04557] [SWS_Rte_08802] [SWS_Rte_08803]

G.9.2 Changed Traceables in 4.3.1

[SWS_Rte_01058] [SWS_Rte_01060] [SWS_Rte_01061] [SWS_Rte_01064] [SWS_Rte_01065] [SWS_Rte_01106] [SWS_Rte_01238] [SWS_Rte_01239] [SWS_Rte_01248] [SWS_Rte_01317] [SWS_Rte_01339] [SWS_Rte_01379] [SWS_Rte_01389] [SWS_Rte_02568] [SWS_Rte_02571] [SWS_Rte_02594]

[SWS_Rte_02702] [SWS_Rte_02706] [SWS_Rte_02739] [SWS_Rte_02747] [SWS_Rte_02757] [SWS_Rte_03809] [SWS_Rte_03810] [SWS_Rte_03812] [SWS_Rte_03853] [SWS_Rte_03983] [SWS_Rte_04526] [SWS_Rte_05173] [SWS_Rte_06061] [SWS_Rte_06113] [SWS_Rte_06114] [SWS_Rte_06611] [SWS_Rte_06631] [SWS_Rte_06706] [SWS_Rte_06707] [SWS_Rte_06711] [SWS_Rte_06828] [SWS_Rte_07054] [SWS_Rte_07055] [SWS_Rte_07072] [SWS_Rte_07087] [SWS_Rte_07175] [SWS_Rte_07228] [SWS_Rte_07289] [SWS_Rte_07290] [SWS_Rte_07384] [SWS_Rte_07410] [SWS_Rte_07411] [SWS_Rte_07412] [SWS_Rte_07562] [SWS_Rte_07563] [SWS_Rte_07655] [SWS_Rte_07822] [SWS_Rte_07823] [SWS_Rte_08001] [SWS_Rte_08002] [SWS_Rte_08065] [SWS_Rte_08082] [SWS_Rte_08083] [SWS_Rte_08084] [SWS_Rte_08085] [SWS_Rte_08400] [SWS_Rte_08531] [SWS_Rte_08532] [SWS_Rte_08551] [SWS_Rte_08725] [SWS_Rte_08726]

G.9.3 Deleted Traceables in 4.3.1

[SWS_Rte_02579] [SWS_Rte_03714] [SWS_Rte_05111] [SWS_Rte_07132] [SWS_Rte_07676] [SWS_Rte_08533]

G.9.4 Added Constraints in 4.3.1

[SWS_Rte_CONSTR_03870]

G.9.5 Changed Constraints in 4.3.1

none

G.9.6 Deleted Constraints in 4.3.1

none

G.10 Changes in Rel. 4.4 Rev. 0 compared to Rel. 4.3 Rev. 1

G.10.1 Added Traceables in 4.4.0

[SWS_Rte_02312] [SWS_Rte_02313] [SWS_Rte_02314] [SWS_Rte_02315] [SWS_Rte_03611] [SWS_Rte_03612] [SWS_Rte_03613] [SWS_Rte_03614] [SWS_Rte_03615] [SWS_Rte_03616] [SWS_Rte_03617] [SWS_Rte_03618] [SWS_Rte_03871] [SWS_Rte_03872] [SWS_Rte_04558] [SWS_Rte_04559] [SWS_Rte_06832] [SWS_Rte_06833] [SWS_Rte_06834] [SWS_Rte_06835]

[SWS_Rte_06836] [SWS_Rte_06837] [SWS_Rte_06838] [SWS_Rte_06839]
[SWS_Rte_06840] [SWS_Rte_07421] [SWS_Rte_07422] [SWS_Rte_07423]
[SWS_Rte_07424] [SWS_Rte_07425] [SWS_Rte_07426] [SWS_Rte_07427]
[SWS_Rte_70000] [SWS_Rte_70001] [SWS_Rte_70002] [SWS_Rte_70003]
[SWS_Rte_70004] [SWS_Rte_70005] [SWS_Rte_70006] [SWS_Rte_70007]
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[SWS_Rte_70037] [SWS_Rte_70038] [SWS_Rte_70039] [SWS_Rte_70040]
[SWS_Rte_70042] [SWS_Rte_70043] [SWS_Rte_70044] [SWS_Rte_70045]
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[SWS_Rte_70062] [SWS_Rte_70063] [SWS_Rte_70064] [SWS_Rte_70065]
[SWS_Rte_70066] [SWS_Rte_70067] [SWS_Rte_70068] [SWS_Rte_70069]
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G.10.2 Changed Traceables in 4.4.0

[SWS_Rte_01003] [SWS_Rte_01016] [SWS_Rte_01055] [SWS_Rte_01058] [SWS_Rte_01060] [SWS_Rte_01061] [SWS_Rte_01064] [SWS_Rte_01065] [SWS_Rte_01071] [SWS_Rte_01072] [SWS_Rte_01083] [SWS_Rte_01084] [SWS_Rte_01086] [SWS_Rte_01091] [SWS_Rte_01092] [SWS_Rte_01093] [SWS_Rte_01094] [SWS_Rte_01095] [SWS_Rte_01102] [SWS_Rte_01104] [SWS_Rte_01105] [SWS_Rte_01106] [SWS_Rte_01107] [SWS_Rte_01111] [SWS_Rte_01112] [SWS_Rte_01113] [SWS_Rte_01114] [SWS_Rte_01118] [SWS_Rte_01120] [SWS_Rte_01123] [SWS_Rte_01126] [SWS_Rte_01130] [SWS_Rte_01132] [SWS_Rte_01150] [SWS_Rte_01157] [SWS_Rte_01158] [SWS_Rte_01161] [SWS_Rte_01162] [SWS_Rte_01164] [SWS_Rte_01166] [SWS_Rte_01169] [SWS_Rte_01171] [SWS_Rte_01206] [SWS_Rte_01207] [SWS_Rte_01236] [SWS_Rte_01238] [SWS_Rte_01239] [SWS_Rte_01240] [SWS_Rte_01241] [SWS_Rte_01242] [SWS_Rte_01243] [SWS_Rte_01244] [SWS_Rte_01245] [SWS_Rte_01246] [SWS_Rte_01247] [SWS_Rte_01248] [SWS_Rte_01249] [SWS_Rte_01250] [SWS_Rte_01252] [SWS_Rte_01257] [SWS_Rte_01259] [SWS_Rte_01260] [SWS_Rte_01261] [SWS_Rte_01262] [SWS_Rte_01269] [SWS_Rte_01279] [SWS_Rte_01317] [SWS_Rte_01318] [SWS_Rte_01321] [SWS_Rte_01322] [SWS_Rte_01323] [SWS_Rte_01324] [SWS_Rte_01325] [SWS_Rte_01330] [SWS_Rte_01331] [SWS_Rte_01332] [SWS_Rte_01333] [SWS_Rte_01334] [SWS_Rte_01339] [SWS_Rte_01342] [SWS_Rte_01343] [SWS_Rte_01344] [SWS_Rte_01350] [SWS_Rte_01354] [SWS_Rte_01363] [SWS_Rte_01364] [SWS_Rte_01365] [SWS_Rte_01371] [SWS_Rte_01372] [SWS_Rte_01376] [SWS_Rte_01379] [SWS_Rte_01388] [SWS_Rte_01389] [SWS_Rte_01390] [SWS_Rte_01391] [SWS_Rte_01392] [SWS_Rte_01393] [SWS_Rte_01395] [SWS_Rte_01396] [SWS_Rte_01397] [SWS_Rte_01398] [SWS_Rte_01399] [SWS_Rte_01400] [SWS_Rte_01401] [SWS_Rte_01402] [SWS_Rte_01403] [SWS_Rte_01404] [SWS_Rte_01405] [SWS_Rte_01406] [SWS_Rte_01407] [SWS_Rte_01408] [SWS_Rte_01409] [SWS_Rte_01410] [SWS_Rte_01411] [SWS_Rte_01412] [SWS_Rte_02301]

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[SWS_Rte_08787] [SWS_Rte_08789] [SWS_Rte_08790] [SWS_Rte_08795] [SWS_Rte_08802] [SWS_Rte_08803]

G.10.3 Deleted Traceables in 4.4.0

[SWS_Rte_05193] [SWS_Rte_07025] [SWS_Rte_08306] [SWS_Rte_08307] [SWS_Rte_08308]

G.10.4 Added Constraints in 4.4.0

[SWS_Rte_CONSTR_03873] [SWS_Rte_CONSTR_03874] [SWS_Rte_CONSTR_04558] [SWS_Rte_CONSTR_04559] [SWS_Rte_CONSTR_09100] [SWS_Rte_CONSTR_09101] [SWS_Rte_CONSTR_09102] [SWS_Rte_CONSTR_80000] [SWS_Rte_CONSTR_80001] [SWS_Rte_CONSTR_80002] [SWS_Rte_CONSTR_80003] [SWS_Rte_CONSTR_80004] [SWS_Rte_CONSTR_80005] [SWS_Rte_CONSTR_80006] [SWS_Rte_CONSTR_80007] [SWS_Rte_CONSTR_80009] [SWS_Rte_CONSTR_80010] [SWS_Rte_CONSTR_80011] [SWS_Rte_CONSTR_80012] [SWS_Rte_CONSTR_80013] [SWS_Rte_CONSTR_80014] [SWS_Rte_CONSTR_80015] [SWS_Rte_CONSTR_80016] [SWS_Rte_CONSTR_80017]

G.10.5 Changed Constraints in 4.4.0

[SWS_Rte_CONSTR_09058] [SWS_Rte_CONSTR_09082]

G.10.6 Deleted Constraints in 4.4.0

none