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1 Scope of Document

The purpose of this document is to define the functional and non-functional requirements of the Time Synchronization module. The Time Synchronization module (from now referred to as TS) provides Synchronized Time Bases to its customers.

The TS is located in the service layer of the AUTOSAR ECU SW Architecture as defined in [4].

2 Conventions to be used

The representation of requirements in AUTOSAR documents follows the table specified in [TPS_STDT_00078], see Standardization Template [1], chapter Support for Traceability.

The verbal forms for the expression of obligation specified in [TPS_STDT_00053] shall be used to indicate requirements, see Standardization Template [1], chapter Support for Traceability.

3 Acronyms and abbreviations

The glossary below includes acronyms and abbreviations relevant to RS_TimeSync that are not included in the AUTOSAR Glossary [2].

Abbreviation / Acronym:	Description:
TS	Time Synchronization
TSP	A bus specific Time Synchronization Provider
OS	Operating System
GPT	General Purpose Timer
HW	Hardware

Table 3.1: Acronyms and Abbreviations

4 Requirements Specification

This chapter describes all requirements driving the work to define the TS Specification.

4.1 Functional Overview

The TS itself does not provide means like network time protocols or time agreement protocols to synchronize its local Time Bases to Time Bases on other nodes. It interacts

with the TSP modules to achieve such synchronization. Those modules take the role of a Time Base Provider and support above mentioned time protocols.

With the information retrieved from the TSP modules, the TS is able to synchronize its Time Bases against Time Bases on other nodes.

Adaptive modules as well as Adaptive Applications which take the role of a customer, consume the time information provided and managed by the TS by autonomously interacting with it to read the time information. Adaptive Applications, when in charge of providing time information, can also interact with the TS to update the timebase maintained by the TS module according to such application's information.

Thus, the TS acts as time base broker by offering the customers access to Synchronized Time Bases. By doing so, the TS abstracts from the "real" Time Base provider (i.e. TSP module).

4.2 Functional Requirements

[RS_TS_00001] The configuration shall allow the TS module to support different roles for a Time Base [

Type:	valid
Description:	The TS configuration shall allow the TS to fulfill different roles (i.e. Time Master, Time Slave) with respect to Global (vehicle wide) TS.
Rationale:	Support of specific communication port role in a given Time Domain
Dependencies:	–
Use Case:	–
Supporting Material:	–

]([RS_Main_00340](#))

[RS_TS_00002] The TS instance, independently of the Role it is acting like, shall always maintain its own Time Base [

Type:	valid
Description:	The TS shall always maintain the Time Base, by using different HW clock references (i.e. OS counter, GPT, Ethernet HW clock, etc.). The configuration depends on the capabilities of the HW and whether specific Role of the TS is enabled / disabled.
Rationale:	Time Base is managed by only one instance within the Global Time cluster.
Dependencies:	–
Use Case:	–
Supporting Material:	–

]([RS_Main_00340](#))

[RS_TS_00003] The TS shall initialize the Local Time Base with zero at startup [

Type:	valid
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Description:	The TS shall initialize the Local Time Base with zero at startup.
Rationale:	Startup with a known default value.
Dependencies:	–
Use Case:	–
Supporting Material:	–

]([RS_Main_00340](#))

[RS_TS_00004] The TS shall initialize the Global Time Base with a configurable startup value. [

Type:	valid
Description:	The TS shall allow configuration of the initialization value of the Global Time Base. The initialization value can be either: - a value from static configuration - a value from non-volatile memory
Rationale:	Startup with a dedicated Time Base value. Resume of time freeze.
Dependencies:	–
Use Case:	–
Supporting Material:	–

]([RS_Main_00340](#))

[RS_TS_00005] The TS shall allow customers to have access to the Synchronized Time Base [

Type:	valid
Description:	The TS shall allow active customers to have access to the Synchronized Time Base. The TS shall provide an interface for customers to access the Synchronized Time Base, i.e., to read the current time and the status of the Time Base (i.e. quality characteristics of the Time Base or Clock, like whether or not it is already externally Synchronized, if it presents leap jumps into the Future/Past, rate deviation, etc.). The customers shall always access a Synchronize Time Base via the TS.
Rationale:	The TS offers the possibility to the customers to access the definition of time if required.
Dependencies:	–
Use Case:	An Adaptive Application wants to know the current definition of time in order to perform a task in a synchronically way to other tasks of other ECUs or Software Components.
Supporting Material:	–

]([RS_Main_00060](#), [RS_Main_00340](#))

[RS_TS_00006] The TS shall provide time information to TSP modules [

Type:	valid
Description:	The TS shall allow the "Time Synchronization Provider" modules to have access to the time information managed by the TS module.

Rationale:	Separation of concerns: The TS does not provide its own time agreement protocol / network time protocol. The TS leaves this to the TSP modules. However, for the time agreement protocol / network time protocol the TSP modules depend on time information managed by the TS.
Dependencies:	–
Use Case:	
Supporting Material:	–

]([RS_Main_00400](#), [RS_Main_00340](#))

[RS_TS_00007] The TS shall synchronize the time base of a Time Slave, on reception of a Time Master value [

Type:	valid
Description:	If configured as Time Slave for a Time Base, the TS shall synchronize its Local Time Base against the Global Time provided by the TSP module each time a valid Time Base value from the latter is received. A valid Global Time Base value replaces the value of the Local Time Base.
Rationale:	Rapid time synchronization and correction
Dependencies:	–
Use Case:	
Supporting Material:	–

]([RS_Main_00340](#))

[RS_TS_00008] The TS shall continuously maintain its Time Bases based on a Time Base reference clock [

Type:	valid
Description:	The TS shall maintain its Time Bases based on a local reference clock. As an example, reference clocks to which the TS could access, could be: * OS counter * GPT * Ethernet HW clock
Rationale:	- Time Base is managed by only one instance within the Global Time cluster. - Availability of time information. Even if synchronization fails on the bus (for a Time Slave), the module is still able to provide a time value.
Dependencies:	–
Use Case:	
Supporting Material:	–

]([RS_Main_00340](#))

[RS_TS_00009] The TS shall maintain the synchronization status of a Time Base [

Type:	valid
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Description:	The TS shall maintain the synchronization status of a Time Base autonomously. Synchronization status refer to the information regarding leap jumps into the Future/Past, whether or not has the time base been synchronized against an external source, daylight settings, etc.
Rationale:	Allows Time Base qualification.
Dependencies:	–
Use Case:	
Supporting Material:	–

]([RS_Main_00340](#))

[RS_TS_00010] The TS shall allow customer on master side to set the Global Time [

Type:	valid
Description:	If configured as Time Master the TS shall allow the customer to set the Global Time Base.
Rationale:	Allows Global Time Base adjustment
Dependencies:	–
Use Case:	
Supporting Material:	–

]([RS_Main_00400](#), [RS_Main_00060](#), [RS_Main_00340](#))

[RS_TS_00011] The TS shall allow customers on master side to trigger time transmission by the TSP module [

Type:	valid
Description:	If configured as Time Master the TS shall allow the customer to trigger time transmission by the TSP modules immediately. That is, the TSP modules shall not wait for the next cyclic transmission, but force immediate transmission.
Rationale:	Allows faster re-synchronization.
Dependencies:	–
Use Case:	
Supporting Material:	–

]([RS_Main_00400](#), [RS_Main_00060](#), [RS_Main_00340](#))

[RS_TS_00012] The TS shall allow customers and TSP modules to read the offset value of an Offset Time Base [

Type:	valid
Description:	The TS shall allow TSP modules to read the offset value of an Offset Time Base.
Rationale:	Allows usage of Offset Time Base.
Dependencies:	–
Use Case:	
Supporting Material:	–

]([RS_Main_00400](#), [RS_Main_00340](#))

[RS_TS_00013] The TS shall allow the customers and TSP modules to set the offset value of an Offset Master Time Base [

Type:	valid
Description:	If configured as Time Master, the TS shall allow customers and/or TSP modules to set the offset value of a Time Base.
Rationale:	Allows usage of Offset Time Base as Timer Master.
Dependencies:	–
Use Case:	
Supporting Material:	–

]([RS_Main_00400](#), [RS_Main_00060](#), [RS_Main_00340](#))

[RS_TS_00014] The TS shall allow customers to read User Data propagated via the TSP modules. [

Type:	valid
Description:	The TS shall allow customers to read User Data propagated via the TSP modules. User Data can be used to characterize the Time Base, e.g., regarding the quality of the underlying clock source or regarding the progress of time.
Rationale:	Allows usage of User Data as Time Slave.
Dependencies:	–
Use Case:	
Supporting Material:	–

]([RS_Main_00400](#), [RS_Main_00060](#), [RS_Main_00340](#))

[RS_TS_00015] The TS shall allow customers to set User Data propagated via the TSP modules. [

Type:	valid
Description:	If configured as Time Master the TS shall allow customers to set User Data propagated via the TSP modules. User Data can be used to characterize the Time Base, e.g., regarding the quality of the underlying clock source or regarding the progress of time.
Rationale:	Allows usage of User Data as Time Master.
Dependencies:	–
Use Case:	
Supporting Material:	–

]([RS_Main_00400](#), [RS_Main_00060](#), [RS_Main_00340](#))

[RS_TS_00016] The TS shall notify customers about status events [

Type:	valid
Description:	The TS shall notify customers (Event Notification Customers) about Time Base related status events.
Rationale:	Immediate information about status change to avoid unnecessary polling.
Dependencies:	–

Use Case:	Status update to application, on (re-)synchronization by TSP modules.
Supporting Material:	–

](RS_Main_00340)

[RS_TS_00017] The TS shall notify customers about elapsed pre-defined time span. [

Type:	valid
Description:	The TS shall notify customers, when a time span (relative to a given Time Base and previously defined/set by the customer) has elapsed.
Rationale:	Immediate information, when a given time span has elapsed to avoid unnecessary polling.
Dependencies:	–
Use Case:	Synchronization of actions over the whole network (i.e., Turning different lights on or off at a specific time).
Supporting Material:	–

](RS_Main_00340)

[RS_TS_00018] The TS shall support rate correction [

Type:	valid
Description:	The TS shall support rate measurement and rate correction for Time Bases.
Rationale:	The precision of Time Bases is improved if the rate deviation (due to clock deviations) between Time Slaves and the Global Time Masters is measured and corrected.
Dependencies:	–
Use Case:	
Supporting Material:	–

](RS_Main_00340)

[RS_TS_00019] The TS shall support damping offset correction [

Type:	valid
Description:	The TS shall support smooth offset correction by applying additional rate correction.
Rationale:	Leaps within the Local Time Base are avoided after resynchronization if the offset between the current value of the Local Time Base and the received value of the Global Time Base is removed smoothly by adding an additional rate correction term instead of applying a hard leap to the Local Time Base.
Dependencies:	–
Use Case:	
Supporting Material:	–

](RS_Main_00340)

[RS_TS_00020] TS shall synchronize with the time clock master over Ethernet [

Type:	valid
Description:	TS shall synchronize with the real-time clock master over Ethernet
Rationale:	To make sure that a correlation in time between different data flows and events is possible at a System wide scope, the different ECUs and SW Components need to be synchronized (in terms of Time) against a same common Time Base source.
Dependencies:	–
Use Case:	As an Adaptive Application developer I want to have shared common time base over the Ethernet in order to allow calculations based on sensor-data from different sources within a car.
Supporting Material:	–

]([RS_Main_00340](#))

[RS_TS_00021] The TS shall provide interfaces to query the synchronization status [

Type:	valid
Description:	The TS shall provide interfaces to query the synchronization status.
Rationale:	To avoid that other components are affected by unsynchronized time information, the synchronicity of the clocks is available and identifiable by the customer.
Dependencies:	–
Use Case:	
Supporting Material:	–

]([RS_Main_00060](#), [RS_Main_00340](#))

[RS_TS_00022] The TS shall support custom clocks [

Type:	valid
Description:	TS shall support custom clocks.
Rationale:	It is desired, to have a provision of multiple clocks based on the same tick source, but with different epochs in order to maintain limited quantity of sources of electrical impulses.
Dependencies:	–
Use Case:	
Supporting Material:	–

]([RS_Main_00340](#), [RS_Main_00340](#))

[RS_TS_00023] The TS shall offer interfaces able to handle std::chrono data types. [

Type:	valid
Description:	The TS shall not only offer interfaces which are able to both accept and return std::chrono data types, but shall also internally work with these data types.

Rationale:	To avoid the possibility, either by mistake or intentionally, of having an implementation trying to compare, add or subtract time_point values between different Roles (i.e. Time Master, Time Slaves, etc.), type safety of clocks are needed so these and other arithmetic operations are possible only between time_points of the same clock.
Dependencies:	–
Use Case:	As an Adaptive Application developer, it is wished to have type safe way of handling different values of time in order to perform arithmetic operations on them.
Supporting Material:	–

](RS_Main_00513)

[RS_TS_00024] The TS shall support storage of the Time Base value at shutdown if configured as Time Master [

Type:	valid
Description:	If configured as Time Master, the TS shall support storage of the last Global Time value to non-volatile memory at shutdown.
Rationale:	Startup with a dedicated Time Base value. Support of time freeze.
Dependencies:	–
Use Case:	
Supporting Material:	–

](RS_Main_00340)

[RS_TS_00025] The TS shall provide fault detection mechanisms [

Type:	valid
Description:	The TS shall provide fault detection mechanisms. It must detect the following state changes: * Loss/Re-Establishment of Synchronized Time Bases * Errors during customer / provider call
Rationale:	Part of the vehicle dynamic subsystem must guarantee a concurrent execution of their distributed functionality. If a synchronization loss is detected, the subsystem must trigger appropriate counteractions.
Dependencies:	–
Use Case:	
Supporting Material:	–

](RS_Main_00340)

[RS_TS_00026] The TS shall provide to the customers a specific API per type of Time Base Resource [

Type:	valid
Description:	The TS shall provide a different and specific API for each type of Time Base Resource

Rationale:	The customer will be provided with a specific API which sets the boundaries of the possible interaction with the Time Base according to its type of Time Base Resource. In this way, the customer cannot try to interact with the Time Base as if it were i.e. a Master Time Base, when it is actually a Slave Time Base.
Dependencies:	–
Use Case:	
Supporting Material:	–

](RS_Main_00340)

4.3 Non-Functional Requirements (Qualities)

[SRS_TS_00027] The TS shall provide a bus independent customer interface [

Type:	valid
Description:	The TS shall provide a bus independent customer interface and time format. The resolution of the received Time Base might vary depending on the origin bus. In such cases, the TS adjusts the time value property. If the ECU is configured as Time Master, reading the Time Base value is furthermore possible.
Rationale:	Hide bus / physical layer specific details to decouple applicaiton / customers from the lower layers.
Dependencies:	The TSP modules will do the conversion to a bus independent time format.
Use Case:	
Supporting Material:	–

](RS_Main_00060)

5 Requirements Tracing

The following table references the features specified in [3] and links to the fulfillments of these.

Feature	Description	Satisfied by
[RS_Main_00060]	AUTOSAR shall provide a standardized software interface for communication between Applications	[RS_TS_00005] [RS_TS_00010] [RS_TS_00011] [RS_TS_00013] [RS_TS_00014] [RS_TS_00015] [RS_TS_00021] [SRS_TS_00027]

[RS_Main_00340]	AUTOSAR shall support the observance of timing requirements	[RS_TS_00001] [RS_TS_00002] [RS_TS_00003] [RS_TS_00004] [RS_TS_00005] [RS_TS_00006] [RS_TS_00007] [RS_TS_00008] [RS_TS_00009] [RS_TS_00010] [RS_TS_00011] [RS_TS_00012] [RS_TS_00013] [RS_TS_00014] [RS_TS_00015] [RS_TS_00016] [RS_TS_00017] [RS_TS_00018] [RS_TS_00019] [RS_TS_00020] [RS_TS_00021] [RS_TS_00022] [RS_TS_00022] [RS_TS_00024] [RS_TS_00025] [RS_TS_00026]
[RS_Main_00400]	AUTOSAR shall provide a layered software architecture	[RS_TS_00006] [RS_TS_00010] [RS_TS_00011] [RS_TS_00012] [RS_TS_00013] [RS_TS_00014] [RS_TS_00015]
[RS_Main_00513]	AUTOSAR shall support language bindings for different programming languages	[RS_TS_00023]

6 References

- [1] System Template
 AUTOSAR_TPS_SystemTemplate
- [2] Glossary
 AUTOSAR_TR_Glossary
- [3] Main Requirements
 AUTOSAR_RS_Main