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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 Protocol.

The specification status is set to "draft" in release 1.5.0.

# 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 <Document Name> that are not included in the AUTOSAR Glossary [2].

Abbreviation / Acronym:	Description:
(G)TD	(Global) Time Domain
(G)TM	(Global)Time Master
<Bus>TSyn	A bus specific Time Synchronization module
AVB	Audio Video Bridging
BMCA	Best Master Clock Algorithm
CID	Company ID (IEEE)
CRC	Cyclic Redundancy Checksum
Debounce Time	Minimum gap between two Tx messages with the same PDU.
ETH	Ethernet
EthTSyn	Time Synchronization Provider module for Ethernet
Follow_Up	Time transport message (Follow-Up)
GM(C)	Grand Master (Clock)
OFS	Offset synchronization
Pdelay	Propagation / path delay as given in IEEE 802.1AS
Pdelay_Req	Propagation / path delay request message
Pdelay_Resp	Propagation / path delay response message
Pdelay_Resp_Follow_Up	Propagation / path delay Follow-Up message
PDU	Protocol Data Unit
PTP	Precision Time Protocol
StbM	(Global) Time Domain
Timesync	Time Synchronization
Sync	Time synchronization message (Sync)
TG	Time Gateway
TLV	Type, Length, Value field (acc. to IEEE 802.1AS)

Abbreviation / Acronym:	Description:
TS	Time Slave
TSD	Time Sub-domain
VLAN	Virtual Local Area Network
TSP	Time Synchronization Provider

## 4 Requirements Specification

### 4.1 Functional Overview

The Time Synchronization Implementation provides means like network time protocols or time agreement protocols to synchronize its local Time Bases to Time Bases on other nodes.

Modules and applications can consume the time information provided and managed by the Time Synchronization Implementation by reading the time information. Modules and applications, when required to provide time information, can update the Time Base maintained by the Time Synchronization Implementation

This specification contains time synchronization requirements for classic and adaptive platform. The classic platform splits the implementation of Time Synchronization into 3 bus protocol specific Time Synchronization Provider (TSP) modules (SWS Time Synchronization over Ethernet, over CAN and over FlexRay) and one module, which manages the Time Bases (SWS Synchronized Time-Base Manager). The adaptive platform defines only one module for Time Synchronization (SWS TimeSync), which also includes the Time Synchronization Provider (TSP) part.

### 4.2 Functional Requirements

#### 4.2.1 Common Requirements

**[RS\_TS\_00002] The Implementation of Time Synchronization, independently of the Role it is acting as, shall always maintain its own Time Base** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization 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 Implementation of Time Synchronization is enabled / disabled.
<b>Rationale:</b>	Time Base is managed by only one instance within the Global Time cluster.



△

<b>Dependencies:</b>	–
<b>Use Case:</b>	–
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00340](#))

**[RS\_TS\_00003] The Implementation of Time Synchronization shall initialize the Local Time Base with zero at startup** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization shall initialize the Local Time Base with zero at startup.
<b>Rationale:</b>	Start up with a known default value.
<b>Dependencies:</b>	–
<b>Use Case:</b>	–
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00340](#))

**[RS\_TS\_00004] The Implementation of Time Synchronization shall initialize the Global Time Base with a configurable startup value.** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization 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
<b>Rationale:</b>	Start up with a dedicated Time Base value. Resume of time freeze.
<b>Dependencies:</b>	–
<b>Use Case:</b>	–
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00340](#))

**[RS\_TS\_00005] The Implementation of Time Synchronization shall allow customers to have access to the Synchronized Time Base** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization shall allow active customers to have access to the Synchronized Time Base. The Implementation of Time Synchronization 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 Implementation of Time Synchronization.
<b>Rationale:</b>	The Implementation of Time Synchronization offers the possibility to the customers to access the definition of time if required.
<b>Dependencies:</b>	–
<b>Use Case:</b>	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.
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00060](#), [RS\\_Main\\_00340](#))

**[RS\_TS\_00006] The Implementation of Time Synchronization shall provide time information to TSP modules** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization shall allow the "Time Synchronization Provider" modules to have access to the time information managed by the Implementation of Time Synchronization module.
<b>Rationale:</b>	Separation of concerns: The Implementation of Time Synchronization does not provide its own time agreement protocol / network time protocol. The Implementation of Time Synchronization 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 Implementation of Time Synchronization.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00400](#), [RS\\_Main\\_00340](#))

**[RS\_TS\_00007] The Implementation of Time Synchronization shall synchronize the Time Base of a Time Slave, on reception of a Time Master value** [

<b>Type:</b>	valid
<b>Description:</b>	If configured as Time Slave for a Time Base, the Implementation of Time Synchronization 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.
<b>Rationale:</b>	Rapid time synchronization and correction
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00340](#))

**[RS\_TS\_00008] The Implementation of Time Synchronization shall continuously maintain its Time Bases based on a Time Base reference clock [**

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization shall maintain its Time Bases based on a local reference clock.  As an example, reference clocks to which the Implementation of Time Synchronization could access, could be: -OS counter -GPT -Ethernet HW clock
<b>Rationale:</b>	- 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.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00340](#))

**[RS\_TS\_00009] The Implementation of Time Synchronization shall maintain the synchronization status of a Time Base [**



<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization 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.
<b>Rationale:</b>	Allows Time Base qualification.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00340](#))

**[RS\_TS\_00010] The Implementation of Time Synchronization shall allow customer on master side to set the Global Time** [

<b>Type:</b>	valid
<b>Description:</b>	If configured as Time Master, the Implementation of Time Synchronization shall allow the customer to set the Global Time Base.
<b>Rationale:</b>	Allows Global Time Base adjustment
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00400](#), [RS\\_Main\\_00060](#), [RS\\_Main\\_00340](#))

**[RS\_TS\_00011] The Implementation of Time Synchronization shall allow customers on master side to trigger time transmission by the TSP module** [

<b>Type:</b>	valid
<b>Description:</b>	If configured as Time Master, the Implementation of Time Synchronization 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.
<b>Rationale:</b>	Allows faster re-synchronization.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00400](#), [RS\\_Main\\_00060](#), [RS\\_Main\\_00340](#))

**[RS\_TS\_00012] The Implementation of Time Synchronization shall allow customers and TSP modules to read the offset value of an Offset Time Base [**

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization shall allow TSP modules to read the offset value of an Offset Time Base.
<b>Rationale:</b>	Allows usage of Offset Time Base.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00400](#), [RS\\_Main\\_00340](#))

**[RS\_TS\_00013] The Implementation of Time Synchronization shall allow the customers and TSP modules to set the offset value of an Offset Master Time Base [**

<b>Type:</b>	valid
<b>Description:</b>	If configured as Time Master, the Implementation of Time Synchronization shall allow customers and/or TSP modules to set the offset value of a Time Base.
<b>Rationale:</b>	Allows usage of Offset Time Base as Time Master.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00400](#), [RS\\_Main\\_00060](#), [RS\\_Main\\_00340](#))

**[RS\_TS\_00014] The Implementation of Time Synchronization shall allow customers to read User Data propagated via the TSP modules. [**

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization 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.
<b>Rationale:</b>	Allows usage of User Data as Time Slave.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–





<b>AppliesTo:</b>	CP, AP
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]([RS\\_Main\\_00400](#), [RS\\_Main\\_00060](#), [RS\\_Main\\_00340](#))

**[RS\_TS\_00015] The Implementation of Time Synchronization shall allow customers to set User Data propagated via the TSP modules.** [

<b>Type:</b>	valid
<b>Description:</b>	If configured as Time Master the Implementation of Time Synchronization 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.
<b>Rationale:</b>	Allows usage of User Data as Time Master.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00400](#), [RS\\_Main\\_00060](#), [RS\\_Main\\_00340](#))

**[RS\_TS\_00016] The Implementation of Time Synchronization shall notify customers about status events** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization shall notify customers (Event Notification Customers) about Time Base related status events.
<b>Rationale:</b>	Immediate information about status change to avoid unnecessary polling.
<b>Dependencies:</b>	–
<b>Use Case:</b>	Status update to application, on (re-)synchronization by TSP modules.
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00340](#))

**[RS\_TS\_00017] The Implementation of Time Synchronization shall notify customers about elapsed pre-defined time span.** [

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

]([RS\\_Main\\_00340](#))

**[RS\_TS\_00018] The Implementation of Time Synchronization shall support rate correction** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization shall support rate measurement and rate correction for Time Bases.
<b>Rationale:</b>	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.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00340](#))

**[RS\_TS\_00019] The Implementation of Time Synchronization shall support damping offset correction** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization shall support smooth offset correction by applying additional rate correction.
<b>Rationale:</b>	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.
<b>Dependencies:</b>	–
<b>Use Case:</b>	



△

<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00340](#))

**[RS\_TS\_00021] The Implementation of Time Synchronization shall provide interfaces to query the synchronization status** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization shall provide interfaces to query the synchronization status.
<b>Rationale:</b>	To avoid that other components are affected by unsynchronized time information, the synchronicity of the clocks is available and identifiable by the customer.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]([RS\\_Main\\_00060](#), [RS\\_Main\\_00340](#))

**[RS\_TS\_00022] The Implementation of Time Synchronization shall support custom clocks** [

<b>Type:</b>	valid
<b>Description:</b>	Implementation of Time Synchronization shall support custom clocks.
<b>Rationale:</b>	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.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	AP

]([RS\\_Main\\_00340](#), [RS\\_Main\\_00340](#))

**[RS\_TS\_00023] The Implementation of Time Synchronization shall offer interfaces able to handle std::chrono data types.** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization 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.
<b>Rationale:</b>	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.
<b>Dependencies:</b>	–
<b>Use Case:</b>	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.
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	AP

]([RS\\_Main\\_00513](#))

**[RS\_TS\_00024] The Implementation of Time Synchronization shall support storage of the Time Base value at shutdown if configured as Time Master** [

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

]([RS\\_Main\\_00340](#))

**[RS\_TS\_00025] The Implementation of Time Synchronization shall provide fault detection mechanisms** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization shall provide fault detection mechanisms. It must detect the following state changes: <ul style="list-style-type: none"> <li>- Loss/Re-Establishment of Synchronized Time Bases</li> <li>- Errors during customer / provider call</li> </ul>





<b>Rationale:</b>	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.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

](RS\_Main\_00340)

**[RS\_TS\_00026] The Implementation of Time Synchronization shall provide to the customers a specific API per type of Time Base Resource** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization shall provide a different and specific API for each type of Time Base Resource.
<b>Rationale:</b>	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.
<b>Dependencies:</b>	–
<b>Use Case:</b>	–
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

](RS\_Main\_00340)

**[RS\_TS\_20001] The configuration of the Time Synchronization implementation shall allow the interaction with different types of customers** [

<b>Type:</b>	valid
<b>Description:</b>	The configuration of Time Synchronization Implementation shall allow the interaction with different types of customers. The Synchronized Time-Base Manager is a service that should provide a time base (if requested) in such a way : a) it triggers interfaced SW-C and BSW (this functionality is currently limited to OS Schedule Tables) b) it provides the time base on demand when the customer asks for it c) it notifies customers on time base related events The customer shall have the possibility to choose the desired interaction with the Synchronized Time-Base Manager.
<b>Rationale:</b>	Allows usage of Offset Time Base as Time Master.
<b>Dependencies:</b>	–



△

<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_00029] The configuration of the Time Synchronization implementation shall allow the implementation to behave as a (vehicle wide) Time Master [**

<b>Type:</b>	valid
<b>Description:</b>	Per supported Time Base the configuration of the Time Synchronization Implementation shall allow to enable / disable the functionality of a (vehicle wide) Time Master with respect to Global Time Synchronization.
<b>Rationale:</b>	Support of specific communication port role in a given Time Domain.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

**[RS\_TS\_00030] The configuration of the Time Synchronization implementation shall allow the implementation to behave as a Time Slave [**

<b>Type:</b>	valid
<b>Description:</b>	Per supported Time Base the configuration of the Time Synchronization Implementation shall allow to enable / disable the functionality of a Time Slave with respect to Global Time Synchronization.
<b>Rationale:</b>	Support of specific communication port role in a given Time Domain.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

**[RS\_TS\_00031] The configuration of the Time Synchronization implementation shall allow the implementation to behave as a Time Gateway [**



<b>Type:</b>	valid
<b>Description:</b>	If configured as Time Gateway, the TBM shall route Time Base information from one vehicle network to another one. That means, the a Time Sync Module on one vehicle network is configured as slave and another Time Sync Module on the other network is configured as master. The Time Base Manager shall forward the Time Base information from the slave to the master.
<b>Rationale:</b>	Support of specific communication port role in a given Time Domain.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_00032] The Implementation of Time Synchronization shall trigger registered customers** [

<b>Type:</b>	valid
<b>Description:</b>	If OS is configured as triggered customer, the Synchronized Time-Base Manager shall periodically synchronize the corresponding schedule table(s) to the configured Time Bases.
<b>Rationale:</b>	Allows Global Time Base adjustment
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_00033] The Implementation of Time Synchronization shall use a time format with a resolution of 1 ns** [

<b>Type:</b>	valid
<b>Description:</b>	<p>The Implementation of Time Synchronization shall use independently of the Timesync modules the same time format, which is compatible to IEEE 802.1AS and allows for a resolution of 1ns.</p> <p><b>Note:</b> The actual resolution of the time value for a Time Base depends on the Timesync module capabilities. The Implementation of Time Synchronization adjusts the time value as needed.</p> <p><b>Note:</b> Some Timesync modules transmit time formats with 4 instead of 6 bytes for the seconds part of the time.</p>



△

<b>Rationale:</b>	Time Base harmonization between all buses regarding design of Global / Local Time Base.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_00034] The Implementation of Time Synchronization shall provide measurement data to the application** [

<b>Type:</b>	valid
<b>Description:</b>	To verify the precision of each Local Time Base compared to the Global Time Base, the Implementation of Time Synchronization shall provide a recording mechanism of Time Base relevant data for Time Slaves.
<b>Rationale:</b>	During development measurement support is required to validate the precision of Time Bases.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_00035] The Implementation of Time Synchronization shall provide a system service interface to applications** [

<b>Type:</b>	valid
<b>Description:</b>	The Synchronized Time-Base Manager shall be located in the AUTOSAR Service Layer and provide its services to customers in the application and in the BSW. It provides its services via a Standardized AUTOSAR Interface to customers in the application and via a standardized C-API to customers in the BSW.
<b>Rationale:</b>	A Synchronized Time is required by customers in application and in the BSW.
<b>Dependencies:</b>	–
<b>Use Case:</b>	An application SW-C wants to get informed about the current value of a Time Base
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_00036] The Implementation of Time Synchronization shall provide a bus independent customer interface** [

<b>Type:</b>	valid
<b>Description:</b>	The Implementation of Time Synchronization shall provide a bus independent customer interface and time format. The resolution of the received Time Base might be vary depending on the origin bus. In such cases, the Implementation of Time Synchronization adjusts the time value properly.
<b>Rationale:</b>	Hide bus / physical layer specific details to decouple application/ customers from the lower layers
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

#### 4.2.2 Time Synchronization over Ethernet

**[RS\_TS\_20047] The Timesync over Ethernet module shall trigger Time Base Synchronization transmission** [

<b>Type:</b>	valid
<b>Description:</b>	If configured as Time Master for a time base the Timesync over Ethernet module shall support two ways to trigger the transmission of the Time Synchronization protocol sequence: <ul style="list-style-type: none"> <li>• Cyclic triggering</li> <li>• Immediate triggering on demand</li> </ul>
<b>Rationale:</b>	Time Synchronization protocol.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

**[RS\_TS\_20048] The Timesync over Ethernet module shall support IEEE 802.1AS as well as AUTOSAR extensions** [

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over Ethernet module shall support IEEE 802.1AS [6], chapter 11 in terms of Sync, Follow_Up (time synchronization) and Pdelay_Req, Pdelay_Resp, Pdelay_Resp_Follow_Up (delay measurement) as well as AUTOSAR extensions belonging to the Addressing scheme and message format.
<b>Rationale:</b>	Time Synchronization protocol.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

**[RS\_TS\_20066] The Timesync over Ethernet module shall support a static (pre)configuration of IEEE 802.1AS Pdelay** [

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over Ethernet module shall support a static (pre)configuration of IEEE 802.1AS Pdelay values as alternative to the Pdelay measuring protocol which uses Pdelay_Req, Pdelay_Resp and Pdelay_Resp_Follow_Up messages.
<b>Rationale:</b>	Time Synchronization protocol.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

**[RS\_TS\_20051] The Timesync over Ethernet module shall detect and handle errors in synchronization protocol / communication** [

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over Ethernet module shall detect and handle errors in synchronization protocol / communication (e.g. Transceiver Link State Lost).
<b>Rationale:</b>	Error handling / detection for synchronization protocol.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–



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<b>AppliesTo:</b>	CP, AP
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**[RS\_TS\_20052] The configuration of the Time Synchronization over Ethernet module shall allow the module to work as a Time Master** [

<b>Type:</b>	valid
<b>Description:</b>	Per supported Time Domain the configuration of the Time Synchronization Implementation shall allow to enable / disable the functionality of a Time Master with respect to Global Time Synchronization.
<b>Rationale:</b>	Support of specific communication port role in a given Time Domain.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

**[RS\_TS\_20053] The configuration of the Time Synchronization over Ethernet module shall allow the module to work as a Time Slave** [

<b>Type:</b>	valid
<b>Description:</b>	Per supported Time Domain the Implementation of the Time Synchronization configuration shall allow to enable / disable the functionality of a Time Slave with respect to Global Time Synchronization.
<b>Rationale:</b>	Support of specific communication port role in a given Time Domain.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

**[RS\_TS\_20054] The Implementation of the Time Synchronization shall evaluate and propagate Time Gateway relevant information** [

<b>Type:</b>	valid
<b>Description:</b>	If configured as part of a Time Gateway, the Ethernet Time Synchronization module shall evaluate and propagate Time Gateway relevant information.
<b>Rationale:</b>	Support of specific communication port role in a given Time Domain.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20058] The Timesync over Ethernet module shall provide the precision of Synchronized Time Bases** [

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over Ethernet module shall capture and provide measurement data for Time Synchronization relevant parameters (e.g. Link Delay).
<b>Rationale:</b>	Allow detailed analysis of the Time Synchronization mechanisms
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

**[RS\_TS\_20059] The Timesync over Ethernet module shall access all communication ports belonging to Time Synchronization** [

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over Ethernet module shall access Time Synchronization relevant data belonging to each communication port. This includes the local Ethernet Controller, all Ports of local and external Switches.
<b>Rationale:</b>	Allow detailed calculation along to a HW passage of Time Synchronization messages.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

**[RS\_TS\_20060] The Timesync over Ethernet module shall provide a Time Base after reception of a valid protocol information** [

<b>Type:</b>	valid
<b>Description:</b>	If configured as Time Slave, the Timesync over Ethernet module shall provide a Time Base after reception of a valid protocol information (Sync + Follow_Up message). This time base is forwarded to the Implementation of Time Synchronization to update the Local Time Base.
<b>Rationale:</b>	Synchronization of Local Time Base to Global Time Base.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

**[RS\_TS\_20061] The Timesync over Ethernet module shall support means to protect the Time Synchronization protocol** [

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over Ethernet module shall support means (e.g. sequence counter, CRC) to protect the Time Synchronization protocol against corruption of the time information.
<b>Rationale:</b>	Detection of wrong protocol sequences and data.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

**[RS\_TS\_20062] The Timesync over Ethernet module shall support user specific data within the time measurement and synchronization protocol** [

<b>Type:</b>	valid
<b>Description:</b>	The Ethernet Time Synchronization Provider module shall support transmission / reception of user specific data via the time measurement and synchronization protocol.
<b>Rationale:</b>	Allows usage of user specific data.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

**[RS\_TS\_20063] The Timesync over Ethernet module shall use the Time Synchronization protocol for Synchronized Time Bases to transmit and receive Offset Time Bases** [

<b>Type:</b>	valid
<b>Description:</b>	In addition to the transmission of Synchronized Time Bases the Timesync over Ethernet module shall support transmission / reception of an Offset Time Base value via the Time Synchronization protocol.
<b>Rationale:</b>	Additional Offset Time Synchronization mechanism.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP, AP

]()

#### 4.2.3 Time Synchronization over CAN

**[RS\_TS\_20031] The Timesync over CAN module shall trigger Time Base Synchronization transmission** [

<b>Type:</b>	valid
<b>Description:</b>	If configured as Time Master for a Time Base the Timesync over CAN module shall support two ways to trigger the transmission of the Time Synchronization protocol sequence: <ul style="list-style-type: none"> <li>• Cyclic triggering</li> <li>• Immediate triggering on demand</li> </ul>
<b>Rationale:</b>	Time Synchronization protocol.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20032] The Timesync over CAN module shall provide the Time Base after reception of a valid Timesync/TS messages** [



<b>Type:</b>	valid
<b>Description:</b>	If configured as Time Slave, the Timesync over CAN module shall provide the Time Base after reception of valid Timesync/TS messages. This Time Base is forwarded to the Implementation of Time Synchronization to update the Local Time Base.
<b>Rationale:</b>	Synchronization of Local Time Base to Global Time Base
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20033] The Timesync over CAN module shall support means to protect the Time synchronization protocol** [

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over CAN module shall support means (e.g. sequence counter, CRC) to protect the Time Synchronization protocol against corruption of the time information.
<b>Rationale:</b>	Detection of wrong protocol sequences and data.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20034] The Timesync over CAN module shall detect and handle timeout and integrity errors in the Time Synchronization protocol** [

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over CAN module shall monitor the Time Synchronization protocol for timeout and integrity (e.g. sequence counter, CRC).
<b>Rationale:</b>	Error handling / detection for Time Synchronization protocol
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20035] The Timesync over CAN module shall support a protocol for precise time measurement and synchronization over CAN** [

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over CAN module shall support a protocol for precise time measurement and synchronization over CAN, which is made up of a sequence of a SYNC (synchronization) and a FUP (follow-up) message to achieve higher precision.
<b>Rationale:</b>	Basic Time Synchronization mechanism.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20036] The Timesync over CAN module shall use the time measurement and synchronization protocol to transmit and receive an offset value [**

<b>Type:</b>	valid
<b>Description:</b>	Additionally to the actual timestamp the Timesync over CAN module shall support transmission / reception of an offset value via the time measurement and synchronization protocol, which is made up of a sequence of an OFS (offset synchronization) and an OFNS (offset adjustment) message. Note: for CAN FD the sequence may consist only of transmitting an extended OFS message.
<b>Rationale:</b>	Additional Offset Time Synchronization mechanism.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20037] The Timesync over CAN module shall support user specific data within the time measurement and synchronization protocol [**

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over CAN module shall support transmission / reception of user specific data via the time measurement and synchronization protocol.
<b>Rationale:</b>	Allows usage of user specific data.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–



△

<b>AppliesTo:</b>	CP
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**[RS\_TS\_20038] The Timesync over CAN module configuration shall allow the Implementation of Time Synchronization for CAN to support different roles for a Time Base** [

<b>Type:</b>	valid
<b>Description:</b>	The CAN Timesync/TS configuration shall allow the Implementation of Time Synchronization for CAN to fulfill 3 different roles: - Time Master - Time Slave - Time Gateway with respect to Global (vehicle wide) Time synchronization. In each role specific functionality is enabled / disabled
<b>Rationale:</b>	Support of specific communication port role in a given Time Domain.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20068] The Timesync over CAN module shall support classic CAN and CAN FD** [

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over CAN module shall use message formats for classic CAN and extended message formats for CAN FD which allows to transmit more than 8 bytes in a CAN frame. By using extended message formats for CAN FD it shall be possible to transmit an Offset Time Base within a single extended Timesync/TS message instead of distributing it to two consecutive Timesync messages.
<b>Rationale:</b>	Optimization for CAN FD by using longer CAN messages.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

#### 4.2.4 Time Synchronization over FlexRay

**[RS\_TS\_20039] The Timesync over FlexRay module shall trigger Time Base Synchronization transmission** [

<b>Type:</b>	valid
<b>Description:</b>	If configured as Time Master for a Time Base the Timesync over FlexRay module shall support two ways to trigger the transmission of the Time Synchronization protocol sequence: <ul style="list-style-type: none"> <li>• Cyclic triggering</li> <li>• Immediate triggering on demand</li> </ul>
<b>Rationale:</b>	Time Synchronization protocol.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20040] The Timesync over FlexRay module shall provide a Time Base after reception of a valid protocol information** [

<b>Type:</b>	valid
<b>Description:</b>	If configured as Time Slave, the Timesync over FlexRay module shall provide a Time Base after reception of a valid protocol information (SYNC message). This Time Base is forwarded to the Implementation of Time Synchronization to update the Local Time Base.
<b>Rationale:</b>	Synchronization of Local Time Base to Global Time Base
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20041] The Timesync over FlexRay module shall support means to protect the Time Synchronization protocol** [

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over FlexRay module shall support means (e.g. sequence counter, CRC) to protect the Time Synchronization protocol against corruption of the time information.
<b>Rationale:</b>	Detection of wrong protocol sequences and data.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20042] The Timesync over FlexRay module shall detect and handle time-out and integrity errors in the Time Synchronization protocol [**

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over FlexRay module shall monitor the Time Synchronization protocol for timeout and integrity (e.g. sequence counter, CRC).
<b>Rationale:</b>	Error handling / detection for synchronization protocol
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20043] The Timesync over FlexRay module shall support a protocol for precise time measurement and synchronization over FlexRay [**

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over FlexRay module shall support a protocol for precise time measurement and synchronization over FlexRay, which is made up of a sequence of SYNC (synchronization) messages.
<b>Rationale:</b>	Basic Time Synchronization mechanism.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20044] The Timesync over FlexRay module shall use the time measurement and synchronization protocol to transmit and receive an offset value [**

<b>Type:</b>	valid
<b>Description:</b>	Additionally to the actual timestamp the Timesync over FlexRay module shall support transmission / reception of an offset value via the time measurement and synchronization protocol, which is made up of a sequence of OFS (offset synchronization) messages.
<b>Rationale:</b>	Additional offset time synchronization mechanism.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20045] The Timesync over FlexRay module shall support user specific data within the time measurement and synchronization protocol [**

<b>Type:</b>	valid
<b>Description:</b>	The Timesync over FlexRay module shall support transmission / reception of user specific data via the time measurement and synchronization protocol.
<b>Rationale:</b>	Allows usage of user specific data.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–
<b>AppliesTo:</b>	CP

]()

**[RS\_TS\_20046] The configuration for Time synchronization over FlexRay shall allow the FlexRay Time Synchronization module to support different roles for a Time Base [**

<b>Type:</b>	valid
<b>Description:</b>	The configuration for Time synchronization over FlexRay shall allow the Implementation of Time Synchronization to fulfill 3 different roles: - Time Master - Time Slave - Time Gateway with respect to Global (vehicle wide) Time synchronization. In each role specific functionality is enabled / disabled.
<b>Rationale:</b>	Support of specific communication port role in a given Time Domain.
<b>Dependencies:</b>	–
<b>Use Case:</b>	



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<b>Supporting Material:</b>	—
<b>AppliesTo:</b>	CP

]()

### 4.3 Non-Functional Requirements (Qualities)

[RS\_TS\_00027] The TS shall provide a bus independent customer interface [

<b>Type:</b>	valid
<b>Description:</b>	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.
<b>Rationale:</b>	Hide bus / physical layer specific details to decouple applicaiton / customers from the lower layers.
<b>Dependencies:</b>	The TSP modules will do the conversion to a bus independent time format.
<b>Use Case:</b>	
<b>Supporting Material:</b>	—

]([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	[ <a href="#">RS_TS_00005</a> ] [ <a href="#">RS_TS_00010</a> ] [ <a href="#">RS_TS_00011</a> ] [ <a href="#">RS_TS_00013</a> ] [ <a href="#">RS_TS_00014</a> ] [ <a href="#">RS_TS_00015</a> ] [ <a href="#">RS_TS_00021</a> ] [ <a href="#">RS_TS_00027</a> ]

[RS_Main_00340]	AUTOSAR shall support the continuous timing requirement analysis	<a href="#">[RS_TS_00002]</a> <a href="#">[RS_TS_00003]</a> <a href="#">[RS_TS_00004]</a> <a href="#">[RS_TS_00005]</a> <a href="#">[RS_TS_00006]</a> <a href="#">[RS_TS_00007]</a> <a href="#">[RS_TS_00008]</a> <a href="#">[RS_TS_00009]</a> <a href="#">[RS_TS_00010]</a> <a href="#">[RS_TS_00011]</a> <a href="#">[RS_TS_00012]</a> <a href="#">[RS_TS_00013]</a> <a href="#">[RS_TS_00014]</a> <a href="#">[RS_TS_00015]</a> <a href="#">[RS_TS_00016]</a> <a href="#">[RS_TS_00017]</a> <a href="#">[RS_TS_00018]</a> <a href="#">[RS_TS_00019]</a> <a href="#">[RS_TS_00021]</a> <a href="#">[RS_TS_00022]</a> <a href="#">[RS_TS_00022]</a> <a href="#">[RS_TS_00024]</a> <a href="#">[RS_TS_00025]</a> <a href="#">[RS_TS_00026]</a>
[RS_Main_00400]	AUTOSAR shall provide a layered software architecture	<a href="#">[RS_TS_00006]</a> <a href="#">[RS_TS_00010]</a> <a href="#">[RS_TS_00011]</a> <a href="#">[RS_TS_00012]</a> <a href="#">[RS_TS_00013]</a> <a href="#">[RS_TS_00014]</a> <a href="#">[RS_TS_00015]</a>
[RS_Main_00513]	AUTOSAR shall support language bindings for different programming languages	<a href="#">[RS_TS_00023]</a>

## 6 References

- [1] System Template  
 AUTOSAR\_TPS\_SystemTemplate
- [2] Glossary  
 AUTOSAR\_TR\_Glossary
- [3] Main Requirements  
 AUTOSAR\_RS\_Main