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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 consumers.

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
GPT	General Purpose Timer

**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.

Functional Clusters as well as Adaptive Applications which take the role of a consumer, 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 consumers 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 [**

<b>Type:</b>	draft
<b>Description:</b>	The TS configuration shall allow the TS to fulfill different roles (i.e. Time Master, Time Slave) with respect to Global (vehicle wide) TS.
<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>	–

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

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

<b>Type:</b>	draft
<b>Description:</b>	<p>The TS shall always maintain the Time Bases based on different HW clock references.</p> <p>As an example, reference clocks to which the TS could access, could be:</p> <ul style="list-style-type: none"> <li>* OS counter</li> <li>* GPT</li> <li>* Ethernet HW clock</li> </ul> <p>The configuration depends on the capabilities of the HW and whether specific Role of the TS is enabled / disabled.</p>



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<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>	—

](RS\_Main\_00340)

**[RS\_TS\_00003] The TS shall initialize the Local Time Base with a configurable startup value** [

<b>Type:</b>	draft
<b>Description:</b>	The TS shall allow configuration of the initialization value of the Local Time Base. The initialization value can be either: - a value from static configuration - a value from non-volatile memory
<b>Rationale:</b>	Startup with a known default value.
<b>Dependencies:</b>	—
<b>Use Case:</b>	—
<b>Supporting Material:</b>	—

](RS\_Main\_00340)

**[RS\_TS\_00004] The TS shall initialize the Global Time Base with a configurable startup value** [

<b>Type:</b>	draft
<b>Description:</b>	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
<b>Rationale:</b>	Startup with a dedicated Time Base value. Resume of time freeze.
<b>Dependencies:</b>	—
<b>Use Case:</b>	—
<b>Supporting Material:</b>	—

](RS\_Main\_00340)

**[RS\_TS\_00005] The TS shall allow consumers to have access to the Synchronized Time Base** [

<b>Type:</b>	draft
<b>Description:</b>	The TS shall allow active consumers to have access to the Synchronized Time Base. The TS shall provide an interface for consumers 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 consumers shall always access a Synchronized Time Base via the TS.
<b>Rationale:</b>	The TS offers the possibility to the consumers 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 synchronous way with other tasks of other ECUs or Software Components.
<b>Supporting Material:</b>	–

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

**[RS\_TS\_00006] The TS shall provide time information to TSP modules [**

<b>Type:</b>	draft
<b>Description:</b>	The TS shall allow the "Time Synchronization Provider" modules to have access to the time information managed by the TS module.
<b>Rationale:</b>	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.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–

]([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 [**

<b>Type:</b>	draft
<b>Description:</b>	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 shall always be preferred against a local time.



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<b>Rationale:</b>	Rapid time synchronization and correction
<b>Dependencies:</b>	—
<b>Use Case:</b>	
<b>Supporting Material:</b>	—

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

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

<b>Type:</b>	draft
<b>Description:</b>	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.
<b>Rationale:</b>	Allows Time Base qualification.
<b>Dependencies:</b>	—
<b>Use Case:</b>	
<b>Supporting Material:</b>	—

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

**[RS\_TS\_00010] The TS shall allow consumer on Master side to set the Global Time**

<b>Type:</b>	draft
<b>Description:</b>	If configured as Time Master the TS shall allow the consumer 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>	—

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

**[RS\_TS\_00011] The TS shall allow consumers on Master side to trigger time transmission by the TSP module**



<b>Type:</b>	draft
<b>Description:</b>	If configured as Time Master the TS shall allow the consumer 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>	–

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

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

<b>Type:</b>	draft
<b>Description:</b>	The TS 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>	–

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

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

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

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

**[RS\_TS\_00014] The TS shall allow consumers to read User Data propagated via the TSP modules.** [

<b>Type:</b>	draft
<b>Description:</b>	The TS shall allow consumers 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>	–

|(RS\_Main\_00400, RS\_Main\_00060, RS\_Main\_00340)

**[RS\_TS\_00015] The TS shall allow consumer on Master side to set User Data propagated via the TSP modules.** [

<b>Type:</b>	draft
<b>Description:</b>	If configured as Time Master the TS shall allow consumers 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>	–

|(RS\_Main\_00400, RS\_Main\_00060, RS\_Main\_00340)

**[RS\_TS\_00016] The TS shall notify consumers about status events** [

<b>Type:</b>	draft
<b>Description:</b>	The TS shall notify consumers (Event Notification Consumers) 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>	–

|(RS\_Main\_00340)

**[RS\_TS\_00017] The TS shall notify consumers about elapsed pre-defined time span.** [

<b>Type:</b>	draft
<b>Description:</b>	The TS shall notify consumers, when a time span (relative to a given Time Base and previously defined/set by the consumer) 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>	–

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

**[RS\_TS\_00018] The TS shall support rate correction [**

<b>Type:</b>	draft
<b>Description:</b>	The TS 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>	–

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

**[RS\_TS\_00019] The TS shall support damping offset correction [**

<b>Type:</b>	draft
<b>Description:</b>	The TS 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>	–

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

**[RS\_TS\_00020] TS shall support synchronizing with the time clock master over Ethernet [**

<b>Type:</b>	draft
<b>Description:</b>	TS shall support synchronizing with the real-time clock master over Ethernet
<b>Rationale:</b>	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.
<b>Dependencies:</b>	–
<b>Use Case:</b>	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.
<b>Supporting Material:</b>	–

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

**[RS\_TS\_00021] The TS shall provide interfaces to query the synchronization status** [

<b>Type:</b>	draft
<b>Description:</b>	The TS 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 consumer.
<b>Dependencies:</b>	–
<b>Use Case:</b>	
<b>Supporting Material:</b>	–

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

**[RS\_TS\_00022] The TS shall support user-customized clocks** [

<b>Type:</b>	draft
<b>Description:</b>	The TS shall support user-customized 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>	A system integrator would require the possibility to customize clocks according to consumer requirements.
<b>Supporting Material:</b>	–

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

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

<b>Type:</b>	draft
<b>Description:</b>	The TS shall offer interfaces able to handle std::chrono 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>	–

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

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

<b>Type:</b>	draft
<b>Description:</b>	If configured as Time Master, the TS 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>	–

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

**[RS\_TS\_00025] The TS shall provide fault detection mechanisms** [

<b>Type:</b>	draft
<b>Description:</b>	The TS shall provide fault detection mechanisms. It must detect the following state changes: * Loss/Re-Establishment of Synchronized Time Bases * Errors during consumer / provider call
<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>	



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<b>Supporting Material:</b>	–
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](RS\_Main\_00340)

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

<b>Type:</b>	draft
<b>Description:</b>	The TS shall provide a different and specific API for each type of Time Base Resource
<b>Rationale:</b>	The consumer 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 consumer 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>	–

](RS\_Main\_00340)

### 4.3 Non-Functional Requirements (Qualities)

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

<b>Type:</b>	draft
<b>Description:</b>	The TS shall provide a bus independent consumer 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 application / consumers 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_00001]</a> <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_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_00020]</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] Standardization Template  
AUTOSAR\_TPS\_StandardizationTemplate
- [2] Glossary  
AUTOSAR\_TR\_Glossary
- [3] Main Requirements  
AUTOSAR\_RS\_Main