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1 Scope of Document

This document specifies requirements of the AUTOSAR Adaptive Platform on the Sensor Interface. The motivation of Sensor interfaces is to specify the service interfaces based on the defintion in the ISO 23150 [1].

2 Conventions to be used

The representation of requirements in AUTOSAR documents follows the table specified in [TPS_STDT_00078], see [2, Standardization Template].

The verbal forms for the expression of obligation specified in [TPS_STDT_00053] shall be used to indicate requirements, see [2, Standardization Template].

3 Acronyms and abbreviations

Abbreviation / Acronym:	Description:
AD	Automated Driving
ADI	Automated Driving Interfaces
AEB	Autonomous Emergency Braking
HiL	Hardware in the Loop
ISO	International Organization for Standardization
LIDAR	LIght Detection And Ranging
MiL	Model in the Loop
OEM	Original Equipment Manufacturer
OSI	Open Simulation Interface
RADAR	RAdio Detection And Ranging
SAE	Society of Automotive Engineers
USS	UltraSonic Sensor
XiL	... in the Loop

Terms:	Description:
V2X	Vehicle-to-X-Communication is the generic term for various communication technologies in automotive, including vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. The information is either transmitted directly between vehicles, between vehicle and roadside infrastructure or by using existing mobile networks.

The acronyms/abbreviations and terms not provided in tables above are included in the AUTOSAR Glossary [3].

4 Constraints and assumptions

No content.

5 Functional Overview

A key point to meet the challenges of developing automated driving functions, especially SAE J3016 automation level 3-5, is standardization: There is a huge potential in reducing development and validation costs by standardizing subsections of the complex hardware and software setup for automated driving functions. Sensors for detecting the vehicle environment and its connected environmental models are considered major enablers for automated driving. The current focus is on the standardization of sensor interfaces that serve as an input to environmental models or data fusion algorithms which in turn serve as the input for automated driving functions equal or greater than SAE level 3. Specifically, the focus is on interfaces for on-board sensors that can independently perceive their environment for performing safety critical tasks, e.g. camera, radar, lidar and ultrasonic sensors. This includes the actual measurement data as well as dynamically changing sensor performance values such as the currently estimated detection range. Other information sources like V2X and maps are considered as potential extensions. With the resulting standardized sensor interfaces, OEMs, suppliers, service providers and tool providers can reduce their costs and time for the development and validation of automated driving functions.

Currently, the interfaces of sensors for automated driving functions are proprietary and differ between suppliers. Thus, the integration of a new sensor requires a lot of effort as both the semantic as well as the logical interface need to be specified and developed according to functional safety requirements. There is an ongoing standardization of the semantic interfaces in the ISO 23150[1], i.e. the ISO defines which sensor data or signals are mandatory or optional and how are they defined, e.g. in terms of coordinate systems and units. The standardization of sensor interfaces aims at creating a well accepted specification, that builds on and is compliant to the sensor interface specification released by the International Organization for Standardization (ISO). While the ISO specification mainly focuses on the semantic definition of interfaces for different sensors, the Sensor Interfaces specification of the AUTOSAR Adaptive platform covers all additional aspects to make it fully compliant to the Adaptive platform. This document includes requirements on camera, radar, lidar and ultrasonic sensors interfaces as defined in ISO 23150 [1].

Further details are described in [4].

6 Requirements Specification

6.1 Sensor Types

[RS_ADI_00001] The ADI shall support the camera sensor technology for on-board sensors ⌈

Description:	The automated driving interface shall support the camera sensor types defined by ISO-23150 in the domain of automated driving.
Rationale:	Camera sensor technology is used for most automated driving functions and fusion algorithm development based on Adaptive Platform shall be supported with a standardized interface to different camera types.
Dependencies:	–
Use Case:	Access camera sensor signals using the ADI for e.g. automated emergency brake.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00002] The ADI shall support the lidar sensor technology for on-board sensors ⌈

Description:	The automated driving interface shall support the lidar sensor types defined by ISO-23150 in the domain of automated driving.
Rationale:	Lidar sensor technology is used for automated driving functions and fusion algorithm development based on Adaptive Platform shall be supported with a standardized interface to different lidar types.
Dependencies:	–
Use Case:	Access lidar sensor signals using the ADI for e.g. creation of environmental maps.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00003] The ADI shall support the radar sensor technology for on-board sensors ⌈

Description:	The automated driving interface shall support the radar sensor types defined by ISO-23150 in the domain of automated driving.
Rationale:	Radar sensor technology is used for most automated driving functions and fusion algorithm development based on Adaptive Platform shall be supported with a standardized interface to different radar types.
Dependencies:	–
Use Case:	Access radar sensor signals using the ADI for e.g. adaptive cruise control.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00004] The ADI shall support the ultrasonic sensor technology for on-board sensors ⌈

Description:	The automated driving interface shall support the ultrasonic sensor types defined by ISO-23150 in the domain of automated driving.
Rationale:	Ultrasonic sensor technology is used for some automated driving functions. Algorithm development based on Adaptive Platform shall be supported with a standardized interface to different ultrasonic types.
Dependencies:	–
Use Case:	Access ultrasonic sensor signals using the ADI for e.g. park distance control.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00005] The ADI shall be open for future extensions towards new sensor technologies ⌈

Description:	The ADI shall be open for future extensions towards new sensor technologies, i.e. to V2X.
Rationale:	
Dependencies:	–
Use Case:	
Supporting Material:	–

⌋

6.2 Sensor Interface

[RS_ADI_00006] The ADI shall provide interfaces which enable exchangeability of service compatible AUTOSAR Adaptive applications without changing the rest of the system. ⌈

Description:	Exchange of sensors as well as updating of data fusion application should be possible without adapting the application binaries on the respective target. Binaries include compiled code, but not calibration data, e.g. opening angle, range min/max. All these criteria as described above are supported by the AUTOSAR services concept.
Rationale:	Rationale should be based on stakeholder view: Supplier: does not want to have engineering efforts on his side while supplying a sensor to an OEM. OEM: Does not want to have migration / interoperability efforts when switching sensors.
Dependencies:	–

▽

△

Use Case:	Exchange of a sensor by another sensor with the same capabilities or specification. Replacement of data fusion or sensor application by new version (e.g. by over-the-air update).
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00007] The ADI shall enable use cases with different resource limitations. ⌈

Description:	The ADI shall respect resource limits (e.g. for network bandwidth, storage) by e.g. defining multiple service profiles for each sensor type defined by ISO-23150. These service profiles shall be based on sensor performance classes with respect to usage scenarios (e.g. low-end and high-end performance scenarios).
Rationale:	For low-end systems, there are cost and performance constraints on the sensor resources. For high-end systems, best performance even at a high cost may be desirable. For anything in between, certain tradeoff between cost, performance and feature set needs to be done. To address the entire spectrum of use cases, a multitude of interface profiles based on sensor performance classes are necessary.
Dependencies:	–
Use Case:	Support various sensor resource constraints (performance, cost, feature set) for Automated Driving systems of different performance-tiers.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00012] The ADI shall support the ISO-23150 interfaces and ISO-23150 interface signals ⌈

Description:	The ADI specification shall include all ISO-23150 [1] interface signals. An application should be able to access each ISO-23150 [1] interface signal, no matter if the ISO-23150 interface signal is mandatory, design-time optional or a conditional element. The ADI specification shall include all ISO-23150 [1] interfaces.
Rationale:	The base of standardization for ADI is defined by the International Organization for Standardization (ISO).
Dependencies:	–
Use Case:	An AUTOSAR Adaptive application supplying ADI interfaces should be able to use all elements (ISO-23150 interfaces and ISO-23150 signals) which are defined by the ISO-23150, regardless of whether the elements are e.g. specified optionally.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00013] The ADI shall interpret the ISO-23150 compliant to AUTOSAR ⌈

Description:	The ADI specification shall support all ISO-23150 [1] definitions with AUTOSAR means as long as they appear feasible.
Rationale:	See SRSDiagnostics of AUTOSAR classic 4.2.2 for examples. In contrast to SRSDiagnostics the ISO-23150 document is not available at the moment and this requirement is more coarse grained.
Dependencies:	–
Use Case:	If the ISO-23150 defines a constant version id as an interface signal then this interface signal could be adapted to a method in AUTOSAR.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00014] The ADI shall be aligned with the semantics of the corresponding elements in the ISO-23150 . ⌈

Description:	The semantic definition of each ISO-23150 [1] signal should be identical in ISO-23150 interfaces and the corresponding ADI API.
Rationale:	The base of standardization for ADI is defined by the International Organization for Standardization.
Dependencies:	–
Use Case:	E.g. ISO-23150 unit definitions are used for ADI interface. E.g. ISO-23150 signal definitions are used for ADI elements, e.g. relative velocity or absolute velocity.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00015] The ADI shall limit the transmission of unused data. ⌈

Description:	The ADI shall e.g. group the logical elements of the ISO-23150 [1] into reduced group-sets containing either mandatory or non-mandatory elements which clients could subscribe to. Non-mandatory elements are optional and/or conditional elements of the sensor list. The grouping shall be performed based on the inter-relation and dependency of mandatory and non-mandatory elements.
Rationale:	Providing interface sets for each combination of non-mandatory elements would dramatically increase the number of sensor interfaces (>1000). Therefore, grouping elements into mandatory and non-mandatory sets shall limit the number of sensor interfaces.
Dependencies:	–
Use Case:	A sensor provides a mandatory and several non-mandatory group-sets. Clients may subscribe to different group-sets based on its sensor usage requirements.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00016] The ADI specification shall support the replacement of a sensor by another one providing more profiles without recompilation of the client software. ⌈

Description:	Exchange of sensors with improved ones needs to be possible without adapting the application binaries. A profile contains the list of data items and update frequencies.
Rationale:	Rationale should be based on stakeholder view: Supplier: does not want to have engineering efforts while supplying a sensor to an OEM. OEM: Does not want to have migration / interoperability efforts when switching sensors.
Dependencies:	–
Use Case:	Exchange of a sensor by a newer sensor that still supports the required profiles. Replacement of sensor at car repair or reuse of sensors for different models. E.g. a new sensor has color information which is used in a new setup but the sensor can be reused in an older configuration where color is not required.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00017] The ADI specification shall support the replacement of a sensor by another one providing less profiles without recompilation of the client software if the removed profiles are not used. ⌈

Description:	Exchange of sensors with less powerful ones needs to be possible without adapting the application binaries when the sensor is sufficient for the use-case. A profile contains the list of data items and update frequencies.
Rationale:	Rationale should be based on stakeholder view: Supplier: does not want to have engineering efforts while supplying a client application to an OEM. OEM: Does not want to have migration / interoperability efforts when reusing client software.
Dependencies:	–
Use Case:	Exchange of a sensor by a newer sensor that still provides the used profiles. An already existing client application shall run in a system that has less powerful sensors but still provides the used profiles. E.g. A parking application, using low precision ultrasonic, when developed into a full equipped system, shall still be able to run in a system that only provides low precision ultrasonic sensors.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00018] The ADI specification shall enable AUTOSAR Adaptive applications to discard sensor data when newer sensor data is available. ⌈

Description:	An application shall be able to access and process the most recent data from a sensor, i.e. it shall be possible for an application to skip data frames.
Rationale:	Many automated driving functions derive their decisions from the current environment state, e.g. the positions, driving directions and velocities of all relevant objects in the host vehicle's surrounding. For that, it is more important to access and process the most recent sensor data than processing all sensor data as the states of the objects may rapidly change, e.g. due to a sudden deceleration.
Dependencies:	–
Use Case:	A sensor provides data more frequently than it is able or required to process.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00019] The ADI shall provide interface specifications that support an automatic translation of an interface specification to an implementable service interface. ⌈

Description:	For a given ADI service interface specification, a developer or a tool shall be able to generate the interface for the service.
Rationale:	To implement a service in C++, data types are required to be known and fixed at compile time. Therefore, the ADI interfaces need to be specified up to the implementation level.
Dependencies:	–
Use Case:	In a tool, the user select one or multiple sensor interfaces from the ADI. Then, the tool generates the C++ implementation of a data fusion service for the selected sensor interfaces.
Supporting Material:	ISO-23150 [1]

⌋

6.3 Replay of recorded sensor data

[RS_ADI_00020] A network of AUTOSAR Adaptive applications using the sensor interfaces should be able to run with replayed recorded sensor data. ⌈

Description:	For validation and debugging purposes a network of applications shall be stimulated with recorded sensor data and the same sensor configuration. The output is the result of a computation chain of the connected applications. For validation and debugging purposes the recorded data should be self-consistent.

▽

△

Rationale:	An application using the sensor interfaces should be able to support recorded sensor data with the same ADI configuration (interfaces, repetition rate etc.) as used for recording.
Dependencies:	–
Use Case:	Validation of data fusion applications.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00021] A network of applications using the sensor interfaces should be able to support recorded sensor data from any arbitrary time. ⌈

Description:	For validation and debugging purposes the applications shall be stimulated with recorded sensor data at: - beginning of the recording - some arbitrary point of the recording
Rationale:	Usually just particular scenarios within a recorded stream are from interest. To be able to analyse scenarios within a stream the interfaces should support the replay of data at any given time.
Dependencies:	–
Use Case:	Validation of data fusion applications.
Supporting Material:	ISO-23150 [1]

⌋

[RS_ADI_00022] The sensor interfaces should allow AUTOSAR Adaptive applications to produce the same output with replayed sensor data. ⌈

Description:	Typical approaches to achieve this is that the network of ARA applications form a directed acyclic graph (DAG), i.e. the network does not include feedback loops. The acyclic graph will not change during runtime. Reuse of recorded sensor data for all applications proceeding a modified application in a DAG.
Rationale:	To reproduce issues that have occurred during recording the applications must be fed in a way that allows to produce the same output.
Dependencies:	–
Use Case:	Validation of data fusion applications.
Supporting Material:	ISO-23150 [1]

⌋

7 References

[1] ISO-23150 Road vehicles–Data communication between sensors and data fusion unit for automated driving functions–Logical interface

[2] Standardization Template
AUTOSAR_FO_TPS_StandardizationTemplate

[3] Glossary
AUTOSAR_FO_TR_Glossary

[4] Explanation of Sensor Interfaces
AUTOSAR_AP_EXP_SensorInterfaces

A Change history of AUTOSAR traceable items

Please note that the lists in this chapter also include traceable items that have been removed from the specification in a later version. These items do not appear as hyperlinks in the document.

A.1 Traceable item history of this document according to AUTOSAR Release R25-11

A.1.1 Added Requirements in R26-11

none

A.1.2 Changed Requirements in R26-11

none

A.1.3 Deleted Requirements in R26-11

none

A.1.4 Added Requirements in R25-11

none

A.1.5 Changed Requirements in R25-11

none

A.1.6 Deleted Requirements in R25-11

none

A.2 Traceable item history of this document according to AUTOSAR Release R24-11

A.2.1 Added Requirements in R24-11

none

A.2.2 Changed Requirements in R24-11

none

A.2.3 Deleted Requirements in R24-11

none

A.3 Traceable item history of this document according to AUTOSAR Release R23-11

A.3.1 Added Requirements in R23-11

none

A.3.2 Changed Requirements in R23-11

none

A.3.3 Deleted Requirements in R23-11

none

A.4 Traceable item history of this document according to AUTOSAR Release R22-11

A.4.1 Added Requirements in R22-11

none

A.4.2 Changed Requirements in R22-11

Number	Heading
[RS_ADI_00001]	The ADI shall support the camera sensor technology for on-board sensors
[RS_ADI_00002]	The ADI shall support the lidar sensor technology for on-board sensors
[RS_ADI_00003]	The ADI shall support the radar sensor technology for on-board sensors
[RS_ADI_00004]	The ADI shall support the ultrasonic sensor technology for on-board sensors
[RS_ADI_00012]	The ADI shall support the ISO-23150 interfaces and ISO-23150 interface signals
[RS_ADI_00013]	The ADI shall interpret the ISO-23150 compliant to AUTOSAR
[RS_ADI_00014]	The ADI shall be aligned with the semantics of the corresponding elements in the ISO-23150 .

Table A.1: Changed Requirements in R22-11

A.4.3 Deleted Requirements in R22-11

none