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Part 1: General information and principles.

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Introduction

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Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 23150-1

Road vehicles — Logical interface between sensors and data fusion unit for automated driving functions —

Part 1: General information and principles

*Véhicules routiers — Interface logique entre capteurs et unité de
fusion de données pour les fonctions de conduite automatisée —*

Partie 1: Informations générales et principes

ICS: 43.040.15

ISO/TC 22/SC 31

Secretariat: DIN

Voting begins on:
2024-12-20

Voting terminates on:
2025-03-14

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 31, *Data communication*.

This second edition cancels and replaces the first edition (ISO 23150:2021), which has been technically revised.

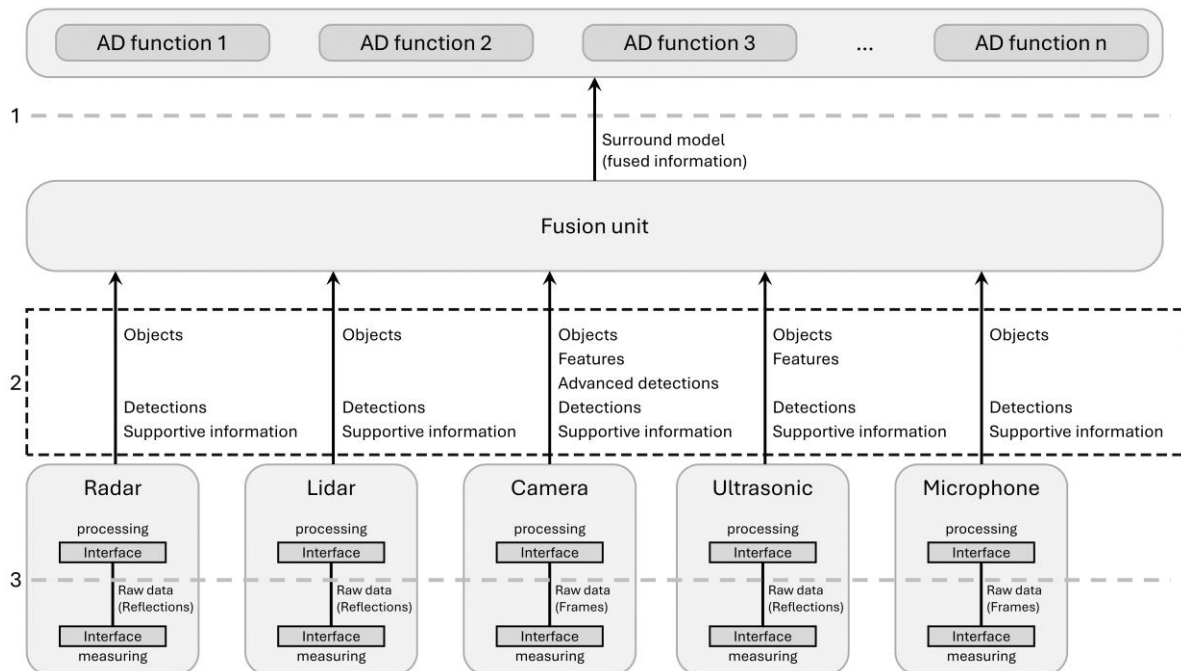
The main changes are as follows:

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

(Highly-)automated driving (AD) functions for road vehicles require a situation awareness of the surroundings of the vehicle and, preferably, a comprehensive scene understanding. For the fast and reliable recognition of real-world objects, a sensor suite is necessary to provide information for the fusion unit. Utilisation of different sensor technologies with different detection capabilities is indispensable to ensure both complementary and redundant information. The fusion unit analyses and evaluates the different sensor signals and finally generates a dynamic surround model with sufficient scene understanding.

While current partly-automated functions utilise only particular objects (for example, vehicles, pedestrians, road markings) to generate a simple surround model, it is necessary for future highly-automated driving functions to merge not only the recognised objects but also to include other sensor-specific properties and characteristics of these objects for the generation of a coherent surround model of the surroundings. To minimise the development efforts for the sensors and the fusion unit and to maximise the re-usability of development and validation efforts for the different functions on the sensor and fusion unit side, a standardised logical interface layer between the sensor suite and the fusion unit and a standardised logical interface layer to the sensor suite are worthwhile and beneficial for both the sensor supplier and the system supplier.

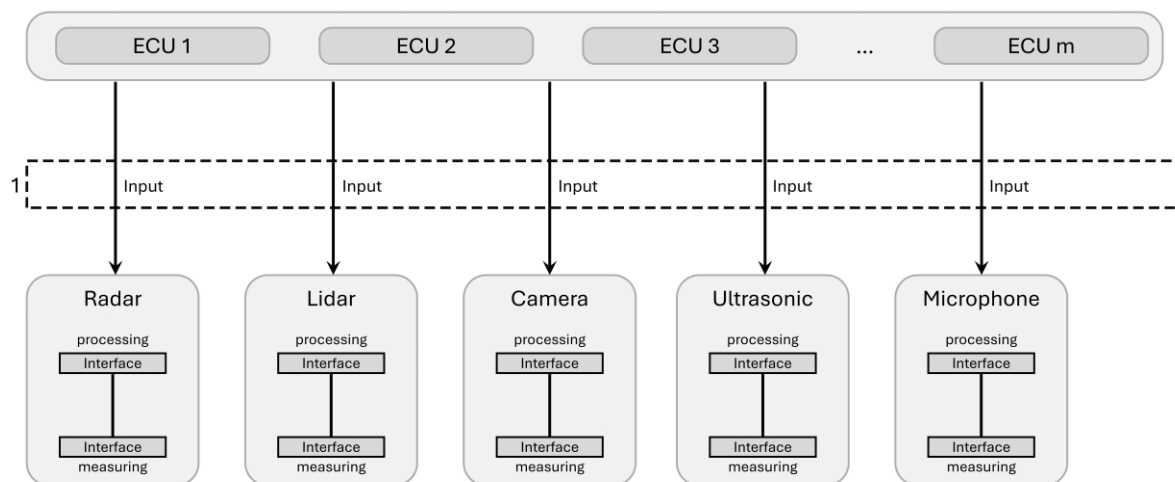


Key

- 1 logical interface layer between the fusion unit and AD functions
- 2 logical interface layer between a single sensor as well as a single sensor cluster and the fusion unit
- 3 interface layer on raw data level of a sensor's sensing element(s) and its processing

Figure 1 — Architecture: sensors/sensor clusters → fusion unit → AD functions

The logical interface layer between a single sensor as well as a single sensor cluster and the fusion unit (see Figure 1, key 2) addresses the encapsulation of technical complexity as well as objects including free space areas, features, advanced detections and detections to enable object-level, feature-level, advanced detection-level and detection-level fusion. Additional supportive information of the sensor as well as the sensor cluster will supplement the data for the fusion unit.

**Key**

- 1 logical interface layer between other in-vehicle electronic control units (ECUs) (for example, odometry) and a single sensor or a single sensor cluster

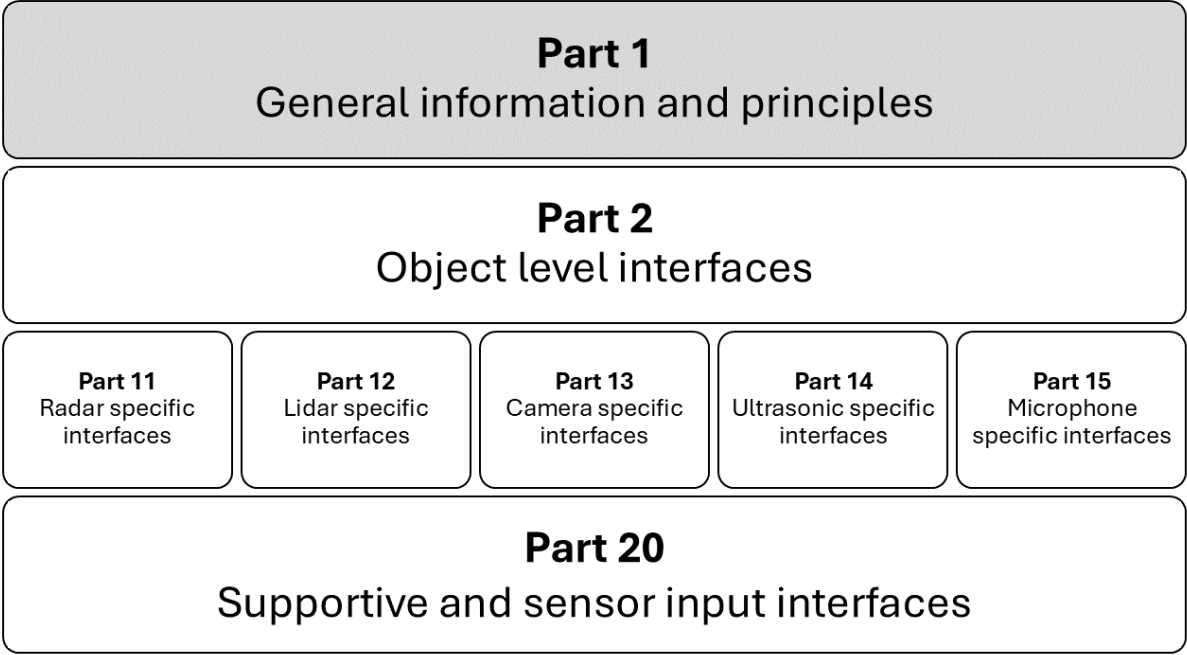
Figure 2 — Architecture: ECUs' sensor input → sensors/sensor clusters

The logical interface layer between an electronic control unit and a single sensor as well as a single sensor cluster (see Figure 2, key 1) addresses the input of a single sensor as well as a single sensor cluster.

All documents of the ISO 23150 document series are:

- ISO 23150-1 "General information and principles"
- ISO 23150-2 "Object level interfaces"
- ISO 23150-11 "Radar specific interfaces"
- ISO 23150-12 "Lidar specific interfaces"
- ISO 23150-13 "Camera specific interfaces"
- ISO 23150-14 "Ultrasonic specific interfaces"
- ISO 23150-15 "Microphone specific interfaces"
- ISO 23150-20 "Supportive and sensor input interfaces"

Figure 3 shows the schematic and contextual relationships between the documents relating to logical interfaces of the ISO 23150 document series.



Key



Scope of this document

Figure 3 — Relationship of the ISO 23150 document series "Road vehicles — Logical interface between sensors and data fusion unit for automated driving functions"

This document is not intended to replace the logical interface specifications of other documents in the ISO 23150 document series.

Road vehicles — Logical interface between sensors and data fusion unit for automated driving functions —

Part 1: General information and principles

1 Scope

This document is applicable to road vehicles with automated driving functions. The document series specifies the logical interface between in-vehicle environmental perception sensors and the fusion unit which generates a surround model and interprets the scene around the vehicle based on the sensor data. The interface is described in a modular and semantic representation and provides information on different abstraction levels based on sensor technology specific information.

This document provides generic interface templates for different interface levels, supportive sensor interfaces and sensor input interfaces.

This document does not provide electrical and mechanical interface specifications. Raw data interfaces are also excluded.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/FDIS 11898-2, *Road vehicles — Controller area network (CAN) — Part 2: High-speed physical medium attachment (PMA) sublayer*

ISO 23150:2023, *Road vehicles — Data communication between sensors and data fusion unit for automated driving functions — Logical interface*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 Architectural components

3.1.1 fusion

act of uniting *signals* from two or more *sensors* as well as *sensor clusters* to create a *surround model*

3.1.2 fusion unit

computing unit where the *fusion* of *sensor* data as well as a *sensor cluster* data is performed

3.1.3

interface

shared boundary between two functional units, defined by various characteristics pertaining to the functions, physical interconnections, *signal* exchanges and other characteristics of the units, as appropriate

[SOURCE: ISO/IEC 2382:2015^[1], 2124351, modified — Notes to entry have been removed.]

3.1.4

logical interface

interface between a *sensor* as well as a *sensor cluster* and the *fusion unit*, defined by logical characteristics

Note 1 to entry: Logical means a semantic description of the interface.

Note 2 to entry: Mechanical and electrical interfaces are excluded.

Note 3 to entry: This document uses the term interface as a shortcut for the term logical interfaces.

3.1.5

sensor

in-vehicle unit which detects entities external of the vehicle with pre-processing capabilities serving at least one *logical interface*

Note 1 to entry: A sensor may use one or more sensing elements.

3.1.6

sensor cluster

group of *sensors* of the same technology serving common *logical interfaces*

Note 1 to entry: A sensor cluster can exceptionally consist of only one sensor.

EXAMPLE A stereo camera, a surround-view camera, an ultrasonic sensor array, a corner radar system.

3.1.7

surround model

representation of the real world adjacent to the ego-vehicle

3.1.8

in-vehicle communication

communication network used in vehicles to connect devices to exchange information

Note 1 to entry: A in-vehicle communication connects, for example, electric control units and *sensors* with each other.

3.2 Terms for logical interface layers

3.2.1

detection

sensor technology specific entity represented in the *sensor coordinate system* based on a single *measurement* of a *sensor*

Note 1 to entry: A small amount of history can be used for some detection *signals*, for example, model-free filtering may be used in track-before-detect algorithms.

3.2.2

detection level

set of *logical interfaces* that provides *detections*

3.2.3

advanced detection

sensor technology specific entity represented in the *sensor coordinate system* based on multiple *measurements* of a *sensor*

Note 1 to entry: Multiple measurements can originate from multiple *measurement cycles*.

3.2.4

advanced detection level

set of *logical interfaces* that provides *advanced detections*

3.2.5

feature

sensor technology specific entity represented in the *vehicle coordinate system* based on multiple *measurements*

Note 1 to entry: Multiple measurements can originate from a *sensor cluster*.

Note 2 to entry: Multiple measurements can originate from multiple *measurement cycles*.

Note 3 to entry: The term feature is used in this document not as function or group of functions as specified in ISO/SAE PAS 22736:2021^[2].

3.2.6

feature level

set of *logical interfaces* that provides *features*

3.2.7

object

representation of a real-world entity with defined boundaries and characteristics in the *vehicle coordinate system*

Note 1 to entry: The geometric description of the object is in the vehicle coordinate system.

Note 2 to entry: Object *signals* are basically sensor technology independent. Sensor technology specific signals may extend the object signals.

EXAMPLE A potentially moving object, a road object, a static object, a free space area object.

3.2.8

object level

set of *logical interfaces* that provides *objects*

3.2.9

sensor input

data received by a *sensor* or a *sensor cluster* via the *in-vehicle communication*

3.3 Structure terms

3.3.1

signal

entity consisting of one or more values and which is part of a *logical interface*

3.3.2

logical signal group

grouping of *signals* that has a logical relationship and a name for the grouping

3.3.3

classification

attribute-based differentiation

Note 1 to entry: An attribute is defined by a list of enumerators.

3.4 Measurement terms

3.4.1

measurement cycle

time period from the start of a data acquisition event to the start of the next data acquisition event

Note 1 to entry: A measurement cycle of one *sensor* is a consistent view of an observed scene and not overlapping in time.

3.4.2

measured quantity value

value of a quantity resulting from a *measurement*

3.4.3

tracked quantity value

value of a quantity determined from observed sequential changes, using information related to the same characteristic

3.4.4

predicted quantity value

value of a quantity assessed before it is actually observable, using information related to the same characteristic

EXAMPLE Related information can be recent and previous *measured quantity values*, *tracked quantity values* and state variables.

[SOURCE: IEV 192-13-02, modified — EXAMPLE has been added and the word "quantity" has been added to the term.]

3.4.5

measurement

processing result of a *measurement cycle*

3.4.6

tracking

computation process used to calculate the *tracked quantity value* of a quantity

3.4.7

prediction

computation process used to obtain the *predicted quantity value* of a quantity

[SOURCE: IEV 192-11-01]

3.4.8

error

discrepancy between a *measured quantity value*, *tracked quantity value* or *predicted quantity value* or condition, and the true, specified or theoretically correct reference quantity value or condition

Note 1 to entry: An error within a system can be caused by failure of one or more of its components, or by the activation of a systematic fault.

[SOURCE: IEV 192-03-02, modified — “computed, observed or measured value” was modified to “measured quantity value, tracked quantity value or predicted quantity value”, “value” was modified to “reference quantity value”, Note 1 to entry has been adapted and Note 2 to entry was deleted.]

3.4.9

accuracy

closeness of agreement between a *measured quantity value*, *tracked quantity value* or *predicted quantity value* and a true quantity value

Note 1 to entry: The concept accuracy is not a quantity and is not given a numerical quantity value. A *measurement*, *tracking* or *prediction* is said to be more accurate when it offers a smaller *error*.

Note 2 to entry: The term accuracy should not be used for *trueness* and the term *precision* should not be used for accuracy, which, however, is related to both these concepts.

Note 3 to entry: Accuracy is sometimes understood as closeness of agreement between measured, tracked or predicted quantity values that are being attributed to the measurand.

[SOURCE: ISO/IEC Guide 99:2007^[3], 2.13, modified — The terms “measurement accuracy” and “accuracy of measurement” were deleted, definition was extended for tracked or predicted quantity values and the Notes to entry have been adapted.]

3.4.10

trueness

closeness of agreement between the average of an infinite number of replicated *measured quantity values*, *tracked quantity values* or *predicted quantity values* and a reference quantity value

Note 1 to entry: Trueness is not a quantity and thus cannot be expressed numerically, but measures for closeness of agreement are given in the ISO 5725-1:2023^[4] series.

Note 2 to entry: Trueness is inversely related to systematic error but is not related to random error.

Note 3 to entry: The term *accuracy* should not be used for trueness.

[SOURCE: ISO/IEC Guide 99:2007^[3], 2.14, modified — The terms “measurement trueness” and “trueness of measurement” were deleted, definition was extended for tracked or predicted quantity values and the Notes to entry have been adapted.]

3.4.11

precision

closeness of agreement between indications or *measured quantity values*, *tracked quantity values* or *predicted quantity values* obtained by replicate *measurements*, *tracking* or *prediction* on the same or similar measurands under specified conditions

Note 1 to entry: Precision is usually expressed numerically by measures, trackings or predictions of imprecision, such as standard deviation, variance or coefficient of variation under the specified conditions of measurement, tracking or prediction.

Note 2 to entry: The specified conditions can be, for example, repeatability conditions of measurement, intermediate precision conditions of measurement or reproducibility conditions of measurement (see ISO 5725-1:2023^[4]).

Note 3 to entry: Precision is used to define measurement, tracking or prediction repeatability, intermediate measurement or prediction precision and measurement, tracking or prediction reproducibility.

Note 4 to entry: Sometimes precision is erroneously used to mean *accuracy*.

Note 5 to entry: Precision is inversely related to random error but is not related to systematic error.

[SOURCE: ISO/IEC Guide 99:2007^[3], 2.15, modified — The term "measurement precision" was deleted, the word "objects" was replaced by "measurands", definition was extended for tracked or predicted quantity values, the Notes to entry have been adapted and Note 5 to entry has been added.]

3.4.12

measurement error

measured quantity value minus a reference quantity value

Note 1 to entry: The concept of measurement error can be used both:

- a) when there is a single reference quantity value to refer to, which occurs if a calibration is made by means of a measurement standard with a measured quantity value having a negligible measurement uncertainty or if a conventional quantity value is given, in which case the *error* is known, and
- b) if a measurand is supposed to be represented by a unique true quantity value or a set of true quantity values of negligible range, in which case the error is not known.

Note 2 to entry: Measurement error should not be confused with production error or mistake.

[SOURCE: ISO/IEC Guide 99:2007^[3], 2.16, modified — The terms "error" and "error of measurement" were deleted and the Notes to entry have been adapted.]

3.4.13

tracking error

quantitative statement about the *tracked quantity value* and the reference quantity value

3.4.14

prediction error

quantitative statement about the *predicted quantity value* and the reference quantity value

3.4.15

error model

model used to estimate the *error*

3.4.16

fixation

short temporal holds of movements that keep alignment of the eyes to a particular point within an area of interest which falls on the fovea (the middle of the retina responsible for our central, sharpest vision) for a given time period

[SOURCE: ISO 15007:2020^[5], 3.1.4, modified — Notes to entry have been deleted.]

3.5 Requirement level terms

3.5.1

conditional

required under certain specified conditions

Note 1 to entry: One of three obligation statuses applied to a *requirement level* of a *logical interface* specification, indicating the conditions under which the *signal* or *logical signal group* is required. In other cases, the signal or logical signal group is optional. See also *mandatory* and *optional*.

[SOURCE: ISO/IEC 11179-3:2023^[6], 3.2.77, modified — Note 1 to entry has been adapted and Note 2 to entry has been removed.]

3.5.2

mandatory

always required

Note 1 to entry: One of three obligation statuses applied to a *requirement level* of a *logical interface* specification, indicating the conditions under which the *signal* or *logical signal group* is required. See also *conditional* and *optional*.

[SOURCE: ISO/IEC 11179-3:2023^[6], 3.2.75, modified — Note 1 to entry has been adapted and Note 2 to entry has been removed.]

3.5.3

optional

permitted but not required

Note 1 to entry: One of three obligation statuses applied to a *requirement level* of a *logical interface* specification, indicating the conditions under which the *signal* or *logical signal group* is required. See also *conditional* and *mandatory*.

[SOURCE: ISO/IEC 11179-3:2023^[6], 3.2.76, modified — Note 1 to entry has been adapted and Note 2 to entry has been removed.]

3.5.4

requirement level

definition of the obligation status of a *logical interface's* *logical signal group*, *signal* as well as a signal's identifier or signal's enumerator

Note 1 to entry: Each requirement level entry has one of three possible obligation statuses applied: *conditional*, *mandatory* or *optional*.

Note 2 to entry: No default requirement level is defined for exemplary signal enumerators. The requirement level is specified during the system design phase.

3.5.5

system design

process of defining the hardware and software architecture, components, modules, interfaces and data for a system to satisfy specified requirements

[SOURCE: ISO/IEC 2382:2015^[1], modified — Note to entries have been removed.]

3.6 Road user relevant entity types

3.6.1

potentially moving object

real-world entity which can potentially move and is relevant for driving situations

Note 1 to entry: A representation of a potentially moving object is part of *logical interfaces* on *object level*.

EXAMPLE A vehicle, a bicycle, a pedestrian, an obstacle.

3.6.2

road object

marking or structure of a road which is relevant for driving situations

Note 1 to entry: A representation of a road object is part of *logical interfaces* on *object level*.

EXAMPLE A road marking, a road boundary, the road surface.

3.6.3

road marking

line, symbol or other mark on the surface of a road or a structure intended to limit, regulate, warn, guide or inform road users

Note 1 to entry: Other marks could be text, numbers, arrows or combinations.

EXAMPLE A lane marking, Botts' dots.

[SOURCE: ISO 6707-1:2020^[7], 3.3.5.80, modified — "user" was modified to "road users", "limit" was added and the Note 1 to entry and EXAMPLE have been added.]

3.6.4

road boundary

structure that limits the road

EXAMPLE A curb stone, a guard rail, the end of the surface of the road.

3.6.5

road surface

surface supporting the tyre and providing friction necessary to generate shear forces in the *road plane*

Note 1 to entry: The surface may be flat, curved, undulated or of other shape.

[SOURCE: ISO 8855:2011^[8], 2.6]

3.6.6

static object

real-world stationary entity which can be used for information and/or localisation

Note 1 to entry: A representation of a static object is part of *logical interfaces* on *object level*.

EXAMPLE A general landmark, a traffic sign, a traffic sign board, a traffic light.

3.6.7

general landmark

real-world stationary entity which can be used for localisation

Note 1 to entry: A stationary *traffic sign* or *traffic light* is also regarded as a general landmark.

EXAMPLE A building, a tunnel, a bridge, a sign gantry structure, a tree.

3.6.8

traffic sign

traffic relevant, authorised sign that limits, regulates, warns, guides or informs road users

Note 1 to entry: One traffic sign usually consists of one *main sign* and none, one or several *supplementary signs*.

EXAMPLE A speed limit which is restricted for trucks.

3.6.9

main sign

traffic sign which gives a general message, obtained by a combination of colour and geometric shape and which, by the addition of a graphical symbol or text, gives a particular message for road users

[SOURCE: ISO 3864-1:2011^[9], 3.12, modified — The original term was "safety sign", "sign" has been replaced by "traffic sign" and the phrases "or text" and "for road users" have been added to the definition.]

3.6.10

supplementary sign

traffic sign that is supportive of a *main sign* and the main purpose of which is to provide additional clarification

[SOURCE: ISO 3864-1:2011^[9], 3.14, modified — "traffic sign" now replaces "sign" and "main sign" replaces "traffic sign".]

3.6.11

traffic sign board

traffic relevant, authorised sign board that limits, regulates, warns, guides or informs road users by abstract representations of lanes and streets ahead to control traffic on the road

3.6.12

traffic light

traffic relevant, official lights

Note 1 to entry: One traffic light consists of one or several light spots with different light colours and/or shapes.

EXAMPLE A pedestrian traffic light.

3.6.13

free space area object

area entity of the *road surface* that can be driven on and is free of obstacles that can limit driving

Note 1 to entry: A representation of a free space area object is part of *logical interfaces on object level*.

3.7 Axis and coordinate system terms

3.7.1

reference frame

geometric environment in which all points remain fixed with respect to each other at all times

[SOURCE: ISO 8855:2011^[8], 2.1]

3.7.2

axis system

set of direction vectors

3.7.3

coordinate system

numbering convention used to assign a unique ordered trio of values to each point in a *reference frame* and which consists of an *axis system* plus an origin point

[SOURCE: ISO 8855:2011^[8], 2.4, modified — "(*x*, *y*, *z*)" has been removed from the definition.]

3.7.4

cartesian coordinate system

set of numerical coordinates (*x*, *y*, *z*), which are the signed distances to the *YZ*-, *ZX*- and *XY*-planes using a set of three orthogonal directions associated with *X*, *Y* and *Z* axes

Note 1 to entry: A right-handed *axis system* is assumed throughout this document, where: $\vec{Z} = \vec{X} \times \vec{Y}$.

3.7.5

spherical coordinate system

set of one distance vector and two angles associated with radial distance, azimuth and elevation

Note 1 to entry: The azimuth angle is the angle in XY -plane [of a *cartesian coordinate system*] of the *axis system* counted from the X -axis. The elevation angle is the angle from the azimuth direction in the XY -plane of the axis system towards the direction of the distance vector, that is XY -plane has an elevation angle = 0 rad.

Note 2 to entry: The angles of the spherical coordinate system have increasing values in counterclockwise direction.

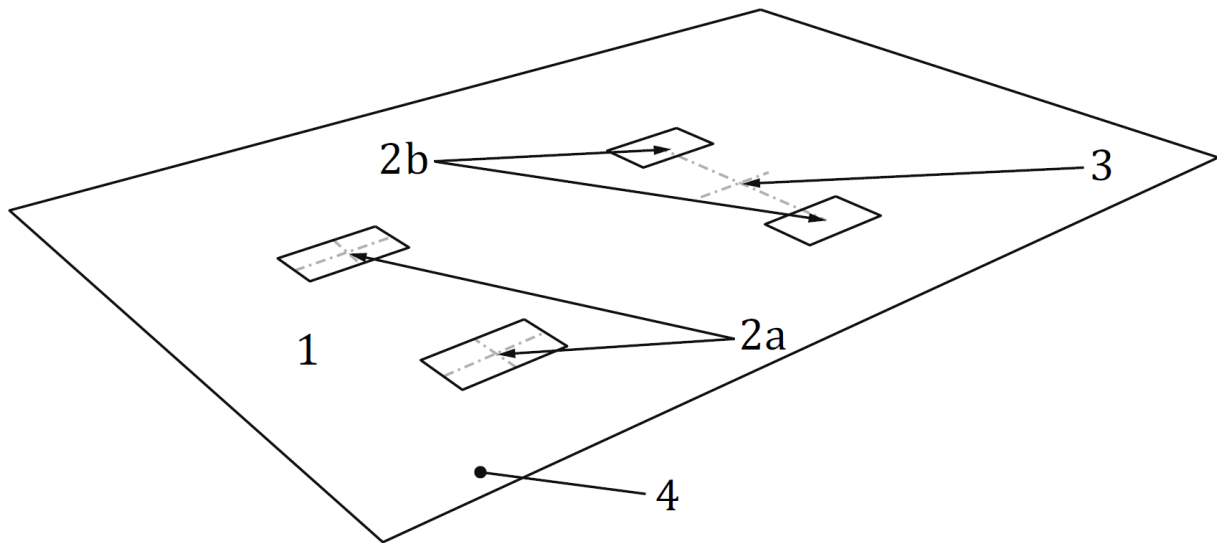
3.7.6

road plane

plane representing the *road surface* within the front tyre contact patches and the *vehicle road-level reference point*

Note 1 to entry: See Figure 4.

Note 2 to entry: For tyre contact patches, see ISO 8855:2011^[8], 4.1.5.



Key

- | | |
|----|--------------------------------------|
| 1 | vehicle front |
| 2a | vehicle's front tyre contact patches |
| 2b | vehicle's rear tyre contact patches |
| 3 | vehicle road-level reference point |
| 4 | vehicle road plane |

Figure 4 — Road plane

[SOURCE: ISO 8855:2011^[8], 2.7, modified — “tyre contact patch” was modified to “front tyre contact patches and the vehicle road-level reference point”, the figure has been added and the Notes to entry have been modified.]

3.7.7

road level

point related to a *road plane*

3.7.8

vehicle unsprung mass

unsprung mass

mass that is not carried by the suspension, but is supported directly by the tyres

[SOURCE: ISO 8855:2011^[8], 4.11, modified — The term “vehicle unsprung mass” has been added.]

3.7.9**vehicle sprung mass**

sprung mass

mass that is supported by the suspension, that is the total vehicle mass less the *vehicle unsprung mass*

[SOURCE: ISO 8855:2011^[8], 4.12, modified — The term vehicle sprung mass has been added and Note 1 to entry has been removed.]

3.7.10**vehicle rear-axle reference point**point fixed in the *vehicle sprung mass* and located at the centre of the rear-axle**3.7.11****vehicle sprung mass axis system**

axis system fixed in the *reference frame* of the *vehicle sprung mass*, so that the *X*-axis is substantially horizontal and forwards (with the vehicle at rest) and is parallel to the vehicle's longitudinal plane of symmetry, additionally the *Y*-axis is perpendicular to the vehicle's longitudinal plane of symmetry and points to the left with the *Z*-axis pointing upward

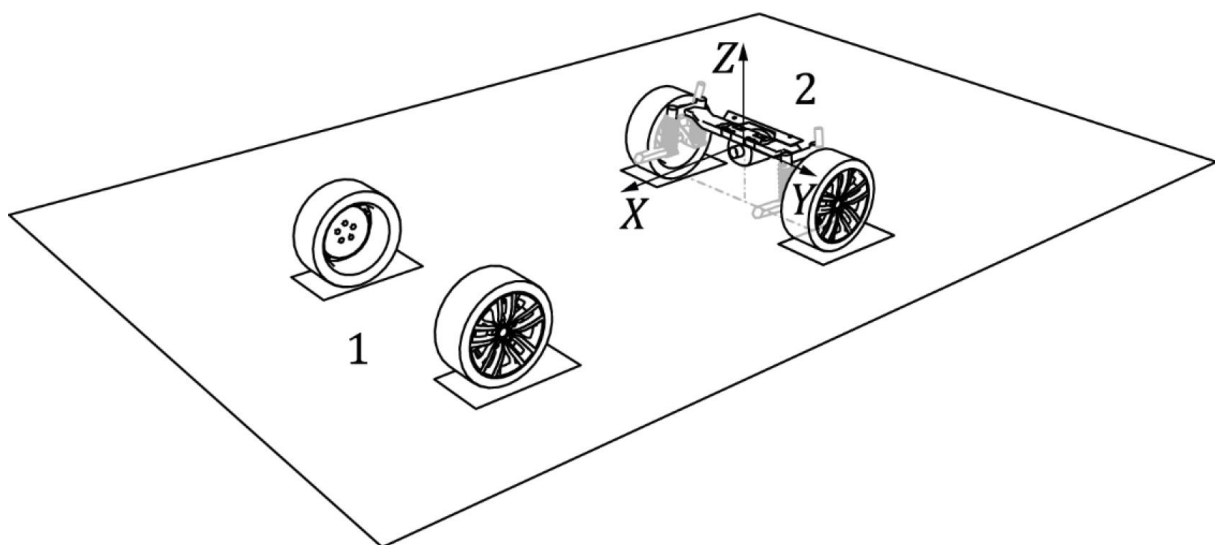
Note 1 to entry: The axis system is a set of three orthogonal directions associated with *X*, *Y* and *Z* axes.

3.7.12**vehicle rear-axle coordinate system**

cartesian coordinate system based on the *vehicle sprung mass axis system* with the origin located at the *vehicle rear-axle reference point*

Note 1 to entry: The vehicle rear-axle coordinate system is a *vehicle coordinate system*.

Note 2 to entry: See Figure 5.

**Key**

- 1 vehicle front
- 2 vehicle rear-axle reference point

Figure 5 — Vehicle rear-axle coordinate system

3.7.13**vehicle road-level reference point**point at *road level* located in the middle of the rear tyre contact patches

Note 1 to entry: For tyre contact patches, see ISO 8855:2011^[8], 4.1.5.

3.7.14

vehicle road-level axis system

axis system fixed in the *reference frame* of the *vehicle unsprung mass*, so that the *X*-axis is parallel to the vehicle's longitudinal plane of symmetry and points into forward moving direction and the *Y*-axis is perpendicular to the vehicle's longitudinal plane of symmetry and points to the left with the *Z*-axis pointing upward

Note 1 to entry: Vehicle road-level axis system's *XY*-plane is parallel to the ego-vehicle's *road plane*.

Note 2 to entry: The axis system is a set of three orthogonal directions associated with *X*, *Y* and *Z* axes.

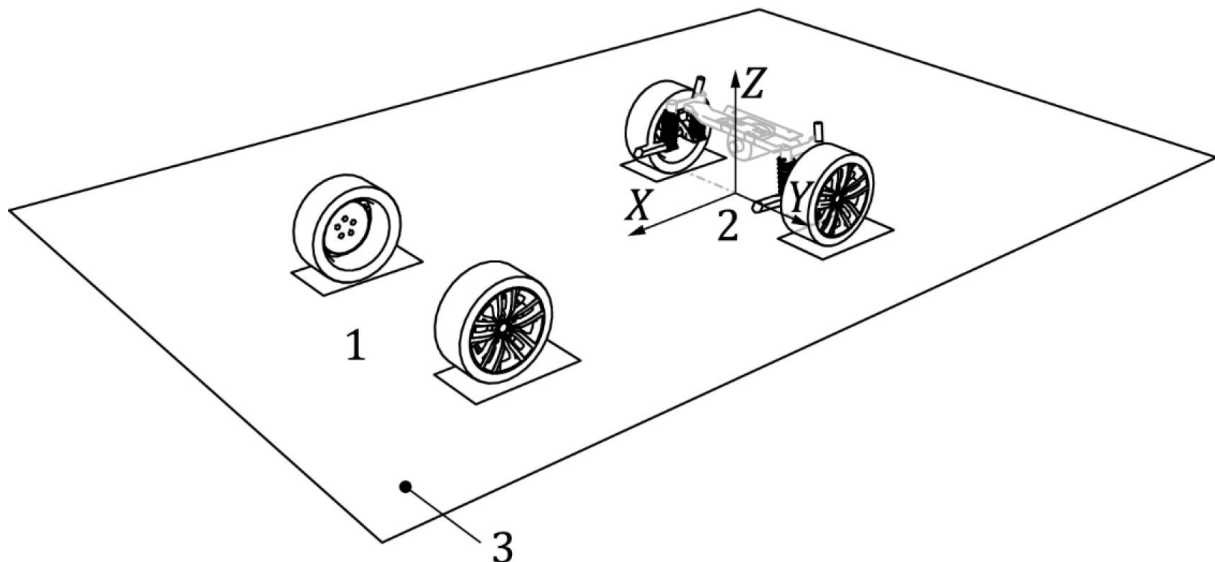
3.7.15

vehicle road-level coordinate system

cartesian coordinate system based on the *vehicle road-level axis system* with the origin located at the *vehicle road-level reference point* at the *vehicle road level*

Note 1 to entry: The vehicle road-level coordinate system is a *vehicle coordinate system*.

Note 2 to entry: See Figure 6.



Key

- 1 vehicle front
- 2 vehicle road-level reference point
- 3 vehicle road plane

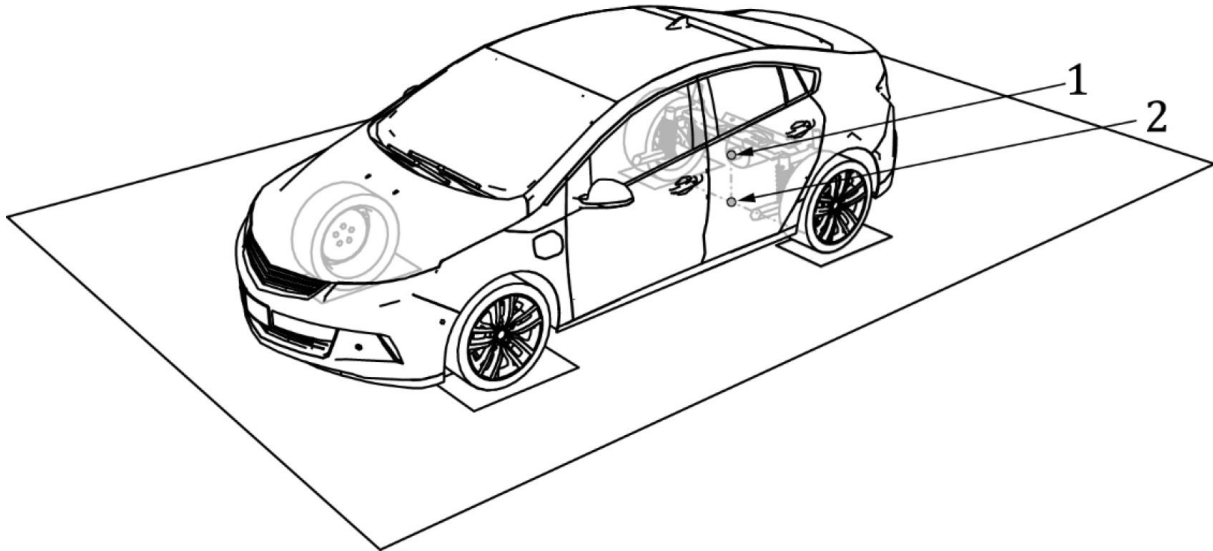
Figure 6 — Vehicle road-level coordinate system

3.7.16

vehicle coordinate system

cartesian coordinate system which is either the *vehicle rear-axle coordinate system* or the *vehicle road-level coordinate system*

Note 1 to entry: See Figure 7.



Key

- 1 vehicle rear-axle reference point of the vehicle rear-axle coordinate system
- 2 vehicle road-level reference point of the vehicle road-level coordinate system

Figure 7 — Vehicle coordinate systems

3.7.17

sensor axis system

axis system fixed in the reference frame of the sensor

Note 1 to entry: The *X*-axis [of a *cartesian coordinate system*] is in viewing direction of the sensor and the *Z*-axis pointing upward.

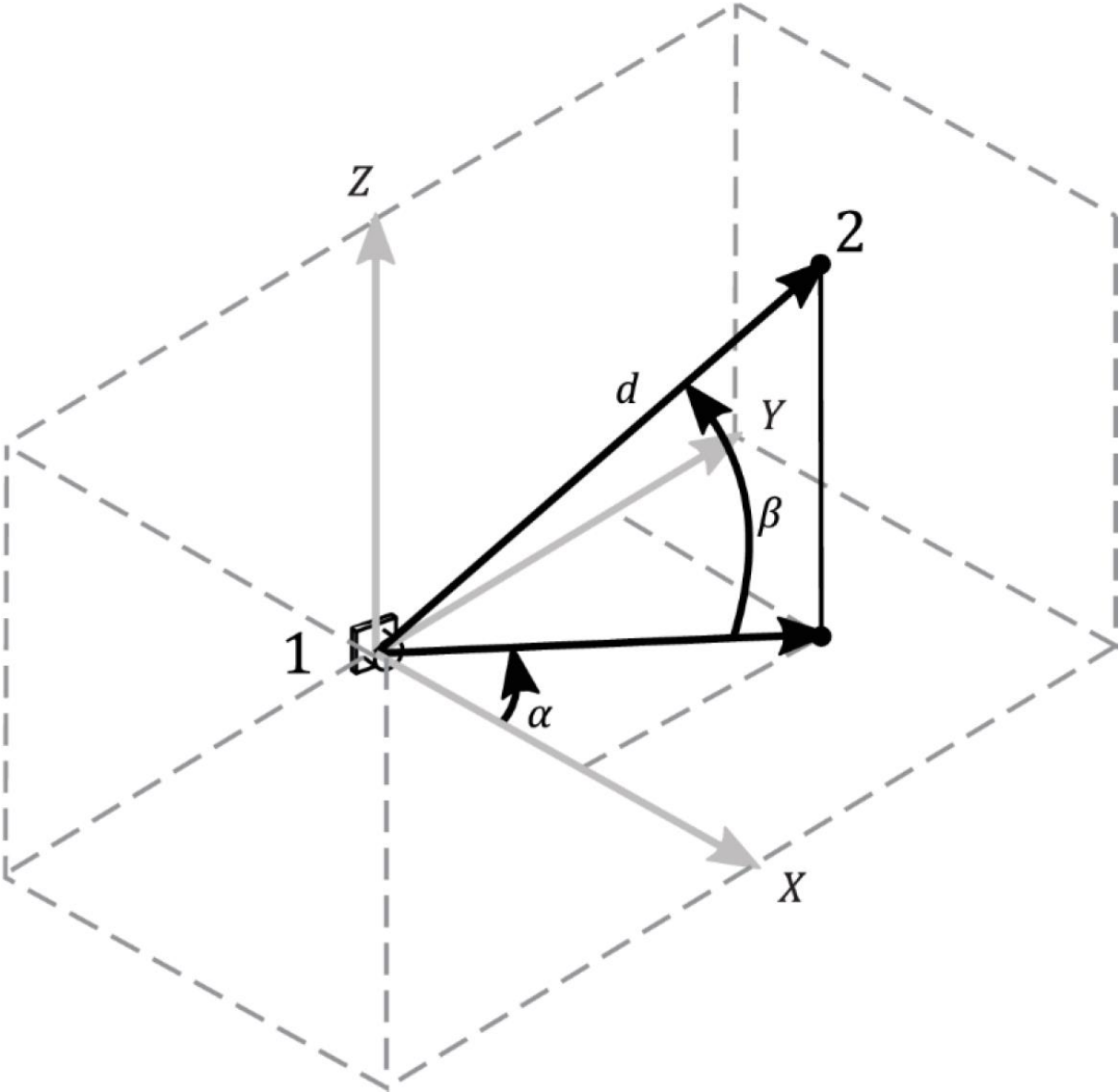
3.7.18

sensor coordinate system

spherical coordinate system based on the sensor axis system at a defined origin point of the sensor

Note 1 to entry: The origin point of the sensor coordinate system has to be selected in a way that *detections* could easily be specified in a spherical coordinate system. For example, the origin point of a camera sensor is the virtual projection centre of the camera's optics.

Note 2 to entry: See Figure 8.



Key	
1	sensor with origin point of the sensor coordinate system
2	detection
d	radial distance
α	azimuth angle
β	elevation angle

Figure 8 — Sensor coordinate system

3.7.19
affine coordinate system

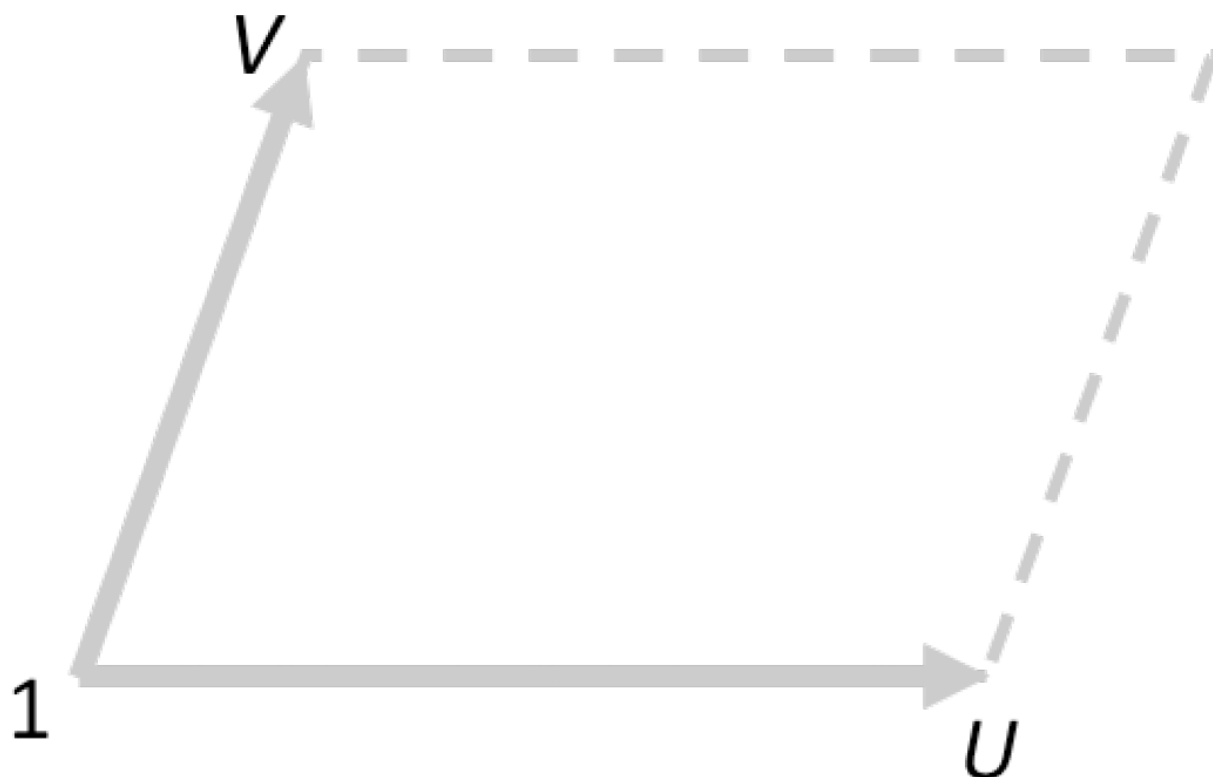
coordinate system of an *object* with an ordered set of non-collinear direction vectors (an affine basis) and a defined origin point

Note 1 to entry: The length of the direction vectors may not be normalised.

Note 2 to entry: For a planar affine coordinate system of an object, a pair of direction vectors (abscissa and ordinate) and an origin point are necessary to define the affine coordinate system.

Note 3 to entry: A right-handed *axis system* is assumed for a three-dimensional affine coordinate system (with the direction vectors abscissa, ordinate and applicate).

Note 4 to entry: See Figure 9.



Key

1	origin point of the affine coordinate system
<i>U</i>	<i>U</i> -axis – abscissa of the affine coordinate system
<i>V</i>	<i>V</i> -axis – ordinate of the affine coordinate system

Figure 9 — Affine coordinate system

4 Abbreviated terms

A2I	assign to interface
AD	automated driving
ADLI	advanced detection level interface
AER	alternative entity representation
C	conditional
D	dimensional
DE	default enumerators
DLI	detection level interface
ECU	electronic control unit

EES	extended enumeration signal
EM	error model
FLI	feature level interface
ID	identifier
IQR	interquartile range
IR	infrared
IV	implicit value
LL	list length
LSG	logical signal group
M	mandatory
O	optional
OLI	object level interface
RL	requirement level
SII	sensor input interface
SSI	supportive sensor interface
UTL	unrolling tuple list
VRO	value representation optimisation

5 Structure of the interface description

5.1 General

The scope of this document are the structure and generic definitions of logical interfaces of sensors and sensor clusters. Therefore, the following parts of this document and the document series use the term interface as a shortcut for the defined term “logical interface” (3.1.4). The interface descriptions use the following structure:

- a definition of interface templates by logical signal group (LSGs), signal names and requirement levels (RLs) (including conditional requirements), additional options and profiles used for interfaces in other parts of the document series;
- a description of generic signals in Annex A;
- generic options and generic conditional requirements in Annex B, which shall be used.

The concretisation of interfaces are defined in other documents of the document series.

The requirement level attribute “conditional” shall be an element used in the document series.

The logical interlink as well as complex dependencies between signals shall be defined in a profile subclause that applies to one or several interfaces.

5.2 Signal and enumeration

Table 1 provides a template of a signal definition used by an interface or several interfaces. The template of an interface definition is provided in subclause "Interface" (5.3). All commonly used signals are specified in Annex A of this document. Signals of specific interfaces are defined in the interface's document in Annex A. Signal names shall be unique in the document series. Similar signals on different interface levels have the interface level, for different technologies have the technology and so forth added to the signal name to guarantee a unique signal naming. Signals which are deprecated are marked with the key word "DEPRECATED:" in the signal name. Signals which are marked as deprecated will be removed in the next edition of the document.

Table 1 — Signal: <Signal name>

Name	Name of the signal and optional list of signal identifiers Each signal respectively signal identifier is implemented by exactly one value.		
Description	Definition of the signal		
Value type	Definition of the signal's value type and optionally the number of values, specifically the number of dimensions defined by the number of identifiers (default dimension: 1D vector)	Unit	Unit definition of the signal value In this document, the unit defines no application or network representation of the signal value (for example, a scaling factor, a fix point representation, linear or non-linear increasing values).

In general, for each signal with value type "enumeration", a list of mandatory enumerators (see Table 2) is defined in an additional table in Annex A. The implementation of an enumeration list shall contain all the supported mandatory enumerators (at least one mandatory enumerator). When defining the enumerators it shall be taken care, that they are unique and there is no overlap of the categories of two lists. The lists must be cut in a way that only one item per list shall be selected to fully describe the lists category. Signals with enumeration lists may be used commonly for different interfaces.

Table 2 — <Signal name> - Mandatory enumeration

Name	Description
<...> ^b _Unknown ^a	Standard enumerator used if no classification is possible.
<...>_Other ^a	Standard enumerator used for a classification with a high confidence that the available enumerators do not apply.
<...>_<...> ^c	Definition of the enumerator. Specific enumerator(s) for (a) recognized classification(s). Each specific mandatory enumerator may reference an exemplary enumeration list (see Table 3).
^{aa} For a complete description of the standard enumerators see B.1.7. ^{bb} The signal name is abbreviated in the name of the enumerator as prefix of all enumerators. ^{cc} Name of the enumerator.	

Each of the mandatory enumerators may be extended by an exemplary enumeration list (see Table 3), which is informative. During the system design phase an exemplary enumeration for the enumerator "<...>_Other" of the mandatory enumeration list may be defined. During the system design phase, additionally to the predefined mandatory enumeration list, a specific enumeration list extension based on the exemplary enumerators shall be defined (see B.1.8).

Table 3 — <...>_<...> - Exemplary enumeration

Name	Description
<...>_<...>_<...> ^{aa}	Specific exemplary enumerator(s) for (a) recognized mandatory enumerator " <...>_<...> ".
^{aa} Name of the enumerator. The signal name is abbreviated in the name of the enumerator as prefix of all enumerators. The referenced mandatory enumerator is abbreviated in the name of the exemplary enumerator as prefix of all exemplary enumerators.	

5.3 Interface

Table 4 provides an overview of a logical interface. An interface is comprised of signals. Signals can be part of a logical signal group (LSG) for ease of logical grouping.

Table 4 — Interface: <Interface name>

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Name of the logical signal group (LSG) – for a logical group of multiple signals	Requirement level for LSG: mandatory , conditional or optional Conditional RL with a reference to a clause in Annex B	Name of the signal, optional: {list of signal identifiers} with a reference to a clause in Annex A	Requirement level for signal: mandatory , conditional or optional is specified for the signal, including all signal identifiers, or for each signal identifier individually Conditional RL with a reference to a clause in Annex B	Additional options for the signal: — a reference to a clause in Annex B — a reference to a profile subclause

Areas in the interface table marked in grey indicate that the enclosed signals are part of a list of entities. The valid number of entities is defined at the beginning of the grey area (specifically, grey area header).

If an interface provides multiple interface entity types (for example, the road object interface provides road surface, road markings and road boundaries), the interface may require not all entity types at once (see specified in B.2.3). Different entry types of an interface are separated with a thick line.

A conditional LSG requirement level shall define the conditions. Under all other conditions, the LSG is optional [see the definition conditional (3.5.1)].

An LSG shall have at least one signal that is mandatory. If a signal of an optional LSG is used, all signals of the LSG shall be considered as defined on their signal requirement levels.

In case of a list, the requirement level of the signal “Number of valid <...>” and its LSG are the base requirement level of all signals in the list. The symbol “↪” indicates that LSG belongs to another LSG, that means the LSG is a nested LSG.

For a signal with signal identifiers and only one defined signal requirement level, the requirement level of each signal identifier individually corresponds to the requirement level for the signal.

Signals with RL mandatory and static, fixed or redundant values, which are defined during the system design phase and/or are implicitly known by the sensor and the fusion unit may be optimised. In this case the applicability of optimisation methods of Clause B.1 are allowed which essentially means that, for example, the mandatory signals will not be explicitly transferred by the interface message. During the system design phase,

additional measures from Annex B are applicable and shall be defined for the sensor as well as the sensor cluster.

5.4 Specific signal grouping

Table 5 provides an overview of a specific signal grouping, for example, the header LSGs, which refers a specific signal grouping of another subclause and extends the specific signal grouping to achieve similar interfaces.

Table 5 — Specific signal grouping: <Title of the specific signal grouping>

Signal	RL signal M/C/O	Option
Name of the signal, optional: {list of signal identifiers} with a reference to a clause in Annex A	Requirement level for signal: mandatory, conditional or optional is specified for the signal, including all signal identifiers, or for each signal identifier individually Conditional RL with a reference to a clause in Annex B Optional: information of the RL for the signal's LSG, if it is not mandatory	Additional options for the signal: — a reference to a clause in Annex B — a reference to a profile subclause

The symbol “↪” indicates that the signal belongs to a list of signals.

Unchanged, inherited signals, signal requirement levels and signal options of the referenced subclause's specific signal grouping are marked in grey.

5.5 Profile

If multiple signals of an interface have an interface-specific semantic interdependency, this interdependency is described in a profile subclause and additional complex conditions are defined. Each signal which is contained in the profile has an annotation of the profile in the signal's option-column definition of the interface (see column “Option” in Table 5). The use of a profile in an interface is noted in the interface's option-column (see column “Option” in Table 4). A single signal, which is used in different interfaces, may be defined as a profile.

6 Logical interface from a sensor as well as a sensor cluster to a fusion unit

6.1 General

The aim of this document is to support different levels of fusion. Therefore, the document provides four logical interface levels (object-, feature-, advanced detection-, detection level). Supportive sensor interfaces (SSI) complement the interfaces of the logical interface levels. Objects, features, advanced detections, detections and supportive sensor information are the basis for a fusion unit. A tracking algorithm within the sensor solely or the sensor cluster using their own information, results in objects or advanced detections with limited quality. The fusion unit can improve these and is able to merge the information on different levels, using object-level fusion as well as feature-, advanced detection- and/or detection-level fusion. In order to perform object-level fusion from a sensor suite ¹⁾, sufficient evidence in the form of correlated entities of lower interface levels belonging to a particular real-world entity shall be provided by each sensor and sensor cluster. An advantage of feature-level fusion is the possible creation of an object in the common fusion unit out of objects, features, advanced detections or detections coming from a sensor suite, which would not have resulted in an object recognition within each sensor or each sensor cluster itself. Detection-level fusion may use machine

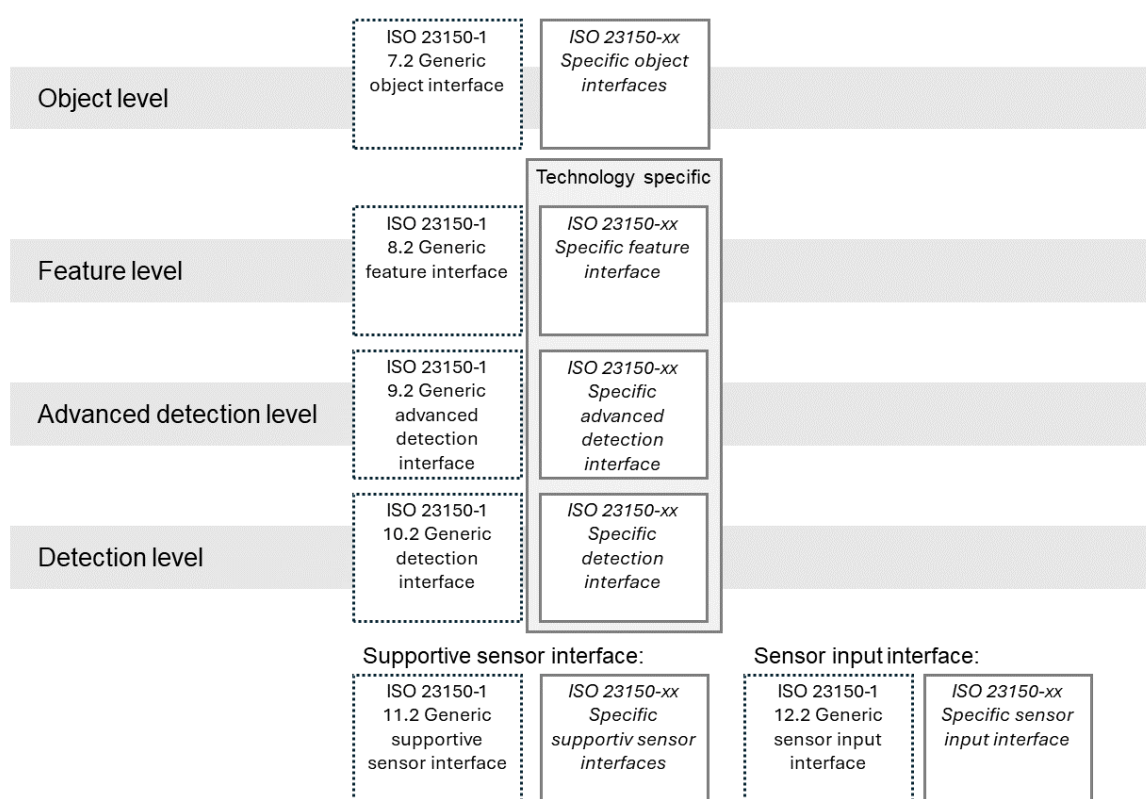
¹⁾ It consists of two or more different and independent sensors or sensor clusters.

learning algorithms to handle complexity. Future vehicles will integrate a sensor suite with many sensors and sensor clusters using different sensor technologies. Different technologies will complement each other to achieve a robust and reliable fusion.

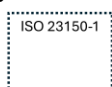
Supportive sensor interfaces are provided so that the fusion is able to process the reliability of the used measurement method or data. These interfaces are sensor technology independent, specifically there are uniform interfaces for various sensor technologies. These supportive sensor interfaces are also used for the implementation of safety concepts.

Additional sensor input interfaces are used to provide data and parametrise the sensors or the sensor cluster from other devices via the in-vehicle communication.

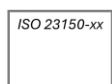
Figure 10 shows the generic interfaces that are in the scope of this document.



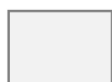
Key



Generic interface in scope of this document



Specific interface in scope of other documents of the document series



Technology specific clustering of interfaces in a single document of the document series

Figure 10 — Interfaces in the scope of this document and the document series

This document provides generic logical interface definitions for all interface levels and extra interfaces. The definitions are the basis for all other documents of the document series.

A sensor as well as a sensor cluster can provide several logical interfaces. They can provide none, one or several interfaces on object level. Additionally, a sensor as well as a sensor cluster can provide sensor technology specific interfaces on feature-, advanced detection- as well as detection level. Each sensor as well as each sensor cluster shall provide at least one interface either on object-, feature-, advanced detection- or detection level to fulfil this document. Supportive sensor interfaces can be provided optionally. Sensors and sensor clusters may serve interfaces on all levels. Sensors mainly serve detection level interfaces (DLIs) and/or advanced detection level interfaces (ADLIs). Sensor clusters mainly serve feature level interfaces (FLIs) and/or object level interfaces (OLIs). Sensor clusters are based on sensors and therefore, sensor clusters without a group of defined sensors should be avoided. If a sensor cluster offers no DLIs and ADLIs, the sensor cluster can be considered as a single sensor with multiple sensing elements. A sensor cluster provides consistent data over all its interfaces. The fusion unit is not required to use each provided interface of the sensor or sensor cluster. The provided interfaces can be used by other applications (for example, AD functions), not only by the fusion unit alone.

The relation between the entities of different interfaces are shown in Figure 11.

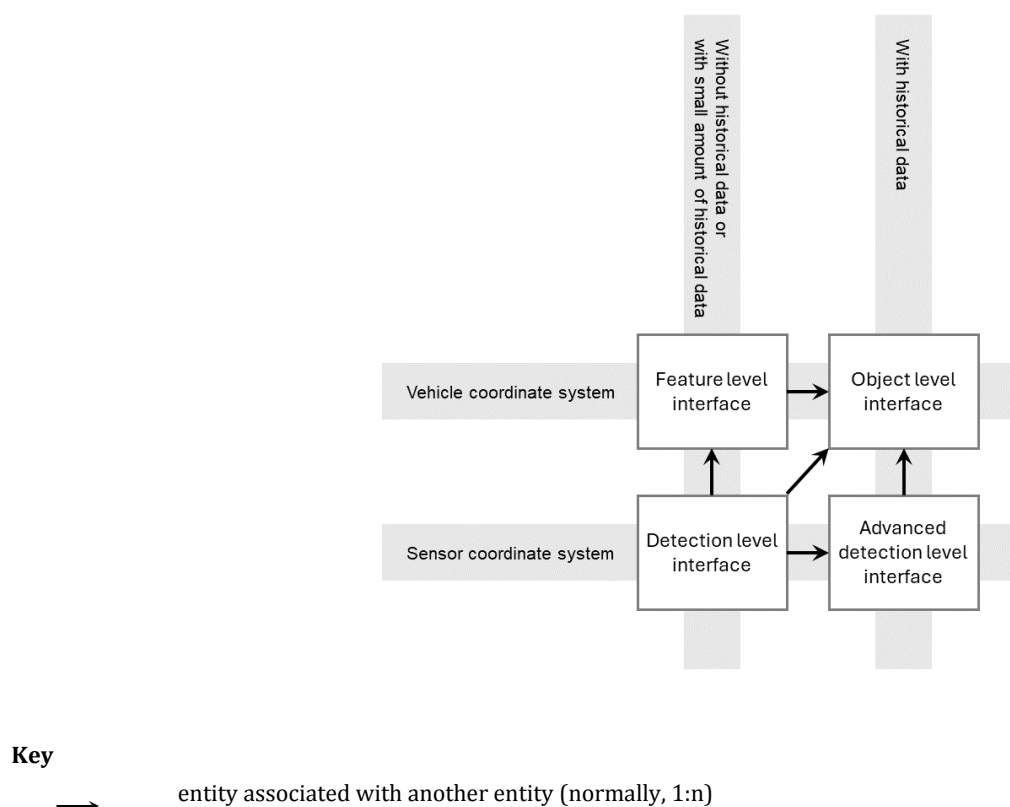


Figure 11 — Relations between the interfaces

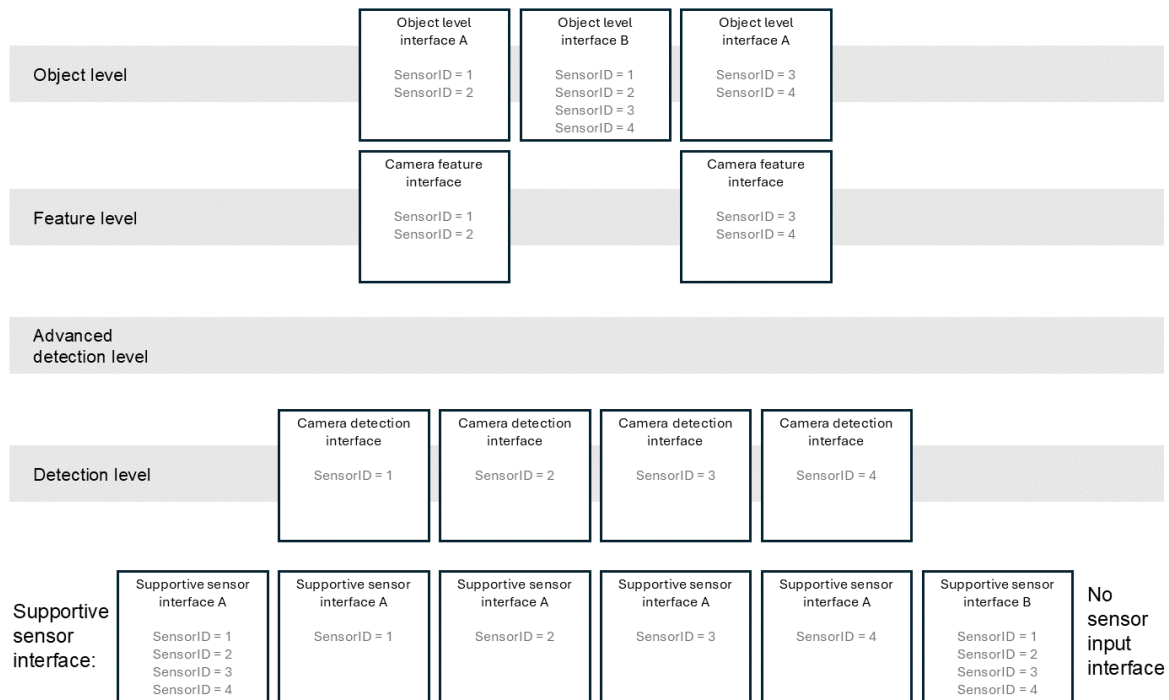


Figure 12 — Example of a camera sensor cluster and its sensor and sensor cluster interfaces

In Figure 12, sensor 1, sensor 2, sensor 3, sensor 4 and sensor sub-cluster {1, 2} and {3, 4} belong to the sensor cluster {1, 2, 3, 4}. The information of all sensors and sensor clusters belongs together and may be referenced between the interfaces. In this example, different combinations of sensors provide interfaces:

- the sensor cluster with the list of the signal “Sensor ID” (A.1.4) values {1, 2, 3, 4} provides one object level interface "Object level interface B" (for example an object interface for static objects) and two supportive sensor interfaces "Supportive sensor interface A" and "Supportive sensor interface B" (for example, supportive sensor interfaces about sensor performance and sensor health information);
- the sensor sub-cluster with the list of the signal “Sensor ID” (A.1.4) values {1, 2} provides one object level interface "Object level interface A" (for example an object interface for potentially moving objects) and one feature level interface (camera feature interface);
- the sensor sub-cluster with the list of the signal “Sensor ID” (A.1.4) values {3, 4} provides one object level interface "Object level interface A" (for example an object interface for potentially moving objects) and one feature level interface (camera feature interface);
- the sensors with signal “Sensor ID” (A.1.4) value 1, 2, 3 or 4 provide each a detection level interface (camera detection interface) and a supportive sensor interface "Supportive sensor interface A" (for example a supportiv sensor interface about sensor performance);
- the sensor or sensor cluster provides no further interface, for example, other object level interfaces or an additional detection level interface;
- the sensor or sensor cluster may not receive a sensor input interface.

6.2 Generic interface

6.3 Generic interface header

Table 6 defines the structure of the “Generic interface header” (6.3) as a specific signal grouping. This header is used by each interface of the document series and is adapted or extended accordingly. However, all the interface headers have at least these or similar signals.

Table 6 — Specific signal grouping: Generic interface header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.5.1)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.5.1)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.5.1) Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Sensor ID (A.1.4)
↪ Sensor ID (A.1.4)	Mandatory	Profile: Uniqueness of interface versioning (6.5.1) Alternative VRO (B.1.3)
Time stamp – <...> (A.1.5)	Mandatory	
<...> counter (A.1.6)	Optional	Redundancy (B.1.2) Signal: Time stamp – <...> (A.1.5)
Interface cycle time (A.1.7)	Optional	
Interface cycle time – variation (A.1.8)	Optional	
Data qualifier (A.1.9)	Mandatory	Default enumerators (B.1.7)
... ^a		Need of logical signal group (B.3.3) Profile: Vehicle coordinate system (6.5.3) Profile: Sensor pose (6.5.4) Profile: Calibration (6.5.5) Profile: Sensor cluster (6.5.6)
^{aa} Further signals of "Need of logical signal group" (B.3.3) profiles may be added to this header (see cell “Options”).		

The generic interface structure (see Table 7) consists of the interface header and a list of entities for each of the entity types of the interface .

Table 7 — Generic interface structure

Structure	Multiplicity	Option
Specific signal grouping: Generic interface header (Table 6)	1	
List of entities of an entity type	Multiple	Size type: dynamic/fixed
^a		
^{aa} Optional additional entity types of the interface		

Each entity type has an generic entity type header (see Table 8).

Table 8 — Specific signal grouping: Entity type header

Signal	RL signal	Option
Recognised <...> – capability (A.1.10)	Optional	
Recognised <...> – status (A.1.11)	Optional	Redundancy (B.1.2) Signal: Recognised <...> – capability (A.1.10) Default enumerators (B.1.7)
Number of valid <...> (A.1.12)	Mandatory	Optimise LL (B.1.1)

6.4 Generic interface entity

The interface entities define the set of signals to define a specific entity type without the header signals of the interface (see 6.3). Normally, a logical interface provides at least one interface specific entity type of entities. Interfaces may only provide specific entity types with exact one entity per cycle. The number of valid entities of each interface entity type list is defined by the signal “Number of valid <...>” (A.1.12) (see Table 8). Implementations of interfaces with multiple entity types may not implement all interface entity type lists [see (B.2.3) for conditional entity types]. The signals “Recognised <...> – capability” (A.1.10) and “Recognised <...> – status” (A.1.11) determine the minimal performance of the sensor for the interface entity type list, for example, at full load (see Table 8).

6.5 General level-independent profiles

6.5.1 Profile: Uniqueness of interface versioning

The concatenation of the signal’s “Interface version ID {major, minor, patch}” (A.1.1) value, the signal’s “Interface ID” (A.1.2) value and the signal’s “Sensor ID” (A.1.4) values of a provided interface is a unique identifier for the interpretation of the interface message implementation. The signal “Number of valid serving sensors” (A.1.3) is also included. The order of the signal’s “Sensor ID” (A.1.4) values is also relevant. If a sensor could provide an interface more than once, this profile is adjusted in the corresponding interface to distinguish each interface implementation of one interface. The uniqueness of interface versioning is achieved using the signal grouping of Table 9. This profile is used on OLI, FLI, ADLI, DLI and SSI.

Table 9 — Signal grouping: Uniqueness of interface versioning

Signal	RL signal M/C/O	Option
Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning (6.5.1)
Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning (6.5.1)
Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning (6.5.1) Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Sensor ID (A.1.4)
Size type: dynamic/fixed Size #: Number of valid serving sensors (A.1.3)		
Sensor ID (A.1.4)	M	Profile: Uniqueness of interface versioning (6.5.1) Alternative VRO (B.1.3)

Sensor input interfaces define a profile for uniqueness of interface versioning (see “Profile: Uniqueness of interface versioning of SII” 12.5.1).

6.5.2 Profile: Colour model

The profile is relevant for camera sensor technology (B.2.1). The signal “Colour model type” (A.1.13) defines the unique colour model for the interface. The signal is provided in the header (see Table 10). This profile is used on OLI, FLI and DLI.

Table 10 — Required header signal for colour model

Signal	RL signal M/C/O	Option
Colour model type (A.1.13)	M	Profile: Colour model (6.5.2) Alternative VRO (B.1.3) Use enumeration to define colours by defining colour values and the applied colour model for each enumerator. Default enumerators (B.1.7)

The signal grouping of a colour tone for an entity's attribute is listed in Table 11. Depending on the colour model, each colour tone is described by a fixed number of colour values [see signal “Colour value” (A.2.17)] to define the colour tone. The confidence of the colour tone is provided by the signal “Colour tone – confidence” (A.2.18).

Table 11 — Signal grouping: Colour tone

Signal	RL signal M/C/O	Option
Size type: dynamic/fixed Size #: Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.13)		
Colour value (A.2.17)	M	Profile: Colour model (6.5.2)
Colour tone – confidence (A.2.18)	O	Profile: Colour model (6.5.2)

6.5.3 Profile: Vehicle coordinate system

The signal grouping profile “Vehicle coordinate system” (see Table 12) is provided by the sensor or sensor cluster. An interface of SSI provides the signal grouping. If the interface is not provided by the sensor or sensor cluster, the signal group may be provided by another SSI or redundant by OLI, FLI, ADLI and DLI. The profile is noted in the headers of the concerning interfaces. This is a “Need of logical signal group” (B.3.3) relevant profile and it is mandatory for a sensor or sensor cluster.

Table 12 — Signal grouping: Vehicle coordinate system

Signal	RL signal M/C/O	Option
Vehicle coordinate system type (A.2.1)	M	Profile: Vehicle coordinate system (6.5.3) Optimise IV (B.1.5)

6.5.4 Profile: Sensor pose

The signal grouping profile “Sensor pose” (see Table 13) is provided by the sensor or sensor cluster. An interface of SSI provides the signal grouping. If the interface is not provided by the sensor or sensor cluster, the signal group may be provided by another SSI or redundant by OLI, FLI, ADLI and DLI. The profile is noted

in the headers of the concerning interfaces. This is a "Need of logical signal group" ([B.3.3](#)) relevant profile and it is mandatory for a sensor or sensor cluster.

Table 13 — Signal grouping: Sensor pose

Signal	RL signal M/C/O	Option
Sensor origin point {x, y, z} (A.2.2)	M	Profile: Sensor pose (6.5.4)
Sensor origin point {x, y, z} – error (A.2.3)	O	Profile: Sensor pose (6.5.4) Implementation EM (B.4.1)
Sensor orientation {yaw, pitch, roll} (A.2.4)	M	Profile: Sensor pose (6.5.4)
Sensor orientation {yaw, pitch, roll} – error (A.2.5)	O	Profile: Sensor pose (6.5.4) Implementation EM (B.4.1)

6.5.5 Profile: Calibration

The signal grouping profile "Calibration" (see Table 14) is provided by the sensor or sensor cluster. An interface of SSI provides the signal grouping. If the interface is not provided by the sensor or sensor cluster, the signal group may be provided by another SSI or redundant by OLI, FLI, ADLI and DLI. The profile is noted in the headers of the concerning interfaces. This is a "Need of logical signal group" (B.3.3) relevant profile and it is optional for a sensor or sensor cluster unless defined otherwise during the system design phase.

Table 14 — Signal grouping: Calibration

Signal	RL signal M/C/O	Option
Number of valid sensor-calibratable components (A.2.6)	M	Profile: Calibration (6.5.5) Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Sensor-calibratable component (A.2.7)
Size type: Dynamic/fixed Size #: Number of valid sensor-calibratable components (A.2.6)		
Sensor-calibratable component (A.2.7)	M	Profile: Calibration (6.5.5) Alternative VRO (B.1.3) Default enumerators (B.1.7)
Sensor calibration status (A.2.8)	M	Profile: Calibration (6.5.5) Default enumerators (B.1.7)
DEPRECATED: Sensor origin point – correction {x, y, z} (A.2.9)	O	Profile: Calibration (6.5.5)
DEPRECATED: Sensor origin point – correction {x, y, z} – error (A.2.10)	O	Profile: Calibration (6.5.5) Implementation EM (B.4.1)
DEPRECATED: Sensor origin translation – correction limit {x _{begin} , x _{end} , y _{begin} , y _{end} , z _{begin} , z _{end} } (A.2.11)	O	Profile: Calibration (6.5.5)
DEPRECATED: Sensor orientation – correction {yaw, pitch, roll} (A.2.12)	O	Profile: Calibration (6.5.5)
DEPRECATED: Sensor orientation – correction {yaw, pitch, roll} – error (A.2.13)	O	Profile: Calibration (6.5.5) Implementation EM (B.4.1)

Signal	RL signal M/C/O	Option
DEPRECATED: Sensor pose angle – correction limit {yaw _{begin} , yaw _{end} , pitch _{begin} , pitch _{end} , roll _{begin} , roll _{end} } (A.2.14)	O	Profile: Calibration (6.5.5)

6.5.6 Profile: Sensor cluster

The signal grouping profile "Sensor cluster" (see Table 15) is provided by the sensor or sensor cluster. An interface of SSI provides the signal grouping. If the interface is not provided by the sensor or sensor cluster, the signal group may be provided by another SSI or redundant by OLI, FLI, ADLI and DLI. The profile is noted in the headers of the concerning interfaces. This is a "Need of logical signal group" (B.3.3) relevant profile and it is optional for a sensor or sensor cluster unless defined otherwise during the system design phase.

Table 15 — Signal grouping: Sensor cluster

Signal	RL signal M/C/O	Option
Number of valid sensors (A.2.15)	M	Profile: Sensor cluster (6.5.6)
Size type: Dynamic/fixed Size #: Number of valid sensors (A.2.15)		
Sensor ID reference (A.2.16)	M	Profile: Sensor cluster (6.5.6)

6.5.7 Profile: Observations

The profile "Observation" provides the history of the tracking. An entity can be, for example, tracked, verified or estimated over several measurements. For a limited number *n* of the last time steps the history over the tracking's property is provided. This profile is used on OLI and FLI.

Table 16 — Signal grouping: Observations

Signal	RL signal M/C/O	Option
Age (A.2.19)	M	Profile: Observations (6.5.7)
Number of valid observations (A.2.20)	O	Profile: Observations (6.5.7) Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.21)
Size type: dynamic/fixed Size #: Number of valid observations (A.2.20)		
Time stamp reference (A.2.21)	M	Profile: Observations (6.5.7) Alternative VRO (B.1.3)
Observation status (A.2.22)	M	Profile: Observations (6.5.7) Redundancy (B.1.2) Signal: Object ID (A.3.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)

6.5.8 Profile: Shape classification

Shapes are observed and classified on different interface levels. The required signal grouping is listed in Table 17. This profile is used on FLI, ADLI and DLI.

Table 17 — Signal grouping: Shape classification

Signal	RL signal M/C/O	Option
Number of valid shape classifications (A.2.23)	M	Profile: Shape classification (6.5.8) Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Shape classification type – ()
Size type: dynamic/fixed Size #: Number of valid shape classifications (A.2.23)		
Shape classification type (A.2.24)	M	Profile: Shape classification (6.5.8) Alternative VRO (B.1.3) Default enumerators (B.1.7)
Shape classification type – confidence (A.2.25)	M	Profile: Shape classification (6.5.8) Default enumerators (B.1.7)

6.5.9 Profile: Shape type <coordinate system>

A shape is defined by vertex points. Additionally the polyline interpolation method shall be defined in the interface, preceding this signal grouping (see Table 18). This profile is used on OLI, FLI and DLI.

Table 18 — Required signal for polyline and shape

Signal	RL signal M/C/O	Option
Polyline interpolation method (A.2.26)	M	Profile: Shape type <coordinate system> (6.5.9) Default enumerators (B.1.7)

The logical signal grouping is listed in Table 19.

Table 19 — Signal grouping: Shape type <coordinate system>

Signal	RL Signal M/C/O	Option
Shape type (A.2.27)	M	Profile: Shape type <coordinate system> (6.5.9) Default enumerators (B.1.7)
Number of valid vertices (A.2.28)	M	Profile: Shape type <coordinate system> (6.5.9) Optimise LL (B.1.1)
Size type: dynamic/fixed Size #: Number of valid vertices (A.2.28)		
Vertex point <coordinate system> (A.2.29)	{M, M, O}	Profile: Shape type <coordinate system> (6.5.9)

Signal		RL Signal M/C/O	Option
	Vertex point <coordinate system> – error (A.2.30)	{M, M, O}	Profile: Shape type <coordinate system> (6.5.9) Implementation EM (B.4.1)
	Vertex point <coordinate system> – confidence (A.2.31)	O	Profile: Shape type <coordinate system> (6.5.9)
	a		
^{aa} If additional information , for example "Extent {width, height} – vertex" (A.2.123), is added, it must be specified whether the information is valid at the "Vertex point <coordinate system>" (A.2.29) or in-between two adjacent vertices.			

6.5.10 Profile: Road properties

The road properties are defined using the signal grouping of Table 20. This profile is used on OLI, DLI and SII.

Table 20 — Signal grouping: Road properties

Signal	RL signal M/C/O	Option
Road property type (A.2.32)	O	Profile: Road properties (6.5.10) Default enumerators (B.1.7)
Road surface condition classification type (A.2.33)	O	Profile: Road properties (6.5.10) Default enumerators (B.1.7)
Road surface feature (A.2.34)	O	Profile: Road properties (6.5.10) Default enumerators (B.1.7)

7 Object level

7.1 General

The object level interfaces (OLI) originate from several sensors. Therefore, at object level, the term sensor cluster is always used, even if a single sensor is serving the interface. The OLIs provide recognised real-world entities and recognition is based on historical data. Recognised objects are tracked and filtered over time. Model-based algorithms classify these objects and rate them with an existence probability value. The sensor cluster refers its recognised objects to one of two predefined vehicle coordinate systems [see signal "Vehicle coordinate system type" (A.2.1)]. The properties, and therefore the signals of the recognised objects, are generally independent of the sensor cluster's sensor technology. Additional properties of the recognised objects can depend on the sensor technology and complement the object description of the interface. These sensor technology dependent signals are grouped in LSGs for each sensor technology.

To link recognised objects with non-OLI interface entities of the sensor cluster or its sensors, each recognised object has a unique signal's "Object ID" (A.3.2) value that does not change over time and which is referenced by these entities. The signal's "Object ID" (A.3.2) value can only be reused after the object has not been recognised for a defined amount of time and the sensor cluster and the fusion unit are therefore certain that the object is no longer visible. Specifically, a reidentification of a previous recognised object with the same signal's "Object ID" (A.3.2) value, after it has not been visible to the sensor cluster for some time, is not guaranteed.

To link recognised objects of the sensor cluster's OLIs, the set of related objects use the same consistent unique signal's "Object grouping ID" (A.3.3) value to link all related objects. One dedicated value may indicate that the object is not linked to another object.