BS ISO 23150:2023

BSI Standards Publication

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

National foreword

This British Standard is the UK implementation of ISO 23150:2023. It supersedes BS ISO 23150:2021, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee AUE/16, Data Communication (Road Vehicles).

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2023

ISBN 978 0 539 18483 9

ICS 43.040.15

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 June 2023.

Amendments/corrigenda issued since publication

Date	Text affected

BS ISO 23150:2023

INTERNATIONAL STANDARD

ISO 23150

Second edition
2023-05

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

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

Reference number
ISO 23150:2023(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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:

— extension of the potentially moving object interface at object level (extension of the logical signal group person);

— update of the road object interface at object level (extension of the road marking sign);

— extension of the static object interface at object level (extension of the entity type traffic sign; addition of new entity type traffic sign board);

— addition of new free space area interface at object level;

— extension of the camera detection interface at detection level (addition of new entity type point; update of existing entity type shape);

— addition of new interfaces group/layer – sensor input interface (addition of new generic sensor input interface; addition of new common sensor input interface);

— extension of the error model (addition of covariances, cross-covariances and time series as error model implementation);

— refinement of the terms, for example, value as measured-, tracked- and predicted quantity value;

— new measures to link signals with their origin, that means linking signals at object level with, for example, detection entities;

— harmonisation of the document, for example, to achieve a better readability;

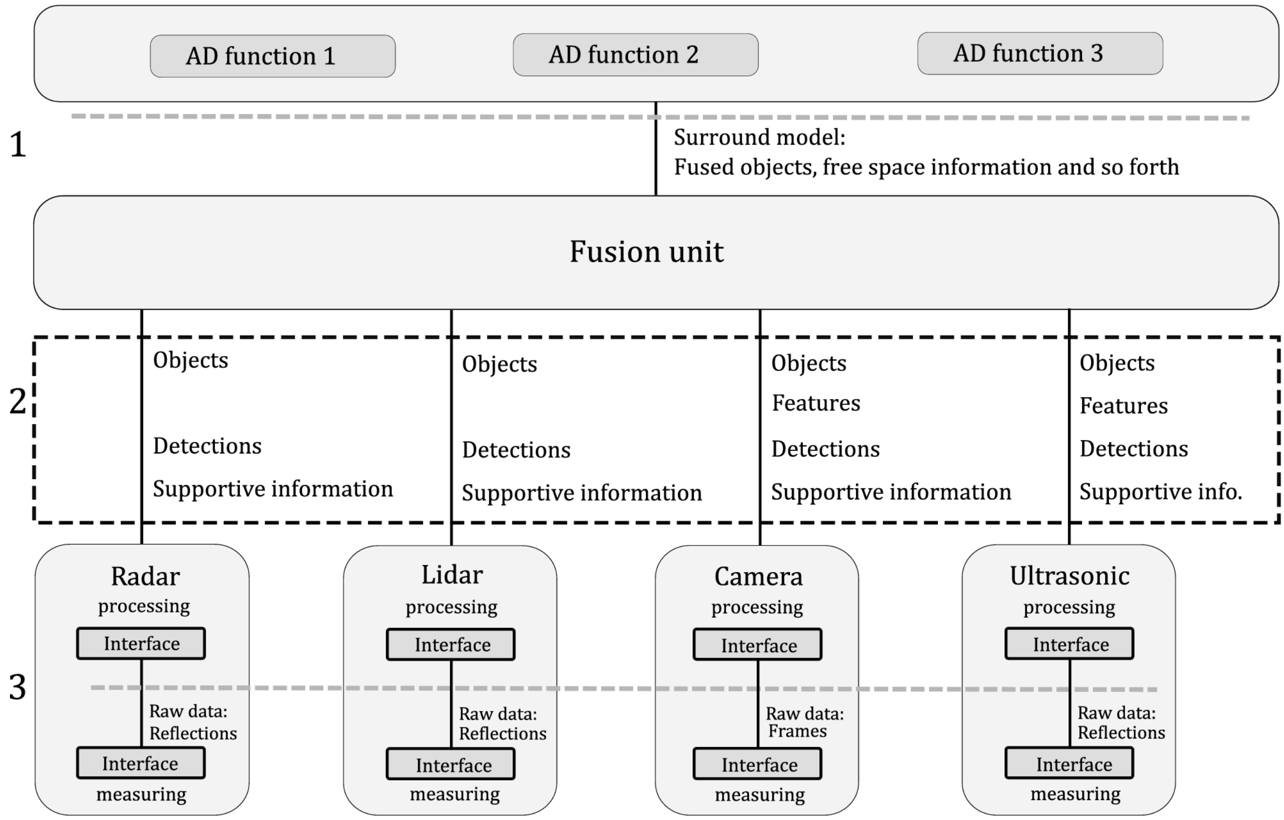
— update and add figures for clarification.

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 like radar, lidar, camera and ultrasonic 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 reusability 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

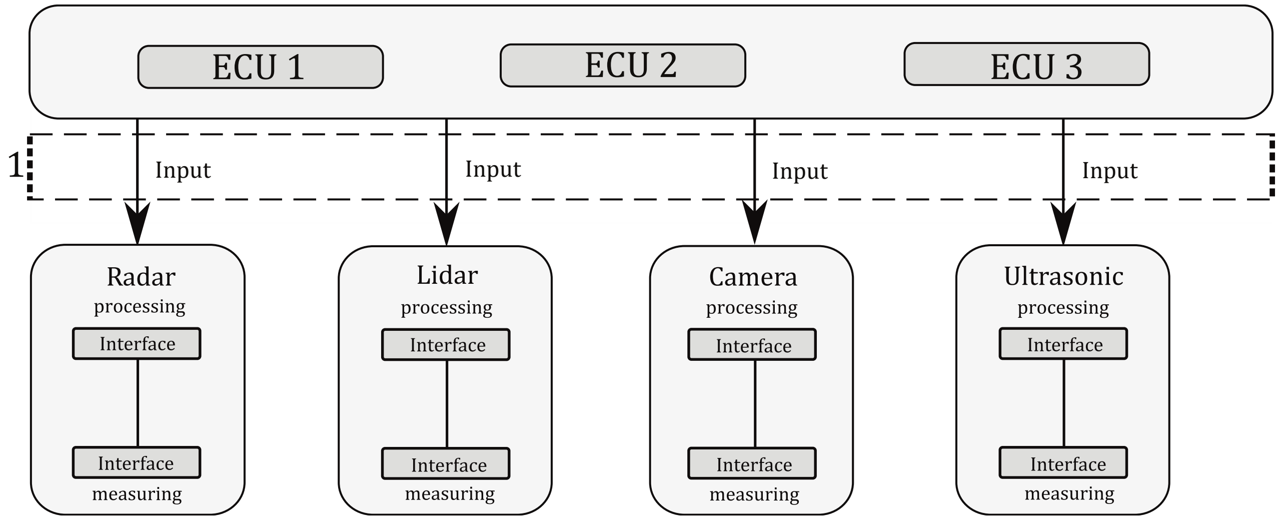
1 logical interface layer between the fusion unit and AD functions

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 and detections to enable object-level, feature-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.

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

1 Scope

This document is applicable to road vehicles with automated driving functions. The document specifies the logical interface between in-vehicle environmental perception sensors (for example, radar, lidar, camera, ultrasonic) 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 object level (for example, potentially moving objects, road objects, static objects) as well as information on feature and detection levels based on sensor technology specific information. Further supportive information is available.

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

2 Normative references

There are no normative references in this document.

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* (3.3.1) from two or more *sensors* (3.1.5) as well as *sensor clusters* (3.1.6) to create a *surround model* (3.1.7)

3.1.2
fusion unit
computing unit where the *fusion* (3.1.1) of *sensor* (3.1.5) data as well as a *sensor cluster* (3.1.6) data is performed

3.1.3
interface
shared boundary between two functional units, defined by various characteristics pertaining to the functions, physical interconnections, *signal* (3.3.1) exchanges and other characteristics of the units, as appropriate

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

3.1.4
logical interface
interface (3.1.3) between a *sensor* (3.1.5) as well as a *sensor cluster* (3.1.6) and the *fusion unit* (3.1.2), 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* (3.1.4)

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

3.1.6
sensor cluster
group of *sensors* (3.1.5) of the same technology serving common *logical interfaces* (3.1.4)

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* (3.1.5) with each other.

3.2 Terms for logical interface layers

3.2.1
detection
sensor technology specific entity represented in the *sensor coordinate system* (3.7.18) based on a single *measurement* (3.4.5) of a *sensor* (3.1.5)

Note 1 to entry: A small amount of history can be used for some detection *signals* (3.3.1), for example, model-free filtering may be used in track-before-detect algorithms.

3.2.2
detection level
set of *logical interfaces* (3.1.4) that provides *detections* (3.2.1)

3.2.3
feature
sensor technology specific entity represented in the *vehicle coordinate system* (3.7.16) based on multiple *measurements* (3.4.5)

Note 1 to entry: Multiple measurements can originate from a *sensor cluster* (3.1.6).

Note 2 to entry: Multiple measurements can originate from multiple *measurement cycles* (3.4.1).

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.

3.2.4
feature level
set of *logical interfaces* (3.1.4) that provides *features* (3.2.3)

3.2.5
object
representation of a real-world entity with defined boundaries and characteristics in the *vehicle coordinate system* (3.7.16)

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

Note 2 to entry: Object *signals* (3.3.1) are basically sensor technology independent. Sensor technology specific signals may extend the object signals.

EXAMPLE A *potentially moving object* (3.6.1), a *road object* (3.6.2), a *static object* (3.6.3), a *free space area object* (3.6.4).

3.2.6
object level
set of *logical interfaces* (3.1.4) that provides *objects* (3.2.5)

3.2.7
sensor input
data received by a *sensor* (3.1.5) or a *sensor cluster* (3.1.6) via the *in-vehicle communication* (3.1.8)

3.3 Structure terms

3.3.1
signal
entity consisting of one or more values and which is part of a *logical interface* (3.1.4)

3.3.2
logical signal group
grouping of *signals* (3.3.1) 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* (3.1.5) 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* (3.4.5)

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* (3.4.2), *tracked quantity values* (3.4.3) 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* (3.4.1)

3.4.6
tracking
computation process used to calculate the *tracked quantity value* (3.4.3) of a quantity

3.4.7
prediction
computation process used to obtain the *predicted quantity value* (3.4.4) of a quantity

[SOURCE: IEV 192-11-01]

3.4.8
error
discrepancy between a *measured quantity value* (3.4.2), *tracked quantity value* (3.4.3) or *predicted quantity value* (3.4.4) 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* (3.4.2), *tracked quantity value* (3.4.3) or *predicted quantity value* (3.4.4) 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* (3.4.5), *tracking* (3.4.6) or *prediction* (3.4.7) is said to be more accurate when it offers a smaller *error* (3.4.8).

Note 2 to entry: The term accuracy should not be used for *trueness* (3.4.10) and the term *precision* (3.4.11) 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, 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* (3.4.2), *tracked quantity values* (3.4.3) or *predicted quantity values* (3.4.4) 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 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* (3.4.9) should not be used for trueness.

[SOURCE: ISO/IEC Guide 99:2007, 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* (3.4.2), *tracked quantity value* (3.4.3) or *predicted quantity values* (3.4.4) obtained by replicate *measurements* (3.4.5), *tracking* (3.4.6) or *prediction* (3.4.7) 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 5725-1:1994).

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* (3.4.9).

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

[SOURCE: ISO/IEC Guide 99:2007, 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 (3.4.2) 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* (3.4.8) 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, 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* (3.4.3) and the reference quantity value

3.4.14
prediction error
quantitative statement about the *predicted quantity value* (3.4.4) and the reference quantity value

3.4.15
error model
model used to estimate the *error* (3.4.8)

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, 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* (3.5.4) of a *logical interface* (3.1.4) specification, indicating the conditions under which the *signal* (3.3.1) or *logical signal group* (3.3.2) is required. In other cases, the signal or logical signal group is optional. See also *mandatory* (3.5.2) and *optional* (3.5.3).

[SOURCE: ISO/IEC 11179-3:2023, 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* (3.5.4) of a *logical interface* (3.1.4) specification, indicating the conditions under which the *signal* (3.3.1) or *logical signal group* (3.3.2) is required. See also *conditional* (3.5.1) and *optional* (3.5.3).

[SOURCE: ISO/IEC 11179-3:2023, 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* (3.5.4) of a *logical interface* (3.1.4) specification, indicating the conditions under which the *signal* (3.3.1) or *logical signal group* (3.3.2) is required. See also *conditional* (3.5.1) and *mandatory* (3.5.2).

[SOURCE: ISO/IEC 11179-3:2023, 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* (3.1.4) *logical signal group* (3.3.2), *signal* (3.3.1) 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* (3.5.1), *mandatory* (3.5.2) or *optional* (3.5.3).

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* (3.1.4) on *object level* (3.2.6).

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* (3.1.4) on *object level* (3.2.6).

EXAMPLE A *road marking* (3.6.2.1), a *road boundary* (3.6.2.2), the *road surface* (3.6.2.3).

3.6.2.1
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, 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.]

3.6.2.2
road boundary
structure that limits the road

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

3.6.2.3
road surface
surface supporting the tyre and providing friction necessary to generate shear forces in the *road plane* (3.7.6)

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

[SOURCE: ISO 8855:2011, 2.6]

3.6.3
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* (3.1.4) on *object level* (3.2.6).

EXAMPLE A *general landmark* (3.6.3.1), a *traffic sign* (3.6.3.2), a *traffic sign board* (3.6.3.3), a *traffic light* (3.6.3.4).

3.6.3.1
general landmark
real-world stationary entity which can be used for localisation

Note 1 to entry: A stationary *traffic sign* (3.6.3.2) or *traffic light* (3.6.3.4) is also regarded as a general landmark.

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

3.6.3.2
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* (3.6.3.2.1) and none, one or several *supplementary signs* (3.6.3.2.2).

EXAMPLE A speed limit which is restricted for trucks.

3.6.3.2.1
main sign
traffic sign (3.6.3.2) 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, 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.]

3.6.3.2.2
supplementary sign
traffic sign (3.6.3.2) that is supportive of a *main sign* (3.6.3.2.1) and the main purpose of which is to provide additional clarification

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

3.6.3.3
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

3.6.3.4
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.

3.6.4
free space area object
area entity of the *road surface* (3.6.2.3) 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* (3.1.4) on *object level* (3.2.6).

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, 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* (3.7.1) and which consists of an *axis system* (3.7.2) plus an origin point

[SOURCE: ISO 8855:2011, 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* (3.7.2) 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

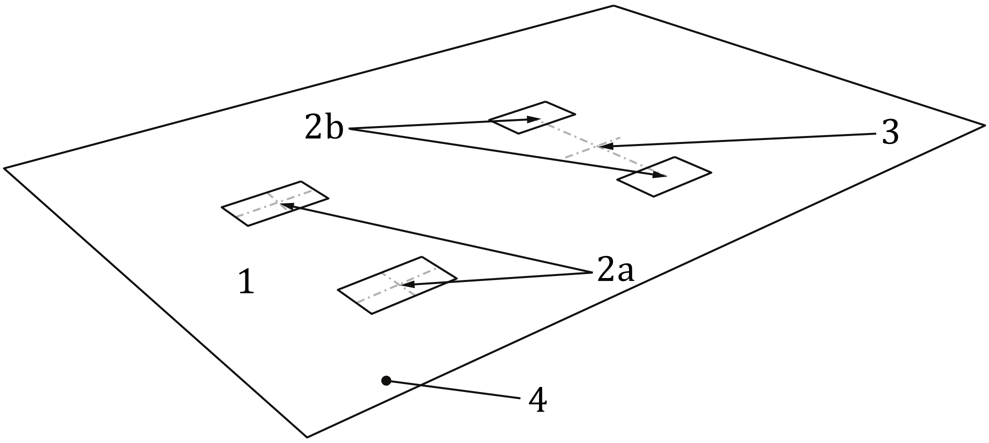
Note 1 to entry: The azimuth angle is the angle in *XY*-plane [of a *cartesian coordinate system* (3.7.4)] of the *axis system* (3.7.2) counted from the *X*-axis. The elevation angle is the angle from the azimuth direction in the *XY*-plane of the axis system towards the direction of the distance vector, 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* (3.6.2.3) within the front tyre contact patches and the *vehicle road-level reference point* (3.7.13)

Note 1 to entry: See Figure 3.

Note 2 to entry: For tyre contact patches, see ISO 8855:2011, 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* (3.7.13)
4 vehicle road plane

Figure 3 — Road plane

[SOURCE: ISO 8855:2011, 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* (3.7.6)

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, 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* (3.7.8)

[SOURCE: ISO 8855:2011, 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* (3.7.9) and located at the centre of the rear-axle

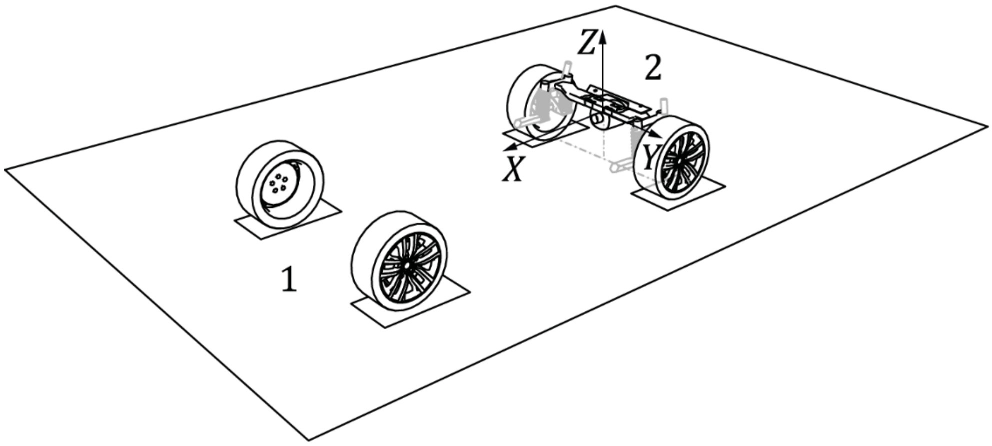
3.7.11
vehicle sprung mass axis system
axis system (3.7.2) fixed in the *reference frame* (3.7.1) of the *vehicle sprung mass* (3.7.9), so that the *X*-axis is substantially horizontal and forwards (with the vehicle at rest) and is parallel to the vehicle's longitudinal plane of symmetry, additionally 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 (3.7.4) based on the *vehicle sprung mass axis system* (3.7.11) with the origin located at the *vehicle rear-axle reference point* (3.7.10)

Note 1 to entry: The vehicle rear-axle coordinate system is a *vehicle coordinate system* (3.7.16).

Note 2 to entry: See Figure 4.



Key
1 vehicle front
2 *vehicle rear-axle reference point* (3.7.10)

Figure 4 — Vehicle rear-axle coordinate system

3.7.13
vehicle road-level reference point
point at *road level* (3.7.7) located in the middle of the rear tyre contact patches

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

3.7.14
vehicle road-level axis system
axis system (3.7.2) fixed in the *reference frame* (3.7.1) of the *vehicle unsprung mass* (3.7.8), 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* (3.7.6).

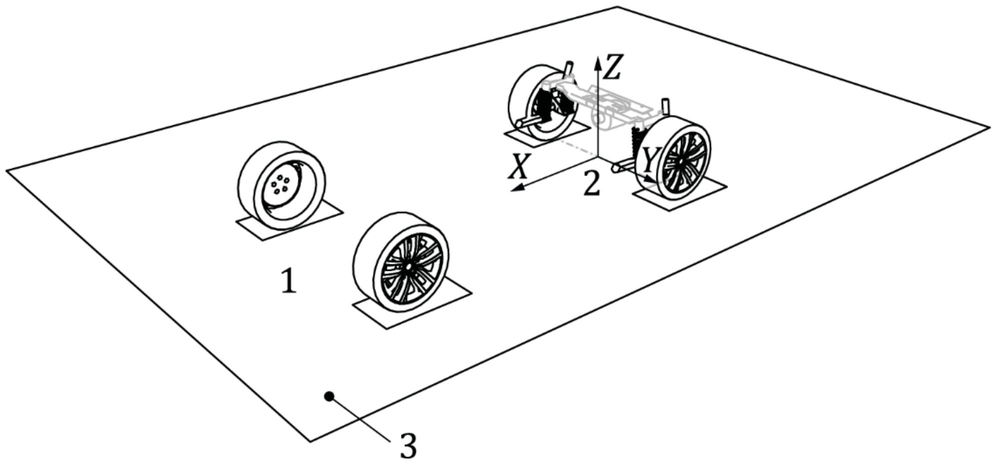
Note 2 to entry: The axis system is a set of three orthogonal directions associated with *X*, *Y* and *Z* axes.

3.7.15
vehicle road-level coordinate system

cartesian coordinate system (3.7.4) based on the *vehicle road-level axis system* (3.7.14) with the origin located at the *vehicle road-level reference point* (3.7.13) at the vehicle *road level* (3.7.7)

Note 1 to entry: The vehicle road-level coordinate system is a *vehicle coordinate system* (3.7.16).

Note 2 to entry: See Figure 5.



Key

1 vehicle front

2 *vehicle road-level reference point* (3.7.13)

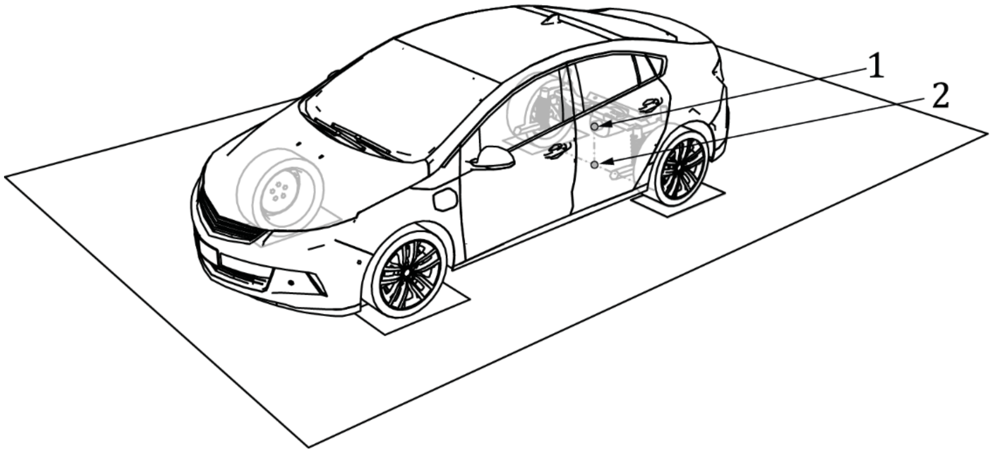
3 vehicle *road plane* (3.7.6)

Figure 5 — Vehicle road-level coordinate system

3.7.16
vehicle coordinate system

cartesian coordinate system (3.7.4) which is either the *vehicle rear-axle coordinate system* (3.7.12) or the *vehicle road-level coordinate system* (3.7.15)

Note 1 to entry: See Figure 6.



Key

1 *vehicle rear-axle reference point* (3.7.10) of the *vehicle rear-axle coordinate system* (3.7.12)

2 *vehicle road-level reference point* (3.7.13) of the *vehicle road-level coordinate system* (3.7.15)

Figure 6 — Vehicle coordinate systems

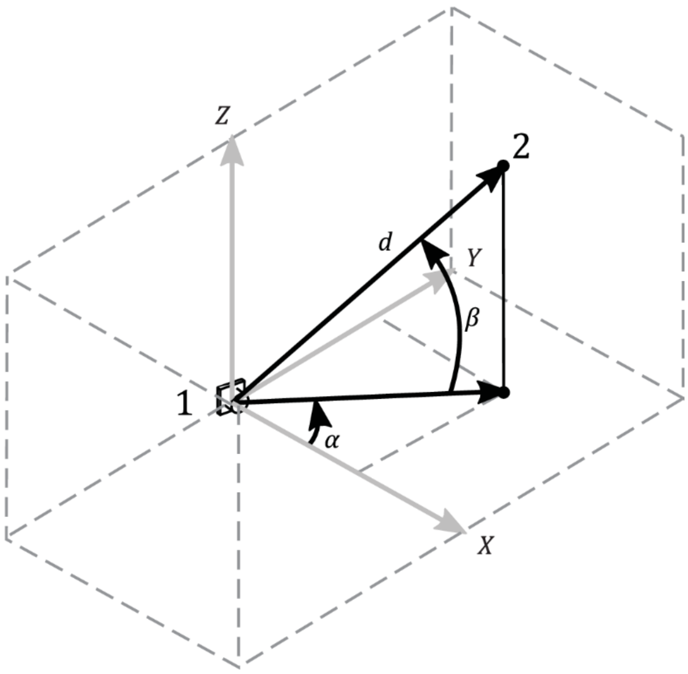
3.7.17
sensor axis system
axis system (3.7.2) fixed in the *reference frame* (3.7.1) of the *sensor* (3.1.5)

Note 1 to entry: The *X*-axis [of a *cartesian coordinate system* (3.7.4)] is in viewing direction of the sensor and the *Z*-axis pointing upward.

3.7.18
sensor coordinate system
spherical coordinate system (3.7.5) based on the *sensor axis system* (3.7.17) at a defined origin point of the *sensor* (3.1.5)

Note 1 to entry: The origin point of the sensor coordinate system has to be selected in a way that *detections* (3.2.1) 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 7.



Key

1 *sensor* (3.1.5) with origin point of the sensor coordinate system

2 *detection* (3.2.1)

d radial distance

α azimuth angle

β elevation angle

Figure 7 — Sensor coordinate system

3.7.19
affine coordinate system

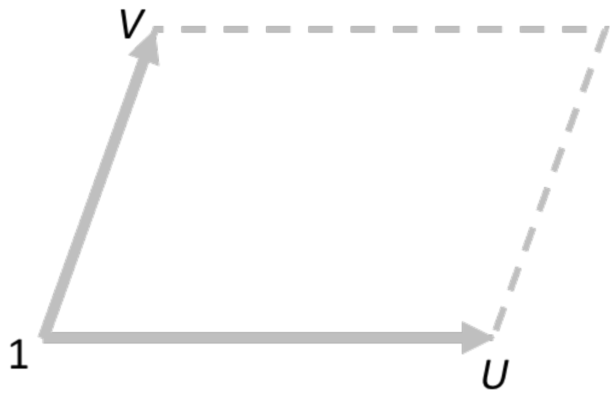
coordinate system (3.7.3) of an *object* (3.2.5) with an ordered set of non-collinear direction vectors (an affine basis) and a defined origin point

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* (3.7.2) is assumed for a three-dimensional affine coordinate system (with the direction vectors abscissa, ordinate and applicate).

Note 4 to entry: See Figure 8.



Key

1 origin point of the affine coordinate system

U *U*-axis – abscissa of the affine coordinate system

V *V*-axis – ordinate of the affine coordinate system

Figure 8 — Affine coordinate system

4 Abbreviated terms

A2I	assign to interface
AD	automated driving
AER	alternative entity representation
C	conditional
CDI	camera detection interface
CFI	camera feature interface
CSII	common sensor input interface
D	dimensional
DLI	detection level interface
ECU	electronic control unit
EM	error model
FFT	fast Fourier transform
FLI	feature level interface
FLP	front-left position of the ego-vehicle
FOV	field-of-view
FRP	front-right position of the ego-vehicle
FSAOI	free space area object interface
FWHM	full width at half maximum
GPS	global positioning system
HW	hardware
ID	identifier
IQR	interquartile range

IR	infrared
IRI	international roughness index
IV	implicit value
LDI	lidar detection interface
LL	list length
LSG	logical signal group
M	mandatory
NIR	near infrared
O	optional
OLI	object level interface
PMOI	potentially moving object interface
RCS	radar cross section
RDI	radar detection interface
RDOI	road object interface
RL	requirement level
RLP	rear-left position of the ego-vehicle
RRP	rear-right position of the ego-vehicle
SHII	sensor health information interface
SII	sensor input interface
SNR	signal to noise ratio
SOI	static object interface
SPI	sensor performance interface
SSI	supportive sensor interface
UDI	ultrasonic detection interface
UFI	ultrasonic feature interface
UTL	unrolling tuple list
VRO	value representation optimisation

5 Structure of the interface description

5.1 General

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

— a description of each interface by logical signal group (LSGs), signal names and requirement levels (RLs) (including conditional requirements) and additional options;

— a detailed description of each signal in Annex A;

— generic options and generic conditional requirements in Annex B, which shall be used.

The requirement level attribute “conditional” shall be an element used in this document. The logical interlink as well as complex dependencies between signals of an interface shall be defined in an interface’s subclause as a profile subclause of the interface.

5.2 Signal

Table 1 provides an overview of a signal used by an interface which is defined in subclause “Interface” (5.3). All signals are specified in Annex A. Signal names shall be unique. Similar signals on different interface levels have the interface level added to the signal name to guarantee a unique signal naming.

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 enumerators or exemplary enumerators is defined in an additional table (see Table 2) in Annex A. Each list of exemplary enumerators is informative. During the system design phase, specific enumerators shall be defined, based upon the list of exemplary enumerators (see Annex A). This can be done by adding new, using a subset of or adapting the existing exemplary enumerators. The implementation of a list of exemplary enumerators shall contain at least one enumerator and should have default ones (B.1.7). An enumeration with exemplary enumerators may allow output of multiple enumerators belonging to different classes. Enumerators of different classes may be otherwise specified during the system design phase by separated enumeration signal identifiers.

Each enumeration with exemplary enumerators shall implement default enumerators (B.1.7). At least one enumerator shall be defined for each implemented exemplary enumeration list. An enumerator with exemplary enumerations may be clustered by multiple enumerations to deal with different classes of enumerators, rather than addressing multiple classes in the enumerators.

Table 2 — Enumeration: <Signal name>

Name	Description	RL enumerator
Name of the enumerator (the signal name is abbreviated in the name of the enumerator)	Definition of the enumerator	Requirement level of the enumerator (mandatory, conditional or optional) or “exemplary”

5.3 Interface

Table 3 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 3 — 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: **m**andatory, **c**onditional or **o**ptional **C**onditional 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: **m**andatory, **c**onditional or **o**ptional is specified for the signal, including all signal identifiers, or for each signal identifier individually **C**onditional 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 [RDOI] 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 double horizontal 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.

Symbol “↪” indicates that LSG belongs to another LSG, that means the LSG is a nested LSG.

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

Signals with RL mandatory and static or fixed 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 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 4 provides an overview of a specific signal grouping, for example, an LSG, which refers a specific signal grouping of another subclause and extends the specific signal grouping to achieve similar interfaces.

Table 4 — Specific signal grouping: <Name for LSG(s)>

Signal	RL signal	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

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 3 and Table 4).

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 three logical interface levels (detection-, feature- and object level). Supportive sensor interfaces (SSIs) complement the interfaces of the three logical interface levels. Detections, features, objects 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 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- and/or detection-level fusion. In order to perform object-level fusion from a sensor suite[1], sufficient evidence in the form of correlated detections 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 detections, features or objects 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 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.

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 9 shows the interfaces that are in the scope of this document.

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

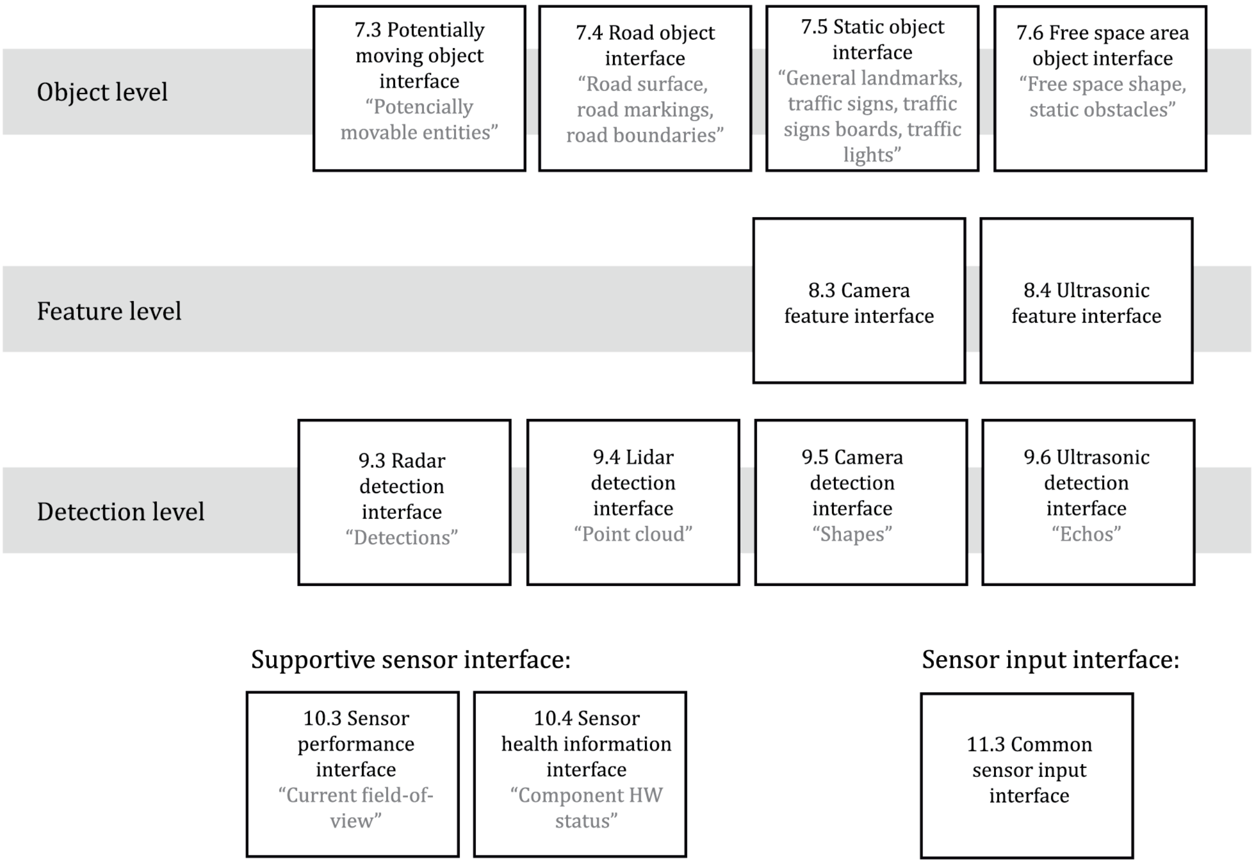


Figure 9 — Interfaces in the scope of this document

The interfaces covered in the scope of this document are the following:

— objects:
  — Potentially moving object interface (7.3): with specific attributes for, for example, lights, pedestrian;
  — Road object interface (7.4): road surface, road markings, road boundaries;
  — Static object interface (7.5): general landmarks, traffic signs, traffic sign boards, traffic lights;
  — Free space area object interface (7.6): free space areas;
— sensor or sensor cluster specific features:
  — Camera feature interface (8.3);
  — Ultrasonic feature interface (8.4);
— sensor or sensor cluster specific detections:
  — Radar detection interface (9.3);
  — Lidar detection interface (9.4);
  — Camera detection interface (9.5);
  — Ultrasonic detection interface (9.6);
— supportive information:
  — Sensor performance interface (10.3): with specific sensor-attributes for, for example, current field-of-view (FOV) segments, object recognition rates, reference target recognition rates;

 — Sensor health information interface (10.4): with specific attributes for, for example, generic sensor statuses, calibration information, sensor cluster definition;

— sensor or sensor cluster specific input:

 — Common sensor input interface (11.3).

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 a sensor technology specific interface on feature- as well as detection level. Each sensor as well as each sensor cluster shall provide at least one interface either on object-, feature- 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) whereas 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, 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 does not have 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.

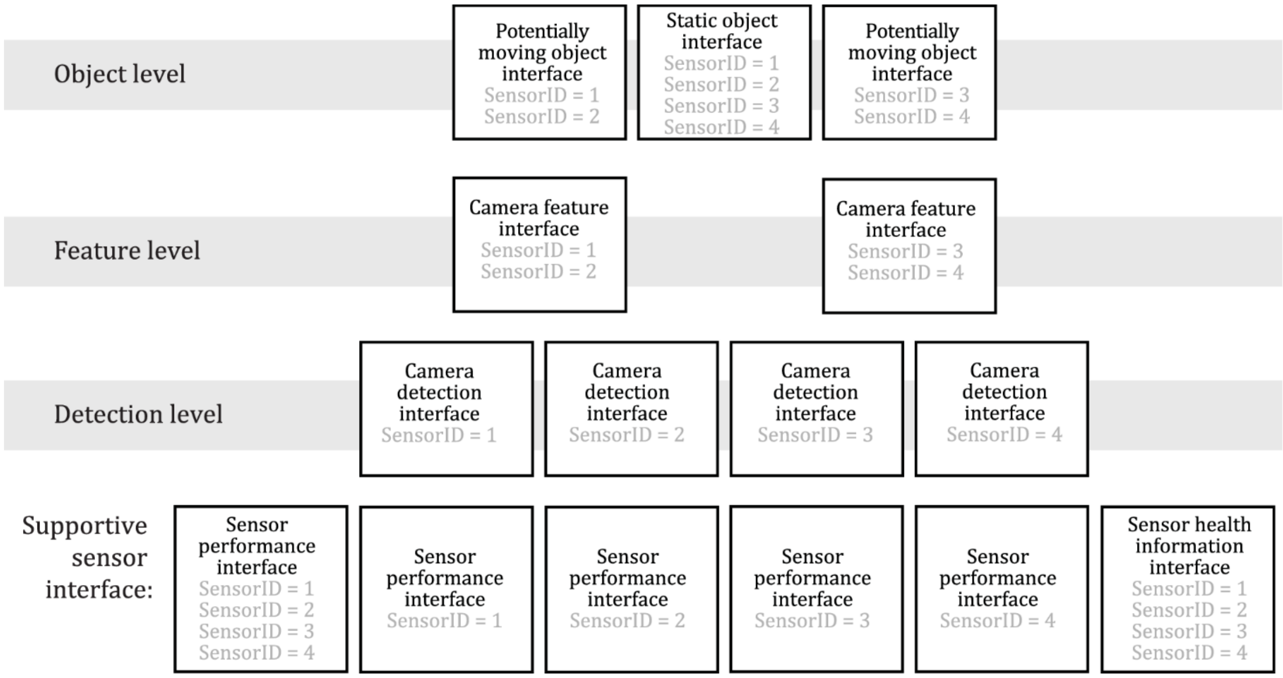


Figure 10 —Example of a camera sensor cluster and its sensor and sensor cluster interfaces

In Figure 10, 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 the static object interface (SOI), sensor performance interface (SPI) and sensor health information interface (SHII);

— the sensor sub-cluster with the list of the signal “Sensor ID” (A.1.4) values {1, 2} provides potentially the moving object interface (PMOI), camera feature interface (CFI);

— the sensor sub-cluster with the list of the signal “Sensor ID” (A.1.4) values {3, 4} provides PMOI, CFI;

— the sensors with signal “Sensor ID” (A.1.4) value 1, 2, 3 or 4 provide each a camera detection interface (CDI) and SPI;

— the sensor or sensor cluster provides no free space area object interface;

— the sensor or sensor cluster may not receive a sensor input interface.

6.2 Generic interface header

Table 5 defines the structure of (6.2) as a specific signal grouping. This header is used by each interface of this document and is adapted or extended accordingly. However, all the interface headers have at least these or similar signals.

Table 5 — 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 (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) 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)
Interface specific header extensions		
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)

6.3 Generic interface entity

The interface entities define the set of signals without the header signals of the interface. Each logical interface provides at least one list of interface specific entities (except SHII and CSII). The number of valid entities of each interface entity type list is defined by the signal “Number of valid <...>” (A.1.12) (see Table 5). 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.

6.4 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.

Sensor input interfaces define a profile for uniqueness of interface versioning (11.2.3).

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 – header” (A.1.20)]. 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.2.2) value that does not change over time and which is referenced by these entities. The signal’s “Object ID” (A.2.2) 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.2.2) 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.2.3) value to link all related objects. One dedicated value may indicate that the object is not linked to another object.

The object recognition algorithm is based on multiple measurements of the sensor cluster and is updated over time. For this reason, the entire object properties are not assigned to the time of one single measurement, but to an estimated point in time at which the properties of the interface’s objects fit together consistently. The object existence probability relates to this consistent set of estimated signals (tracked or predicted quantity values) of the object at this estimated point in time.

On object level the following interfaces are available:

— Potentially moving object interface (7.3);

— Road object interface (7.4);

— Static object interface (7.5);

— Free space area object interface (7.6).

7.2 Generic object level interface

Table 6 defines the generic structure of an OLI.

Table 6 — Generic object level interface

Structure	Multiplicity	Option
Generic object level header (7.2.1)	1	
Generic object level entity (7.2.2), specifically an individual object level entity list	Multiple	Size type: dynamic/fixed

Each OLI's individual object level entity list can also be a set of different, specific object type lists [for example, for subclause "Road object interface" (7.4) there are two entity lists for the object types: road marking and road boundary and a single entity for the object type: road surface].

7.2.1 Generic object level header

Table 7 defines the interface header in subclause "Generic object level header" (7.2.1) and the changes due to the adaptation in comparison to the generic interface header in subclause "Generic interface header" (6.2).

Table 7 — Specific signal grouping: Generic object level header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) Optimise LL (B.1.1) Alternative UTP (B.1.6) Key: Sensor ID (A.1.4)
Sensor ID (A.1.4)	Mandatory	Profile: Uniqueness of interface versioning (6.4) Alternative VRO (B.1.3)
Time stamp – prediction (A.1.5.1)	Mandatory	
Cycle counter (A.1.6.1)	Optional	Redundancy (B.1.2) Signal: Time stamp – prediction (A.1.5.1)
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)
OLI specific header extensions		
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)

The following LSGs, which normally shall be provided by the sensor cluster in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor cluster (see B.3.3):

— Interface: SPI; LSG “Information: vehicle coordinate system” (see Table 51);

— Interface: SHII; LSG “Calibration” (see Table 53);

— Interface: SHII; LSG “Sensor cluster” (see Table 53).

7.2.2 Generic object level entity

Table 8 defines the generic signal grouping “Generic object level entity status” for each OLI object type, except of road surface.

Table 8 — Specific signal grouping: Generic object level entity status

Signal	RL signal	Option
Existence probability – object level (A.2.1)	Mandatory	
Object ID (A.2.2)	Mandatory	Alternative A2I (B.3.2)
Object grouping ID (A.2.3)	Optional	
Age (A.2.4)	Mandatory	
Number of valid observations – object level (A.2.5)	Optional	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
Time stamp reference – object level (A.2.6)	Mandatory	Alternative VRO (B.1.3)
Observation status – object level (A.2.7)	Mandatory	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
Track quality (A.2.8)	Optional	
Measurement status – object level (A.2.9)	Mandatory	Default enumerators (B.1.7)

Each interface type adds individual properties to the interface entity types. Geometric information of the object references the vehicle coordinate system [see signal “Vehicle coordinate system type – header” (A.1.20)]. Detections and features of the sensor cluster and its sensors shall reference objects of the OLIs with the signal “Object ID” (A.2.2). Potentially connected objects of a sensor cluster shall be linked together, and the sensor cluster shall use the same signal’s “Object grouping ID” (A.2.3) value for all objects of this connected object group.

7.3 Potentially moving object interface

At object level, the potentially moving object interface (PMOI) contains the list of objects that could potentially move and are relevant for driving situations. This includes all objects that currently move, have moved (see Figure 11) and that are not definitely static three-dimensional structures. Table 9 defines the logical structure of the potentially moving object interface. The object interface defines sets of signals for more detailed potentially moving object types (for example, lights, persons).

Table 9 — Potentially moving object interface

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning (6.4)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
		Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
		Time stamp – prediction (A.1.5.1)	M	
		Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – prediction (A.1.5.1)
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	
		Data qualifier (A.1.9)	M	Default enumerators (B.1.7)
		Motion type (A.1.13)	M	Profile: Motion type (7.3.3) Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Potentially moving objects	M	Recognised potentially moving objects – capability (A.1.10.1)	O	
		Recognised potentially moving objects – status (A.1.11.1)	O	Redundancy (B.1.2) Signal: Recognised potentially moving objects – capability (A.1.10.1) Default enumerators (B.1.7)
		Number of valid potentially moving objects (A.1.12.1)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid potentially moving objects (A.1.12.1)		
⊆ Potentially moving object status	M	Existence probability – object level (A.2.1)	M	
		Object ID (A.2.2)	M	Alternative A2I (B.3.2)
		Object grouping ID (A.2.3)	O	
		Age (A.2.4)	M	
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
Potentially moving object information	M	Tracking motion model (A.2.10)	O	Default enumerators (B.1.7)
		Number of valid potentially moving object classifications (A.2.11)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Potentially moving object classification type (A.2.12)
		Size type: dynamic/fixed Size #: Number of valid potentially moving object classifications (A.2.11)		
		Potentially moving object classification type (A.2.12)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Potentially moving object classification type – confidence (A.2.13)	M	
Potentially moving object position	M	Reference point (A.2.14)	O	Default enumerators (B.1.7)
		Position – object level {x, y, z} (A.2.15)	{M, M, O}	Profile: Motion state vector (7.3.4)
		Position – object level {x, y, z} – error (A.2.16)	{M, M, O}	Profile: Motion state vector (7.3.4) Implementation EM (B.4.1)

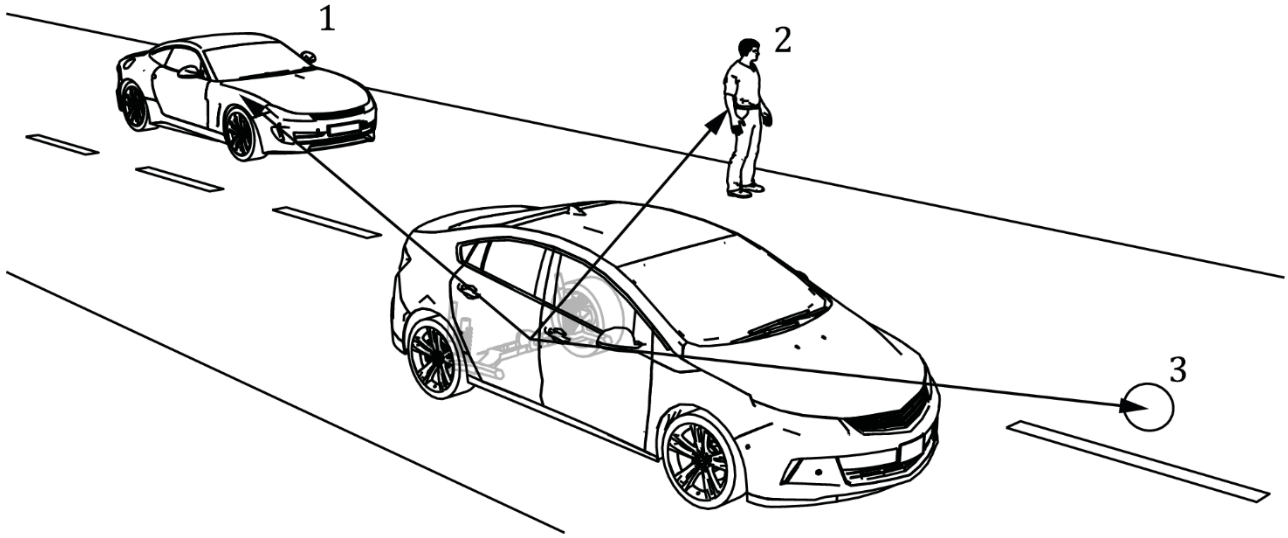
LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Orientation {yaw, pitch, roll} (A.2.17)	{C (B.2.1) Relevant: camera, O, O}	Profile: Motion state vector (7.3.4)
		Orientation {yaw, pitch, roll} – error (A.2.18)	O	Profile: Motion state vector (7.3.4) Implementation EM (B.4.1)
		Road level (A.2.19)	O	Redundancy (B.1.2) Signal: {z} of Position – object level {x, y, z} (A.2.15) Default enumerators (B.1.7)
Potentially moving object bounding box	C (B.2.1) Relevant: camera	Bounding box extent {length, width, height} (A.2.20)	{M, M, O}	
		Bounding box extent {length, width, height} – error (A.2.21)	O	Implementation EM (B.4.1)
		Clearance of the object {height} (A.2.22)	O	
		Included geometric structures (A.2.23)	O	Default enumerators (B.1.7)
Potentially moving object dynamics	M	Velocity {x, y, z} – object level (A.2.24)	{C, C, C (B.2.2) Signal: Position {z} (A.2.15)} (B.2.1) Relevant: except ultrasonic	Profile: Motion type (7.3.3) Profile: Motion state vector (7.3.4)
		Velocity {x, y, z} – object level – error (A.2.25)	O	Profile: Motion type (7.3.3) Profile: Motion state vector (7.3.4) Implementation EM (B.4.1)
		Acceleration {x, y, z} (A.2.26)	O	Profile: Motion type (7.3.3)
		Acceleration {x, y, z} – error (A.2.27)	O	Profile: Motion type (7.3.3) Implementation EM (B.4.1)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Instantaneous centre of rotation {x, y} (A.2.28)	C (B.2.2) Signal: Rotation rate at instantaneous centre of rotation {yaw} (A.2.30)	
		Instantaneous centre of rotation {x, y} – error (A.2.29)	O	Implementation EM (B.4.1)
		Rotation rate at instantaneous centre of rotation {yaw} (A.2.30)	O	Profile: Motion type (7.3.3) Profile: Motion state vector (7.3.4)
		Rotation rate at instantaneous centre of rotation {yaw} – error (A.2.31)	O	Profile: Motion type (7.3.3) Profile: Motion state vector (7.3.4) Implementation EM (B.4.1)
		Movement status (A.2.32)	O	Default enumerators (B.1.7)
Potentially moving object's lights	C (B.2.1) Relevant: camera	Number of valid lights (A.2.33)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Light type (A.2.34)
		Size type: dynamic/fixed Size #: Number of valid lights (A.2.33)		
		Light type (A.2.34)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Light status (A.2.35)	M	Default enumerators (B.1.7)
Potentially moving object: persons	O	Number of valid persons (A.2.36)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid persons (A.2.36)		
		Number of valid person type roles (A.2.37)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Person type role (A.2.38)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Size type: dynamic/fixed Size #: Number of valid person type roles (A.2.37)		
		Person type role (A.2.38)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Person type role – confidence (A.2.39)	M	
		Number of valid person gestures (A.2.40)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Person gesture indication type (A.2.41)
		Size type: dynamic/fixed Size #: Number of valid person gestures (A.2.40)		
		Person gesture indication type (A.2.41)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Person gesture indication type – confidence (A.2.42)	O	
		Person gesture direction type (A.2.43)	O	Default enumerators (B.1.7)
		Person gesture direction type – confidence (A.2.44)	O	
		Number of valid person's body part poses (A.2.45)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Person body part (A.2.46)
		Size type: dynamic/fixed Size #: Number of valid person's body part poses (A.2.45)		
		Person body part (A.2.46)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Person body part orientation {yaw, pitch, roll} (A.2.47)	M	
		Person body part orientation {yaw, pitch, roll} – error (A.2.48)	O	Implementation EM (B.4.1)
		Person body part origin {x, y, z} (A.2.49)	O	
		Person body part origin {x, y, z} – error (A.2.50)	O	Implementation EM (B.4.1)
		Eye state (A.2.51)	O	Default enumerators (B.1.7)
		Eye state – confidence (A.2.52)	O	
		Viewing fixation time (A.2.53)	O	
		Viewing fixation time – error (A.2.54)	O	Implementation EM (B.4.1)
		Viewing fixation direction (A.2.55)	O	Default enumerators (B.1.7)
		Viewing fixation direction – confidence (A.2.56)	O	
		Action type (A.2.57)	O	Default enumerators (B.1.7)
		Action type – confidence (A.2.58)	O	
		Number of valid person accessories (A.2.59)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Person accessory classification type (A.2.60)
		Size type: dynamic/fixed Size #: Number of valid person accessories (A.2.59)		
		Person accessory classification type (A.2.60)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Person accessory classification type – confidence (A.2.61)	O	
		Accessory connection to person type (A.2.62)	O	Default enumerators (B.1.7)
		Included geometric structure of accessory (A.2.63)	O	Default enumerators (B.1.7)
Lane related information	O	Object lane association (A.2.64)	M	Default enumerators (B.1.7)
		Angle between object edge and lane {left edge right lane, right edge left lane} (A.2.65)	O	
		Angle between object edge and lane {left edge right lane, right edge left lane} – error (A.2.66)	O	Implementation EM (B.4.1)
		Percentage side lane {left, right} (A.2.67)	O	
Motion related information	O	Angular position {azimuth} (A.2.68)	M	
		Angular velocity {azimuth} (A.2.69)	M	
Camera sensor technology specific	C (B.2.1) Relevant: camera	Scale change – object level (A.2.70)	M	
Radar sensor technology specific	C (B.2.1) Relevant: radar	Entity radar cross section (A.2.71)	M	
Lidar sensor technology specific	C (B.2.1) Relevant: lidar	Entity lidar reflectivity (A.2.72)	M	



Key

1 vehicle

2 pedestrian

3 potentially moving object – classification unknown, for example, “Potentially moving object classification type” (A.2.12) with default enumerator “PMOCT_Unknown”

Figure 11 — Example for potentially moving objects

7.3.1 Potentially moving object header

Table 10 defines the interface header in subclause “Potentially moving object header” (7.3.1) and the changes due to the adaptation in comparison to the generic interface header in 7.2.1. The header of the PMOI can contain a list of valid potentially moving object entities (see 7.3.2)

Table 10 — Specific signal grouping: Potentially moving object header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
Time stamp – prediction (A.1.5.1)	Mandatory	
Cycle counter (A.1.6.1)	Optional	Redundancy (B.1.2) Signal: Time stamp – prediction (A.1.5.1)
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)

Signal	RL signal	Option
Motion type (A.1.13)	Mandatory	Profile: Motion type (7.3.3) Default enumerators (B.1.7)
Recognised potentially moving objects – capability (A.1.10.1)	Optional	
Recognised potentially moving objects – status (A.1.11.1)	Optional	Redundancy (B.1.2) Signal: Recognised potentially moving objects – capability (A.1.10.1) Default enumerators (B.1.7)
Number of valid potentially moving objects (A.1.12.1)	Mandatory	Optimise LL (B.1.1)

The following LSGs, which normally shall be provided by the sensor cluster in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor cluster (see B.3.3):

— interface: SPI; LSG “Information: vehicle coordinate system” (see Table 51);

— interface: SHII; LSG “Calibration” (see Table 53);

— interface: SHII; LSG “Sensor cluster” (see Table 53).

7.3.2 Potentially moving object entity

Each potentially moving object describes a recognised real-world object and consists of several LSGs. Each object, which may move, even if it might have not moved yet since first recognition of the real-world object, is an entity of potentially moving objects.

A potentially moving object is described by the following LSGs for potentially moving objects with attributes for different parts (for example, vehicle, pedestrian).

— **Status:** the status describes general information of the tracked potentially moving object. This information is based on history of the object tracking. Table 11 defines the signal grouping “Potentially moving object entity status”. It defines this status LSG of the potentially moving object and redefines the signal grouping “Generic object level entity status” (see Table 8).

— **Information:** the information describes properties such as the confidence of an object type.

— **Position:** the position describes the geometric position of the object relative to the vehicle coordinate system [see signal “Vehicle coordinate system type – header” (A.1.20)].

— **Bounding box:** the object bounding box describes the 3D rectangular hull that encloses the recognised object.

— **Dynamics:** the dynamics describe the motion information of the tracked potentially moving object with respect to the motion type defined by the signal “Motion type” (A.1.13) [see Profile: Motion type (7.3.3)].

— **Lights:** the lights describe the status of the tracked potentially moving object’s lights.

— **Persons:** the persons describe recognised person type, its gestures and poses of the tracked persons if the tracked potentially moving object may be a pedestrian or include persons (for example, the driver of a vehicle).

— **Lane related information:** the lane related information describes the tracked potentially moving object in relation with real-world lanes.

— **Motion related information:** the motion related information describes additional motion information of the tracked potentially moving object.

— **Camera sensor technology specific:** the camera sensor technology specific data describe dynamic information in the camera projection plane.

— **Radar sensor technology specific:** the radar sensor technology specific data describe different surface and material properties of the potentially moving object with respect to the radar.

— **Lidar sensor technology specific:** the lidar sensor technology specific data describes different surface and material properties of the potentially moving object with respect to the lidar (for example, reflection strength of a surface).

Table 11 — Specific signal grouping: Potentially moving object entity status

Signal	RL signal	Option
Existence probability – object level (A.2.1)	Mandatory	
Object ID (A.2.2)	Mandatory	Alternative A2I (B.3.2)
Object grouping ID (A.2.3)	Optional	
Age (A.2.4)	Mandatory	
Number of valid observations – object level (A.2.5)	Optional	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
Time stamp reference – object level (A.2.6)	Mandatory	Alternative VRO (B.1.3)
Observation status – object level (A.2.7)	Mandatory	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
Track quality (A.2.8)	Optional	
Measurement status – object level (A.2.9)	Mandatory	Default enumerators (B.1.7)

Potentially moving objects or other object entities on object level may be linked together (for example, a truck with a trailer or a construction site vehicle with a traffic sign at the rear of the vehicle) by using the same signal’s “Object grouping ID” (A.2.3) value in all connected objects.

7.3.3 Profile: Motion type

The signal “Motion type” (A.1.13) defines the interpretation of the signal “Velocity {x, y, z} – object level” (A.2.24)”, “Velocity {x, y, z} – object level – error” (A.2.25), “Acceleration {x, y, z}” (A.2.26), “Acceleration {x, y, z} – error” (A.2.27), “Rotation rate at instantaneous centre of rotation {yaw}” (A.2.30) and “Rotation rate at instantaneous centre of rotation {yaw} – error” (A.2.31) values.

7.3.4 Profile: Motion state vector

A potentially moving object entity provides a motion state vector. The sensor may provide a full or enhanced error model according to B.4.1.3.5. For example, the motion state vector of the sensor is provided together with an enhanced error model {“Position – object level {x, y, z}” (A.2.15), “Velocity {x, y, z} – object level” (A.2.24), “Orientation {yaw, pitch, roll}” (A.2.17) and “Rotation rate at instantaneous centre of rotation {yaw}” (A.2.30)}.

The resulting error model based on variances, covariances and cross-covariances (see B.4.1.3.4 and B.4.1.3.5) may provide a symmetric nD matrix:

$$\left\{\begin{array}{cccc} \text{Position} - \text{error (A.2.16)} & \text{Position x Velocity} - \text{error} & \text{Position x Orientation} - \text{error} & \text{Position x Rotation rate} - \text{error} \\ \text{Velocity x Position} - \text{error} & \text{Velocity} - \text{error (A.2.25)} & \text{Velocity x Orientation} - \text{error} & \text{Velocity x Rotation rate} - \text{error} \\ \text{Orientation x Position} - \text{error} & \text{Orientation x Velocity} - \text{error} & \text{Orientation} - \text{error(A.2.17)} & \text{Orientation x Rotation rate} - \text{error} \\ \text{Rotation rate x Position} - \text{error} & \text{Rotation rate x Velocity} - \text{error} & \text{Rotation rate x Orientation} - \text{error} & \text{Rotation rate} - \text{error (A.2.30)} \end{array}\right\}$$

In addition to existing error signals “Position – object level {x, y, z} – error” (A.2.16), “Velocity {x, y, z} – object level – error” (A.2.25), “Orientation {yaw, pitch, roll} – error” (A.2.18) and “Rotation rate at instantaneous centre of rotation {yaw} – error” (A.2.31); the additional signals may be provided as sets of cross-covariances. All covariances of the motion state vector error model are symmetric and therefore additional optimisation methods are applicable; this means only half of non-diagonal elements need to be provided.

For example, the LSG “Potentially moving object motion state vector cross-covariances” may provide, for example, “Position {x, y, z} x Velocity {x, y, z} – object level – error”, “Position {x, y, z} x Orientation {yaw, pitch, roll} – object level – error”. The redundant symmetrical signals for the cross-covariances: “Velocity {x, y, z} x Position {x, y, z} – object level – error”, “Orientation {yaw, pitch, roll} x Position {x, y, z} – object level – error” may be skipped. Similar, the symmetric covariances of the signals “Position – object level {x, y, z} – error” (A.2.16), “Velocity {x, y, z} – object level – error” (A.2.25), “Orientation {yaw, pitch, roll} – error” (A.2.18) and “Rotation rate at instantaneous centre of rotation {yaw} – error” (A.2.31) may not transmit redundant values (see optimisation method B.1.5).

Table 12 provides a subset of the PMOI with the relevant signals for the motion state vector of this profile and the additional signals in the LSG “Potentially moving object motion state vector cross-covariances”.

Table 12 — Signal grouping: Exemplary motion state vector cross-covariances LSG

Potentially moving object position	M		Position – object level {x, y, z} (A.2.15)	{M, M, O}	Profile: Motion state vector (7.3.4)
			Position – object level {x, y, z} – error (A.2.16)	{M, M, O}	Profile: Motion state vector (7.3.4) …
			Orientation {yaw, pitch, roll} (A.2.17)	{C (B.2.1) Relevant: camera, O, O}	Profile: Motion state vector (7.3.4)
			Orientation {yaw, pitch, roll} – error (A.2.18)	O	Profile: Motion state vector (7.3.4) …
			…	…	…

Potentially moving object dynamics	M		Velocity {x, y, z} – object level (A.2.24)	{C, C, C (B.2.2) Signal: Position {z} (A.2.15)} (B.2.1) Relevant: except ultrasonic	Profile: Motion state vector (7.3.4) …
			Velocity {x, y, z} – object level – error (A.2.25)	O	Profile: Motion state vector (7.3.4) …
			Rotation rate at instantaneous centre of rotation {yaw} (A.2.30)	O	Profile: Motion state vector (7.3.4) …
			Rotation rate at instantaneous centre of rotation {yaw} – error (A.2.31)	O	Profile: Motion state vector (7.3.4) …
			…	…	…
Potentially moving object motion state vector cross-covariances	O		Position {x, y, z} x Velocity {x, y, z} – object level – error	O[a]	Implementation EM (B.4.1)
			Position {x, y, z} x Orientation {yaw, pitch, roll} – object level – error	O	Implementation EM (B.4.1)
			Position {x, y, z} x Rotation rate at instantaneous centre of rotation {yaw} – object level – error	O	Implementation EM (B.4.1)
			Velocity {x, y, z} x Orientation {yaw, pitch, roll} – object level – error	O	Implementation EM (B.4.1)
			Velocity {x, y, z} x Rotation rate at instantaneous centre of rotation {yaw} – object level – error	O	Implementation EM (B.4.1)
			Orientation {yaw, pitch, roll} x Rotation rate at instantaneous centre of rotation {yaw} – object level – error	O	Implementation EM (B.4.1)

[a] The signal's RL is optional by definition of B.4.1.3.5 but for this profile (7.3.4) it should be defined as mandatory during the system design phase so that at least one signal is mandatory in the LSG.

Additionally, in most cases the description of the signals in planar space (*XY*-plane) is sufficient. Therefore, below covariances may either be only 2D (position, velocity) or 1D (orientation, rotation rate).

Optimisation method may be also applied by selection of most relevant covariance matrix elements (or cross-covariance matrix elements).

Missing covariance values shall be substituted by suitable values in the fusion tracking system to guarantee a stabile tracking.

7.4 Road object interface

The road object interface (RDOI) consists of a general road surface information and two types of objects: road markings and road boundaries (see Figure 12). Table 13 defines the logical structure of the road object interface.

Table 13 — Road object interface

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning (6.4)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
		Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
		Time stamp – prediction (A.1.5.1)	M	
		Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – prediction (A.1.5.1)
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	
		Data qualifier (A.1.9)	M	Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Colour model type (A.1.14)	C (B.2.1) Relevant: camera	Profile: Colour model for RDOI (7.4.3) 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)
Road surface	C (B.2.3) multiple entity types	Road type – object level (A.2.73)	M	Default enumerators (B.1.7)
		Road type – confidence (A.2.74)	O	
		Number of valid road surface classifications (A.2.75)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Road surface classification type – object level (A.2.76)
		Size type: dynamic/fixed Size #: Number of valid road surface classifications (A.2.75)		
		Road surface classification type – object level (A.2.76)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Road surface classification type – confidence (A.2.77)	M	
		Road surface roughness – object level (A.2.78)	O	
		Road surface texture – object level (A.2.79)	O	
		Number of valid road surface condition classifications (A.2.80)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Road surface condition classification type – object level (A.2.81)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Size type: dynamic/fixed Size #: Number of valid road surface condition classifications (A.2.80)		
		Road surface condition classification type – object level (A.2.81)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Road surface condition classification type – confidence (A.2.82)	M	
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	O	Default enumerators (B.1.7)
Road markings	C (B.2.3) multiple entity types	Recognised road markings – capability (A.1.10.2)	O	
		Recognised road markings – status (A.1.11.2)	O	Redundancy (B.1.2) Signal: Recognised road markings – capability (A.1.10.2) Default enumerators (B.1.7)
		Number of valid road markings (A.1.12.2)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid road markings (A.1.12.2)		
Road marking status	M	Existence probability – object level (A.2.1)	M	
		Object ID (A.2.2)	M	Alternative A2I (B.3.2)
		Object grouping ID (A.2.3)	O	
		Age (A.2.4)	M	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see "Time stamp reference – object level" (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
⊆ Road marking information	M	Number of valid road marking classifications (A.2.83)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid road marking classifications (A.2.83)		
		Road marking type (A.2.84)	M	Default enumerators (B.1.7)
		Road marking type – confidence (A.2.85)	M	
		Road object lane association (A.2.86)	O	Default enumerators (B.1.7)
		Road object lane association – confidence (A.2.87)	O	
		Arrow orientation {yaw} (A.2.88)	O	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Arrow direction (A.2.89)	C (B.2.2) * The signal “Road marking type” (A.2.84) has “RMT_Arrow” or a similar enumerator defined during the system design phase.	Default enumerators (B.1.7)
Road marking sign information	M	Number of valid sign classifications (A.2.90)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Sign classification type (A.2.91)
		Size type: dynamic/fixed Size #: Number of valid sign classifications (A.2.90)		
		Sign classification type (A.2.91)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Sign classification type – confidence (A.2.92)	M	
		Sign value (A.2.93)	O	
		Sign value unit (A.2.94)	O	Default enumerators (B.1.7)
		Sign text (A.2.95)	O	
		Sign text font (A.2.96)	O	Default enumerators (B.1.7)
		Sign text – confidence (A.2.97)	O	
		Number of valid entity states (A.2.98)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Entity state (A.2.99)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Size type: dynamic/fixed Size #: Number of valid entity states (A.2.98)		
		Entity state (A.2.99)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
Road marking message colour tone	C (B.2.1) Relevant: camera	Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – object level (A.2.100)	M	Profile: Colour model for RDOI (7.4.3)
		Colour tone – confidence – object level (A.2.101)	O	Profile: Colour model for RDOI (7.4.3)
Road marking background colour tone	C (B.2.1) Relevant: camera	Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – object level (A.2.100)	M	Profile: Colour model for RDOI (7.4.3)
		Colour tone – confidence – object level (A.2.101)	O	Profile: Colour model for RDOI (7.4.3)
Road marking connections	C (B.2.1) Relevant: camera, lidar	Number of valid connections (A.2.102)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Connection type (A.2.103)
		Size type: dynamic/fixed Size #: Number of valid connections (A.2.102)		
		Connection type (A.2.103)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Connection grouping ID (A.2.104)	M	
		Vertex point {x, y, z} (A.2.105)	{M, M, O}	
		Vertex point {x, y, z} – error (A.2.106)	{M, M, O}	Implementation EM (B.4.1)

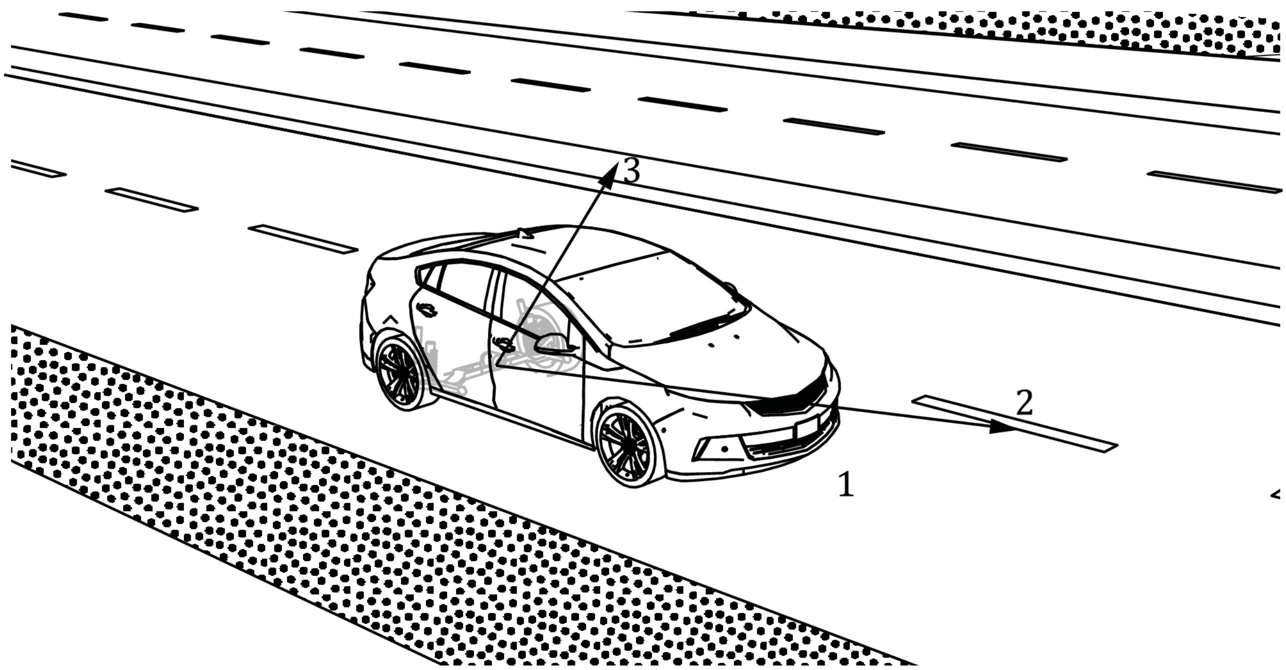
LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Vertex point – confidence {x, y, z} (A.2.107)	O	
⊆ Road marking polynomials	C (B.2.1) Relevant: camera, lidar	Number of valid polynomials (A.2.108)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid polynomials (A.2.108)		
		Polynomial coefficient y {*c0, c1, c2, c3*} (A.2.109)	M	
		Polynomial coefficient z {*c0, c1, c2, c3*} (A.2.110)	O	
		Polynomial y – error (A.2.111)	O	Implementation EM (B.4.1)
		Polynomial z – error (A.2.112)	O	Implementation EM (B.4.1)
		Polynomial range x {begin, end} (A.2.113)	M	
		Extent {width, height} – polynomial (A.2.114)	O	
		Extent {width, height} – polynomial – error (A.2.115)	O	Implementation EM (B.4.1)
		Extent {width, height} – polynomial – confidence (A.2.116)	O	
		Number of valid data ranges (A.2.117)	O	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid data ranges (A.2.117)		
		Supported data range x {begin, end} (A.2.118)	M	
		Supported axis (A.2.119)	M	
⊆ Road marking polylines	C (B.2.1) Relevant: camera, lidar	Polyline interpolation method (A.2.120)	M	Default enumerators (B.1.7)
		Number of valid polylines (A.2.121)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid polylines (A.2.121)		
		Number of valid vertices (A.2.122)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid vertices (A.2.122)		

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Vertex point {x, y, z} (A.2.105)	{M, M, O}	
		Vertex point {x, y, z} – error (A.2.106)	{M, M, O}	Implementation EM (B.4.1)
		Vertex point – confidence {x, y, z} (A.2.107)	O	
		Extent {width, height} – vertex (A.2.123)	O	
		Extent {width, height} – vertex – error (A.2.124)	O	Implementation EM (B.4.1)
		Extent {width, height} – vertex – confidence (A.2.125)	O	
Road boundaries	C (B.2.3) multiple entity types	Recognised road boundaries – capability (A.1.10.3)	O	
		Recognised road boundaries – status (A.1.11.3)	O	Redundancy (B.1.2) Signal: Recognised road boundaries – capability (A.1.10.3) Default enumerators (B.1.7)
		Number of valid road boundaries (A.1.12.3)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid road boundaries (A.1.12.3)		
Road boundary status	M	Existence probability – object level (A.2.1)	M	
		Object ID (A.2.2)	M	Alternative A2I (B.3.2)
		Object grouping ID (A.2.3)	O	
		Age (A.2.4)	M	
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
Road boundary information	M	Number of valid road boundary classifications (A.2.126)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Road boundary type (A.2.127)
		Size type: dynamic/fixed Size #: Number of valid road boundary classifications (A.2.126)		
		Road boundary type (A.2.127)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Road boundary type – confidence (A.2.128)	M	
		Road object lane association (A.2.86)	O	Default enumerators (B.1.7)
		Road object lane association – confidence (A.2.87)	O	
Road boundary colour tone	C (B.2.1) Relevant: camera	Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – object level (A.2.100)	M	Profile: Colour model for RDOI (7.4.3)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Colour tone – confidence – object level (A.2.101)	O	Profile: Colour model for RDOI (7.4.3)
Road boundary polynomials	C (B.2.1) Relevant: camera, lidar, radar	Number of valid polynomials (A.2.108)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid polynomials (A.2.108)		
		Polynomial coefficient y {*c0, c1, c2, c3*} (A.2.109)	M	
		Polynomial coefficient z {*c0, c1, c2, c3*} (A.2.110)	O	
		Polynomial y – error (A.2.111)	O	Implementation EM (B.4.1)
		Polynomial z – error (A.2.112)	O	Implementation EM (B.4.1)
		Polynomial range x {begin, end} (A.2.113)	M	
		Extent {width, height} – polynomial (A.2.114)	O	
		Extent {width, height} – polynomial – error (A.2.115)	O	Implementation EM (B.4.1)
		Extent {width, height} – polynomial – confidence (A.2.116)	O	
		Number of valid data ranges (A.2.117)	O	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid data ranges (A.2.117)		
		Supported data range x {begin, end} (A.2.118)	M	
		Supported axis (A.2.119)	M	
Road boundary polylines	C (B.2.1) Relevant: camera, lidar, radar	Polyline interpolation method (A.2.120)	M	Default enumerators (B.1.7)
		Number of valid polylines (A.2.121)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid polylines (A.2.121)		
		Number of valid vertices (A.2.122)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid vertices (A.2.122)		

LSG	RL LSG M/C/O	Signal				RL signal M/C/O	Option
					Vertex point {x, y, z} (A.2.105)	{M, M, O}	
					Vertex point {x, y, z} – error (A.2.106)	{M, M, O}	Implementation EM (B.4.1)
					Vertex point – confidence {x, y, z} (A.2.107)	O	
					Extent {width, height} – vertex (A.2.123)	O	
					Extent {width, height} – vertex – error (A.2.124)	O	Implementation EM (B.4.1)
					Extent {width, height} – vertex – confidence (A.2.125)	O	



Key

1 road surface; relevant for the ego-vehicle

2 road marking

3 road boundary

Figure 12 — Example for road objects

7.4.1 Road object header

Table 14 defines the interface header in subclause “Road object header” (7.4.1) and the changes due to the adaptation in comparison to the generic interface header in 7.2.1. The header of the RDOI can contain a list of valid road marking entities, a list of valid road boundary entities and/or a single road surface entity (see 7.4.2).

Table 14 — Specific signal grouping: Road object header

<table>
<tr><th>Signal</th><th colspan="2">RL signal</th><th>Option</th></tr>
<tr><td>Interface version ID {major, minor, patch} (A.1.1)</td><td colspan="2">Mandatory</td><td>Profile: Uniqueness of interface versioning (6.4)</td></tr>
<tr><td>Interface ID (A.1.2)</td><td colspan="2">Optional</td><td>Profile: Uniqueness of interface versioning (6.4)
Default enumerators (B.1.7)</td></tr>
<tr><td>Number of valid serving sensors (A.1.3)</td><td colspan="2">Mandatory</td><td>Profile: Uniqueness of interface versioning (6.4)
Optimise LL (B.1.1)
Alternative UTL (B.1.6)
Key: Sensor ID (A.1.4)</td></tr>
<tr><td>Sensor ID (A.1.4)</td><td colspan="2">Mandatory</td><td>Profile: Uniqueness of interface versioning (6.4)
Alternative VRO (B.1.3)</td></tr>
<tr><td>Time stamp – prediction (A.1.5.1)</td><td colspan="2">Mandatory</td><td></td></tr>
<tr><td>Cycle counter (A.1.6.1)</td><td colspan="2">Optional</td><td>Redundancy (B.1.2)
Signal: Time stamp – prediction (A.1.5.1)</td></tr>
<tr><td>Interface cycle time (A.1.7)</td><td colspan="2">Optional</td><td></td></tr>
<tr><td>Interface cycle time – variation (A.1.8)</td><td colspan="2">Optional</td><td></td></tr>
<tr><td>Data qualifier (A.1.9)</td><td colspan="2">Mandatory</td><td>Default enumerators (B.1.7)</td></tr>
<tr><td>Colour model type (A.1.14)</td><td colspan="2">Conditional (B.2.1)
Relevant: camera</td><td>Profile: Colour model for RDOI (7.4.3)
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)</td></tr>
<tr><td>Recognised road markings – capability (A.1.10.2)</td><td rowspan="6">RL LSG conditional (B.2.3) multiple entity types</td><td>Optional</td><td></td></tr>
<tr><td>Recognised road markings – status (A.1.11.2)</td><td>Optional</td><td>Redundancy (B.1.2)
Signal: Recognised road markings – capability (A.1.10.2)
Default enumerators (B.1.7)</td></tr>
<tr><td>Number of valid road markings (A.1.12.2)</td><td>Mandatory</td><td>Optimise LL (B.1.1)</td></tr>
<tr><td>Recognised road boundaries – capability (A.1.10.3)</td><td>Optional</td><td></td></tr>
<tr><td>Recognised road boundaries – status (A.1.11.3)</td><td>Optional</td><td>Redundancy (B.1.2)
Signal: Recognised road boundaries – capability (A.1.10.3)
Default enumerators (B.1.7)</td></tr>
<tr><td>Number of valid road boundaries (A.1.12.3)</td><td>Mandatory</td><td>Optimise LL (B.1.1)</td></tr>
</table>

The following LSGs, which normally shall be provided by the sensor cluster in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor cluster (see B.3.3):

— interface: SPI; LSG "Information: vehicle coordinate system" (see Table 51);

— interface: SHII; LSG "Calibration" (see Table 53);

— interface: SHII; LSG "Sensor cluster" (see Table 53).

7.4.2 Road object entity

Each road object describes a recognised real-world road limitation (road marking or road boundary) or the relevant road surface for the ego-vehicle. They consist of several LSGs.

The road surface is described by the road surface LSG. The road surface provides no LSG "Status".

A road marking is described by the following LSGs for road marking.

— **Status:** the status describes the general information of a tracked road marking. This information is based on history of the object tracking. Table 15 defines the signal grouping "Road object entity status". It defines this status LSG of the road marking and redefines the signal grouping "Generic object level entity status" (see Table 8).

— **Information:** the information describes the road marking type and different visual properties related to the road marking.

— **Sign information:** the sign information describes optional the sign symbol of the road marking, which may be equivalent to a traffic sign as traffic main sign.

— **Colour tone:** the colour tone describes the main colour of the message text and the background of the road marking.

— The contour of a road marking could be described by polynomials and/or polylines and connections:

  — **Connections:** the contour can be connected with other road markings contours of the road and each connection has a common vertex point at the connection of the road markings.

  — **Polynomials:** the polynomials of a road marking describe the detailed shape and bounds in a 3D vector space with polynomial lines. Different polynomials describe the y and z values of the contour independently.

  — **Polylines:** the polylines of a road marking describe the detailed shape and bounds in a 3D vector space with multiple line segments and a defined interpolation method.

A road boundary is described by the following LSGs for road boundary:

— **Status:** the status describes the general information of a tracked road boundary. This information is based on history of the object tracking. Table 15 defines the signal grouping "Road object entity status". It defines this status LSG of the road boundary and redefines the signal grouping "Generic object level entity status" (see Table 8).

— **Information:** the information describes the road boundary type and different visual properties related to the road boundary.

— **Colour tone:** the colour tone describes the main colour of the road boundary.

— The contour could be described by polynomials and/or polylines:

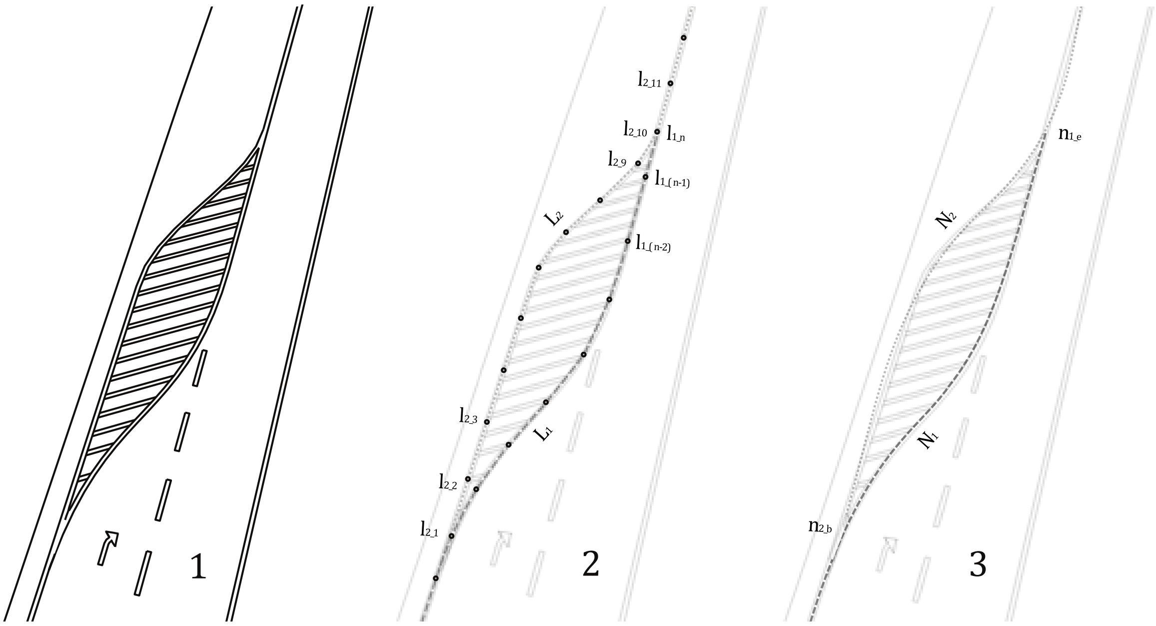
- **Polynomials:** the polynomials of a road boundary describe the detailed shape and bounds in a 3D vector space with polynomial lines. Different polynomials describe the y and z values of the contour independently.

- **Polylines:** the polylines of a road boundary describe the detailed shape and bounds in a 3D vector space with multiple line segments and a defined interpolation method.

Table 15 — Specific signal grouping: Road object entity status

Signal	RL signal	Option
Existence probability – object level (A.2.1)	Mandatory	
Object ID (A.2.2)	Mandatory	Alternative A2I (B.3.2)
Object grouping ID (A.2.3)	Optional	
Age (A.2.4)	Mandatory	
Number of valid observations – object level (A.2.5)	Optional	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see "Time stamp reference – object level" (A.2.6)]
Time stamp reference – object level (A.2.6)	Mandatory	Alternative VRO (B.1.3)
Observation status – object level (A.2.7)	Mandatory	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
Track quality (A.2.8)	Optional	
Measurement status – object level (A.2.9)	Mandatory	Default enumerators (B.1.7)

Road markings and road boundaries can be represented either by polynomials of degree 3 or by polylines consisting of one or more segments merged at the vertex points (see Figure 13 and see informative figures in Annex A for details: Figure A.11 and Figure A.14).



Key

1 real-world scene

2 polyline contour representation

L_x x^{th} polyline

l_{x_y} y^{th} vertex point [signal “Vertex point {x, y, z}” (A.2.105)] of the x^{th} polyline

3 polynomial contour representation

N_x x^{th} polynomial

n_{x_b} range begin of the x^{th} polynomial [see “Polynomial range x {begin, end}” (A.2.113)]

n_{x_e} range end of the x^{th} polynomial [see “Polynomial range x {begin, end}” (A.2.113)]

Figure 13 — Example for alternative contour representations

The road marking contours are specified with road marking polynomials and/or road marking polylines and refer to connections of road markings by the signal “Connection type” (A.2.103) and the signal “Connection grouping ID” (A.2.104). Each road marking connection is defined by a unique signal “Connection grouping ID” (A.2.104) value and connects two or more road marking contours.

7.4.3 Profile: Colour model for RDOI

The profile is relevant for camera sensor technology (B.2.1). The signal “Colour model type” (A.1.14) defines the colour model for the interface. Depending on the colour model, each colour is described by a fixed number of colour values [see signal “Colour value – object level” (A.2.100)] to define the colour tone. The confidence of the colour tone is provided by the signal “Colour tone – confidence – object level” (A.2.101).

The interface provides colour tones for road markings and road boundaries.

7.5 Static object interface

The static object interface (SOI) consists of four types of entities: general landmarks, traffic signs (traffic main sign and additional supplementary signs), traffic sign boards and traffic lights (see Figure 14). Table 16 defines the logical structure of the static object interface.

Table 16 — Static object interface

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning (6.4)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
		Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
		Time stamp – prediction (A.1.5.1)	M	
		Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – prediction (A.1.5.1)
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	
		Data qualifier (A.1.9)	M	Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Colour model type (A.1.14)	C (B.2.1) Relevant: camera	Profile: Colour model for SOI (7.5.3) 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)
General landmarks	C (B.2.3) multiple entity types	Recognised general landmarks – capability (A.1.10.4)	O	
		Recognised general landmarks – status (A.1.11.4)	O	Redundancy (B.1.2) Signal: Recognised general landmarks – capability (A.1.10.4) Default enumerators (B.1.7)
		Number of valid general landmarks (A.1.12.4)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid general landmarks (A.1.12.4)		
General landmark status	M	Existence probability – object level (A.2.1)	M	
		Object ID (A.2.2)	M	Alternative A2I (B.3.2)
		Object grouping ID (A.2.3)	O	
		Age (A.2.4)	M	
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
General landmark information	M	Number of valid general landmark classifications (A.2.129)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: General landmark classification type (A.2.130)
		Size type: dynamic/fixed Size #: Number of valid general landmark classifications (A.2.129)		
		General landmark classification type (A.2.130)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		General landmark classification type – confidence (A.2.131)	M	
General landmark position	M	Reference point (A.2.14)	O	Default enumerators (B.1.7)
		Position – object level {x, y, z} (A.2.15)	{M, M, O}	
		Position – object level {x, y, z} – error (A.2.16)	{M, M, O}	Implementation EM (B.4.1)
		Orientation {yaw, pitch, roll} (A.2.17)	{C (B.2.1) Relevant: camera, O, O}	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Orientation {yaw, pitch, roll} – error (A.2.18)	O	Implementation EM (B.4.1)
General landmark bounding box	C (B.2.1) Relevant: camera	Bounding box extent {length, width, height} (A.2.20)	{M, M, O}	
		Bounding box extent {length, width, height} – error (A.2.21)	O	Implementation EM (B.4.1)
Traffic signs	C (B.2.3) multiple entity types	Recognised traffic signs – capability (A.1.10.5)	O	
		Recognised traffic signs – status (A.1.11.5)	O	Redundancy (B.1.2) Signal: Recognised traffic signs – capability (A.1.10.5) Default enumerators (B.1.7)
		Number of valid traffic signs (A.1.12.5)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid traffic signs (A.1.12.5)		
Traffic main sign status	M	Existence probability – object level (A.2.1)	M	
		Object ID (A.2.2)	M	Alternative A2I (B.3.2)
		Object grouping ID (A.2.3)	O	
		Age (A.2.4)	M	
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
Traffic main sign information	M	Number of valid sign classifications (A.2.90)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Sign classification type (A.2.91)
		Size type: dynamic/fixed Size #: Number of valid sign classifications (A.2.90)		
		Sign classification type (A.2.91)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Sign classification type – confidence (A.2.92)	M	
		Sign value (A.2.93)	M	
		Sign value unit (A.2.94)	M	Default enumerators (B.1.7)
		Sign text (A.2.95)	O	
		Sign text font (A.2.96)	O	Default enumerators (B.1.7)
		Sign text – confidence (A.2.97)	O	
		Number of valid entity states (A.2.98)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Entity state (A.2.99)
		Size type: dynamic/fixed Size #: Number of valid entity states (A.2.98)		

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Entity state (A.2.99)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Sign geometry (A.2.132)	O	Default enumerators (B.1.7)
Traffic main sign message colour tone	C (B.2.1) Relevant: camera	Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – object level (A.2.100)	M	Profile: Colour model for SOI (7.5.3)
		Colour tone – confidence – object level (A.2.101)	O	Profile: Colour model for SOI (7.5.3)
Traffic main sign background colour tone	C (B.2.1) Relevant: camera	Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – object level (A.2.100)	M	Profile: Colour model for SOI (7.5.3)
		Colour tone – confidence – object level (A.2.101)	O	Profile: Colour model for SOI (7.5.3)
Traffic main sign lane relevance	O	Number of valid lane relevance classifications (A.2.133)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Lane relevance classification type (A.2.134)
		Size type: dynamic/fixed Size #: Number of valid lane relevance classifications (A.2.133)		
		Lane relevance classification type (A.2.134)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Lane relevance classification type – confidence (A.2.135)	M	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Traffic main sign position	M	Reference point (A.2.14)	O	Default enumerators (B.1.7)
		Position – object level {x, y, z} (A.2.15)	{M, M, O}	
		Position – object level {x, y, z} – error (A.2.16)	{M, M, O}	Implementation EM (B.4.1)
		Orientation {yaw, pitch, roll} (A.2.17)	{C (B.2.1) Relevant: camera, O, O}	
		Orientation {yaw, pitch, roll} – error (A.2.18)	O	Implementation EM (B.4.1)
Traffic main sign bounding box	O	Bounding box extent {length, width, height} (A.2.20)	{O, M, M}	
		Bounding box extent {length, width, height} – error (A.2.21)	O	Implementation EM (B.4.1)
Supplementary signs	M	Number of valid traffic supplementary signs (A.2.136)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid traffic supplementary signs (A.2.136)		
Supplementary sign status	M	Existence probability – object level (A.2.1)	M	
		Age (A.2.4)	M	
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
Supplementary sign information	M	Number of valid supplementary sign classifications (A.2.137)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Supplementary sign classification type (A.2.138)
		Size type: dynamic/fixed Size #: Number of valid supplementary sign classifications (A.2.137)		
		Supplementary sign classification type (A.2.138)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Supplementary sign classification type – confidence (A.2.139)	M	
		Sign value (A.2.93)	M	
		Sign value unit (A.2.94)	M	Default enumerators (B.1.7)
		Sign text (A.2.95)	O	
		Sign text font (A.2.96)	O	Default enumerators (B.1.7)
		Sign text – confidence (A.2.97)	O	
		Number of valid entity states (A.2.98)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Entity state (A.2.99)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Size type: dynamic/fixed Size #: Number of valid entity states (A.2.98)		
		Entity state (A.2.99)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
Supplementary sign message colour tone	C (B.2.1) Relevant: camera	Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – object level (A.2.100)	M	Profile: Colour model for SOI (7.5.3)
		Colour tone – confidence – object level (A.2.101)	O	Profile: Colour model for SOI (7.5.3)
Supplementary sign background colour tone	C (B.2.1) Relevant: camera	Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – object level (A.2.100)	M	Profile: Colour model for SOI (7.5.3)
		Colour tone – confidence – object level (A.2.101)	O	Profile: Colour model for SOI (7.5.3)
Supplementary sign position	M	Relative position (A.2.140)	M	Default enumerators (B.1.7)
		Relative position order (A.2.141)	M	
Traffic sign boards	C (B.2.3) multiple entity types	Recognised traffic sign boards – capability (A.1.10.6)	O	
		Recognised traffic sign boards – status (A.1.11.6)	O	Redundancy (B.1.2) Signal: Recognised traffic sign boards – capability (A.1.10.6) Default enumerators (B.1.7)
		Number of valid traffic sign boards (A.1.12.6)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid traffic sign boards (A.1.12.6)		

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Traffic sign board status	M	Existence probability – object level (A.2.1)	M	
		Object ID (A.2.2)	M	Alternative A2I (B.3.2)
		Object grouping ID (A.2.3)	O	
		Age (A.2.4)	M	
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see "Time stamp reference – object level" (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
Traffic sign board information	O	Number of valid entity states (A.2.98)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Entity state (A.2.99)
		Size type: dynamic/fixed Size #: Number of valid entity states (A.2.98)		

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Entity state (A.2.99)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
Traffic sign board colour tone	C (B.2.1) Relevant: camera	Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – object level (A.2.100)	M	Profile: Colour model for SOI (7.5.3)
		Colour tone – confidence – object level (A.2.101)	O	Profile: Colour model for SOI (7.5.3)
Traffic sign board position	M	Position uv_origin {x, y, z} (A.2.142)	M	Profile: Detection references for 3D detections (7.5.4)
		Position uv_origin {x, y, z} – error (A.2.143)	M	Profile: Detection references for 3D detections (7.5.4) Implementation EM (B.4.1)
		Position u_end {x, y, z} (A.2.144)	M	Profile: Detection references for 3D detections (7.5.4)
		Position u_end {x, y, z} – error (A.2.145)	M	Profile: Detection references for 3D detections (7.5.4) Implementation EM (B.4.1)
		Position v_end {x, y, z} (A.2.146)	M	Profile: Detection references for 3D detections (7.5.4)
		Position v_end {x, y, z} – error (A.2.147)	M	Profile: Detection references for 3D detections (7.5.4) Implementation EM (B.4.1)
		Ratio U- to V-axis (A.2.148)	O	
		Ratio U- to V-axis – error (A.2.149)	O	Implementation EM (B.4.1)
Traffic sign board regions	C (B.2.3) multiple traffic sign board entity types	Number of valid traffic sign board regions (A.2.150)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid traffic sign board regions (A.2.150)		

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Traffic sign board region status	M	Existence probability – object level (A.2.1)	M	
		Age (A.2.4)	M	
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see "Time stamp reference – object level" (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
		Sign board entity ID (A.2.151)	O	Alternative A2I (B.3.2)
		Number of valid entity ID references – object level (A.2.152)	O	Optimise LL (B.1.1) Alternative A2I (B.3.2)
		Size type: dynamic/fixed Size #: Number of valid entity ID references – object level (A.2.152)		
		Sign board entity ID reference – object level (A.2.153)	M	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Traffic sign board region information	O	Number of valid entity states (A.2.98)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Entity state (A.2.99)
		Size type: dynamic/fixed Size #: Number of valid entity states (A.2.98)		
		Entity state (A.2.99)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Border width {u, v} (A.2.154)	O	
		Border width {u, v} – error (A.2.155)	O	Implementation EM (B.4.1)
		Traffic sign board region – confidence (A.2.156)	O	
Traffic sign board region colour tone	C (B.2.1) Relevant: camera	Number of valid colour tones (A.2.157)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Colour tone type (A.2.158)
		Size type: dynamic/fixed Size #: Number of valid colour tones (A.2.157)		
		Colour tone type (A.2.158)	M	Alternative VRO (B.1.3)
		Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – object level (A.2.100)	M	Profile: Colour model for SOI (7.5.3)
		Colour tone – confidence – object level (A.2.101)	O	Profile: Colour model for SOI (7.5.3)
Traffic sign board region vertex points	M	Number of valid vertex points (A.2.159)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid vertex points (A.2.159)		
		Local position {u, v} (A.2.160)	M	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Local position {u, v} – error (A.2.161)	M	Implementation EM (B.4.1)
Traffic sign board guiding graphs	C (B.2.3) multiple traffic sign board entity types	Number of valid traffic sign board guiding graphs (A.2.162)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid traffic sign board guiding graphs (A.2.162)		
Traffic sign board guiding graph status	M	Existence probability – object level (A.2.1)	M	
		Age (A.2.4)	M	
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
		Sign board entity ID (A.2.151)	O	Alternative A2I (B.3.2)
		Number of valid entity ID references – object level (A.2.152)	O	Optimise LL (B.1.1) Alternative A2I (B.3.2)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Size type: dynamic/fixed Size #: Number of valid entity ID references – object level (A.2.152)		
		Sign board entity ID reference – object level (A.2.153)	M	
Traffic sign board guiding graph information	O	Traffic sign board guiding graph – confidence (A.2.163)	M	
Traffic sign board guiding graph vertex points	M	Number of valid vertex points (A.2.159)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Local position ID (A.2.164)
		Size type: dynamic/fixed Size #: Number of valid vertex points (A.2.159)		
		Local position ID (A.2.164)	M	Alternative VRO (B.1.3)
		Local position {u, v} (A.2.160)	M	
		Local position {u, v} – error (A.2.161)	M	Implementation EM (B.4.1)
Traffic sign board guiding graph edges	M	Number of valid edges (A.2.165)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid edges (A.2.165)		
		Local position ID reference {begin, end} (A.2.166)	M	
		Edge type (A.2.167)	M	Default enumerators (B.1.7)
		Edge width {u, v} (A.2.168)	O	
		Edge width {u, v} – error (A.2.169)	O	Implementation EM (B.4.1)
		Border width {u, v} (A.2.154)	O	
		Border width {u, v} – error (A.2.155)	O	Implementation EM (B.4.1)
		Edge curve type (A.2.170)	O	Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Arrow type (A.2.171)	O	Default enumerators (B.1.7)
		Number of valid entity states (A.2.98)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Entity state (A.2.99)
		Size type: dynamic/fixed Size #: Number of valid entity states (A.2.98)		
		Entity state (A.2.99)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
⊆ ⊆ Traffic sign board guiding graph edge colour tone	M	Number of valid colour tones (A.2.157)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Colour tone type (A.2.158)
		Size type: dynamic/fixed Size #: Number of valid colour tones (A.2.157)		
		Colour tone type (A.2.158)	M	Alternative VRO (B.1.3)
		Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – object level (A.2.100)	M	Profile: Colour model for SOI (7.5.3)
		Colour tone – confidence – object level (A.2.101)	O	Profile: Colour model for SOI (7.5.3)
⊆ Traffic sign board text	C (B.2.3) multiple traffic sign board entity types	Number of valid traffic sign board texts (A.2.172)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid traffic sign board texts (A.2.172)		
⊆ ⊆ Traffic sign board text status	M	Existence probability – object level (A.2.1)	M	
		Age (A.2.4)	M	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
		Sign board entity ID (A.2.151)	O	Alternative A2I (B.3.2)
		Number of valid entity ID references – object level (A.2.152)	O	Optimise LL (B.1.1) Alternative A2I (B.3.2)
		Size type: dynamic/fixed Size #: Number of valid entity ID references – object level (A.2.152)		
		Sign board entity ID reference – object level (A.2.153)	M	
Traffic sign board text information	M	Sign text (A.2.95)	M	
		Sign text font (A.2.96)	O	Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Sign text – confidence (A.2.97)	O	
		Number of valid entity states (A.2.98)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Entity state (A.2.99)
		Size type: dynamic/fixed Size #: Number of valid entity states (A.2.98)		
		Entity state (A.2.99)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
Traffic sign board text colour tone	M	Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – object level (A.2.100)	M	Profile: Colour model for SOI (7.5.3)
		Colour tone – confidence – object level (A.2.101)	O	Profile: Colour model for SOI (7.5.3)
Traffic sign board text bounding box	M	Bounding box $\{u_{Begin}, u_{End}, v_{Begin}, v_{End}\}$ (A.2.173)	M	
		Bounding box $\{u_{Begin}, u_{End}, v_{Begin}, v_{End}\}$ – error (A.2.174)	O	Implementation EM (B.4.1)
Traffic sign board icons and symbols	C (B.2.3) multiple traffic sign board entity types	Number of valid traffic sign board icons and symbols (A.2.175)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid traffic sign board icons and symbols (A.2.175)		
Traffic sign board icon or symbol status	M	Existence probability – object level (A.2.1)	M	
		Age (A.2.4)	M	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
		Sign board entity ID (A.2.151)	O	Alternative A2I (B.3.2)
		Number of valid entity ID references – object level (A.2.152)	O	Optimise LL (B.1.1) Alternative A2I (B.3.2)
		Size type: dynamic/fixed Size #: Number of valid entity ID references – object level (A.2.152)		
		Sign board entity ID reference – object level (A.2.153)	M	
Traffic sign board icon or symbol information	M	Icon and symbol type (A.2.176)	M	Default enumerators (B.1.7)
		Icon and symbol type – confidence (A.2.177)	O	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Number of valid entity states (A.2.98)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Entity state (A.2.99)
		Size type: dynamic/fixed Size #: Number of valid entity states (A.2.98)		
		Entity state (A.2.99)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
Traffic sign board icon or symbol bounding box	M	Bounding box {u_{Begin}, u_{End}, v_{Begin}, v_{End}} (A.2.173)	M	
		Bounding box {u_{Begin}, u_{End}, v_{Begin}, v_{End}} – error (A.2.174)	O	Implementation EM (B.4.1)
Traffic sign board object references	C (B.2.3) multiple traffic sign board entity types	Number of valid traffic sign board object references (A.2.178)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid traffic sign board object references (A.2.178)		
Traffic sign board object reference status	M	Existence probability – object level (A.2.1)	M	
		Age (A.2.4)	M	
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
		Sign board entity ID (A.2.151)	O	Alternative A2I (B.3.2)
		Number of valid entity ID references – object level (A.2.152)	O	Optimise LL (B.1.1) Alternative A2I (B.3.2)
		Size type: dynamic/fixed Size #: Number of valid entity ID references – object level (A.2.152)		
		Sign board entity ID reference – object level (A.2.153)	M	
Traffic sign board object reference information	M	Object ID reference – object level (A.2.179)	M	[a]
		Object ID reference – confidence (A.2.180)	O	
Traffic sign board object reference bounding box	M	Bounding box $\{u_{Begin}, u_{End}, v_{Begin}, v_{End}\}$ (A.2.173)	M	
		Bounding box $\{u_{Begin}, u_{End}, v_{Begin}, v_{End}\}$ – error (A.2.174)	O	Implementation EM (B.4.1)
Traffic sign board occlusion	C (B.2.3) multiple traffic sign board entity types	Number of valid traffic sign board occlusions (A.2.181)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid traffic sign board occlusions (A.2.181)		
Traffic sign board occlusion status	M	Existence probability – object level (A.2.1)	M	
		Age (A.2.4)	M	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
		Sign board entity ID (A.2.151)	O	Alternative A2I (B.3.2)
		Number of valid entity ID references – object level (A.2.152)	O	Optimise LL (B.1.1) Alternative A2I (B.3.2)
		Size type: dynamic/fixed Size #: Number of valid entity ID references – object level (A.2.152)		
		Sign board entity ID reference – object level (A.2.153)	M	
Traffic sign board occlusion information	O	Occlusion type (A.2.182)	M	Default enumerators (B.1.7)
		Occlusion type – confidence (A.2.183)	O	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
⊆ ⊆ Traffic sign board occlusion vertex points	M	Number of valid vertex points (A.2.159)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid vertex points (A.2.159)		
		Local position {u, v} (A.2.160)	M	
		Local position {u, v} – error (A.2.161)	M	Implementation EM (B.4.1)
Traffic lights	C (B.2.3) multiple entity types	Recognised traffic lights – capability (A.1.10.7)	O	
		Recognised traffic lights – status (A.1.11.7)	O	Redundancy (B.1.2) Signal: Recognised traffic lights – capability (A.1.10.7) Default enumerators (B.1.7)
		Number of valid traffic lights (A.1.12.7)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid traffic lights (A.1.12.7)		
⊆ Traffic light status	M	Existence probability – object level (A.2.1)	M	
		Object ID (A.2.2)	M	Alternative A2I (B.3.2)
		Object grouping ID (A.2.3)	O	
		Age (A.2.4)	M	
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)

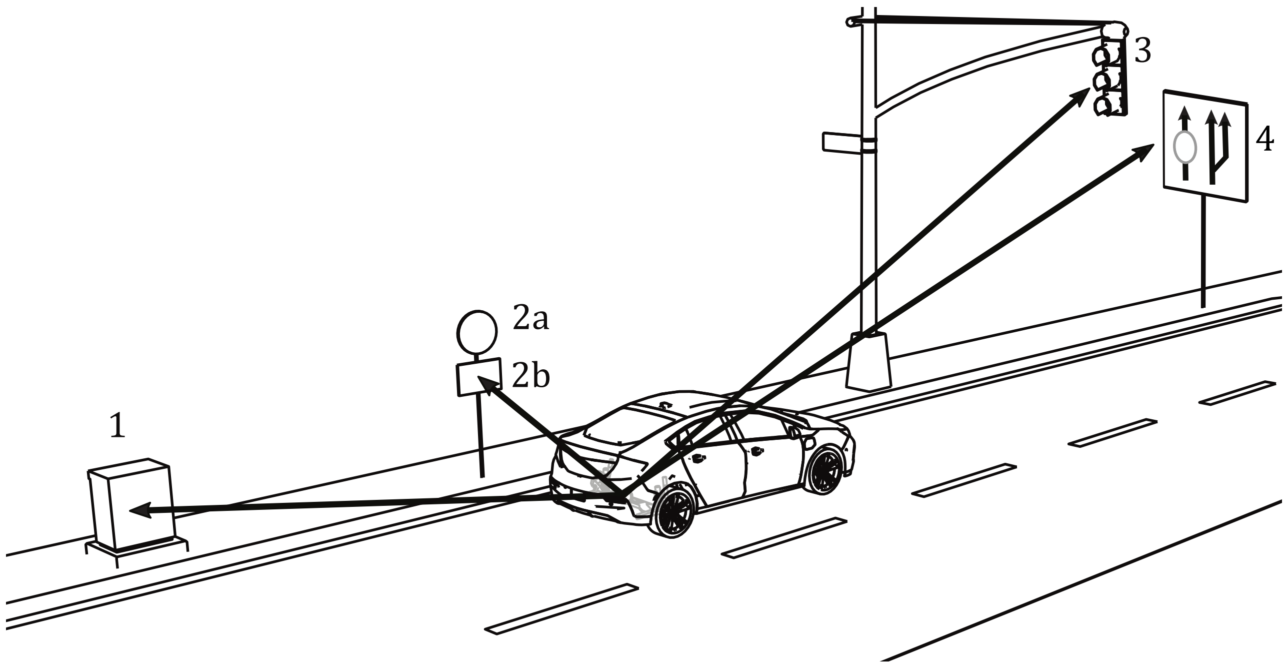
LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
Traffic light information	M	Number of valid structure light classifications (A.2.184)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Structure light classification type (A.2.185)
		Size type: dynamic/fixed Size #: Number of valid structure light classifications (A.2.184)		
		Structure light classification type (A.2.185)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Structure light classification type – confidence (A.2.186)	M	
Traffic light position	M	Reference point (A.2.14)	O	Default enumerators (B.1.7)
		Position – object level {x, y, z} (A.2.15)	{M, M, O}	
		Position – object level {x, y, z} – error (A.2.16)	{M, M, O}	Implementation EM (B.4.1)
		Orientation {yaw, pitch, roll} (A.2.17)	{C (B.2.1) Relevant: camera, O, O}	
		Orientation {yaw, pitch, roll} – error (A.2.18)	O	Implementation EM (B.4.1)
		Minimum visibility distance (A.2.187)	M	
Traffic light bounding	C (B.2.1) Relevant:	Bounding box extent {length, width, height} (A.2.20)	{O, M, M}	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
box	camera	Bounding box extent {length, width, height} – error (A.2.21)	O	Implementation EM (B.4.1)
Traffic light spots	M	Total number of traffic light spots (A.2.188)	O	
		Total number of traffic light spots – confidence (A.2.189)	O	
		Number of valid traffic light spots (A.2.190)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid traffic light spots (A.2.190)		
Traffic light spot status	M	Existence probability – object level (A.2.1)	M	
		Age (A.2.4)	M	
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Traffic light spot information	M	Number of valid light shape classifications (A.2.191)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Light shape classification type (A.2.192)
		Size type: dynamic/fixed Size #: Number of valid light shape classifications (A.2.191)		
		Light shape classification type (A.2.192)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Light shape classification type – confidence (A.2.193)	M	
		Light shape value (A.2.194)	C (B.2.2) * The signal "Light shape classification type" (A.2.192) has "LSCT_CountdownSecond", "LSCT_CountdownPercent" or a similar enumerator defined during the system design phase.	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Traffic light spot colour	C (B.2.1) Relevant: camera	Number of valid colour classifications (A.2.195)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Colour classification type (A.2.196)
		Size type: dynamic/fixed Size #: Number of valid colour classifications (A.2.195)		
		Colour classification type (A.2.196)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Colour classification type – confidence (A.2.197)	M	
		Number of valid light mode classifications (A.2.198)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Light mode classification type (A.2.199)
		Size type: dynamic/fixed Size #: Number of valid light mode classifications (A.2.198)		
		Light mode classification type (A.2.199)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Light mode classification type – confidence (A.2.200)	M	
Traffic light spot position	M	Position – object level {x, y, z} (A.2.15)	{M, M, O}	
		Position – object level {x, y, z} – error (A.2.16)	{M, M, O}	Implementation EM (B.4.1)
		Number of valid lane relevance classifications (A.2.133)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Lane relevance classification type (A.2.134)

LSG	RL LSG M/C/O	Signal				RL signal M/C/O	Option
					Size type: dynamic/fixed Size #: Number of valid lane relevance classifications (A.2.133)		
					Lane relevance classification type (A.2.134)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
					Lane relevance classification type – confidence (A.2.135)	M	
[a] Reference only SOI traffic sign or traffic light							



Key

1 general landmark

2a main sign of a traffic sign

2b supplementary sign of a traffic sign

3 traffic light (with 3 traffic light spots)

4 traffic sign board (with guiding graph and a traffic main sign, which is a referenced traffic sign entity)

Figure 14 — Example for static objects

7.5.1 Static object header

Table 17 defines the interface header in subclause “Static object header” (7.5.1) and the changes due to the adaptation in comparison to the generic interface header in 7.2.1. The header of the SOI can contain a list of general landmarks, a list of valid traffic signs and/or a list of valid traffic light entities (see 7.5.2).

Table 17 — Specific signal grouping: Static object header

<table>
<tr><th>Signal</th><th colspan="2">RL signal</th><th>Option</th></tr>
<tr><td>Interface version ID {major, minor, patch} (A.1.1)</td><td colspan="2">Mandatory</td><td>Profile: Uniqueness of interface versioning (6.4)</td></tr>
<tr><td>Interface ID (A.1.2)</td><td colspan="2">Optional</td><td>Profile: Uniqueness of interface versioning (6.4)
Default enumerators (B.1.7)</td></tr>
<tr><td>Number of valid serving sensors (A.1.3)</td><td colspan="2">Mandatory</td><td>Profile: Uniqueness of interface versioning (6.4)
Optimise LL (B.1.1)
Alternative UTL (B.1.6)
Key: Sensor ID (A.1.4)</td></tr>
<tr><td>Sensor ID (A.1.4)</td><td colspan="2">Mandatory</td><td>Profile: Uniqueness of interface versioning (6.4)
Alternative VRO (B.1.3)</td></tr>
<tr><td>Time stamp – prediction (A.1.5.1)</td><td colspan="2">Mandatory</td><td></td></tr>
<tr><td>Cycle counter (A.1.6.1)</td><td colspan="2">Optional</td><td>Redundancy (B.1.2)
Signal: Time stamp – prediction (A.1.5.1)</td></tr>
<tr><td>Interface cycle time (A.1.7)</td><td colspan="2">Optional</td><td></td></tr>
<tr><td>Interface cycle time – variation (A.1.8)</td><td colspan="2">Optional</td><td></td></tr>
<tr><td>Data qualifier (A.1.9)</td><td colspan="2">Mandatory</td><td>Default enumerators (B.1.7)</td></tr>
<tr><td>Colour model type (A.1.14)</td><td colspan="2">Conditional (B.2.1)
Relevant: camera</td><td>Profile: Colour model for SOI (7.5.3)
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)</td></tr>
<tr><td>Recognised general landmarks – capability (A.1.10.4)</td><td rowspan="6">RL LSG conditional (B.2.3) multiple entity types</td><td>Optional</td><td></td></tr>
<tr><td>Recognised general landmarks – status (A.1.11.4)</td><td>Optional</td><td>Redundancy (B.1.2)
Signal: Recognised general landmarks – capability (A.1.10.4)
Default enumerators (B.1.7)</td></tr>
<tr><td>Number of valid general landmarks (A.1.12.4)</td><td>Mandatory</td><td>Optimise LL (B.1.1)</td></tr>
<tr><td>Recognised traffic signs – capability (A.1.10.5)</td><td>Optional</td><td></td></tr>
<tr><td>Recognised traffic signs – status (A.1.11.5)</td><td>Optional</td><td>Redundancy (B.1.2)
Signal: Recognised traffic signs – capability (A.1.10.5)
Default enumerators (B.1.7)</td></tr>
<tr><td>Number of valid traffic signs (A.1.12.5)</td><td>Mandatory</td><td>Optimise LL (B.1.1)</td></tr>
</table>

Signal	RL signal		Option
Recognised traffic sign boards – capability (A.1.10.6)		Optional	
Recognised traffic sign boards – status (A.1.11.6)		Optional	Redundancy (B.1.2) Signal: Recognised traffic sign boards – capability (A.1.10.6) Default enumerators (B.1.7)
Number of valid traffic sign boards (A.1.12.6)		Mandatory	Optimise LL (B.1.1)
Recognised traffic lights – capability (A.1.10.7)		Optional	
Recognised traffic lights – status (A.1.11.7)		Optional	Redundancy (B.1.2) Signal: Recognised traffic lights – capability (A.1.10.7) Default enumerators (B.1.7)
Number of valid traffic lights (A.1.12.7)		Mandatory	Optimise LL (B.1.1)

The following LSGs, which normally shall be provided by the sensor cluster in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor cluster (see B.3.3):

— interface: SPI; LSG “Information: vehicle coordinate system” (see Table 51);

— interface: SHII; LSG “Calibration” (see Table 53);

— interface: SHII; LSG “Sensor cluster” (see Table 53).

7.5.2 Static object entity

Each static object describes a recognised real-world general landmark, traffic sign, traffic sign board or traffic light. They consist of several LSGs. The traffic sign consists of a main sign and none, one or more supplementary signs. A main sign is a traffic sign that can be followed on its own (for example, a stop sign). A supplementary sign is a sign with conditions under which the main sign is valid (for example, under wet conditions only). A traffic sign board may consist of regions on the board, guiding graphs, text strings, icons and symbols, referenced object entities (for example, traffic signs, traffic lights) and occlusions.

A general landmark is described by the following LSGs.

— **Status:** the status describes general information of the tracked general landmark. This information is based on history of the object tracking. Table 18 defines the signal grouping “Static object entity status”. It defines this status LSG of the general landmark and redefines the signal grouping “Generic object level entity status” (see Table 8).

— **Information:** the information describes the general landmark type and confidence.

— **Position:** the position describes the position information of the tracked static object.

— **Bounding box:** the bounding box describes the 3D rectangular hull that encloses the recognised static object.

A traffic sign is described by the following LSGs.

— **Main sign status:** the main sign status describes general information of the tracked main sign. This information is based on history of the object tracking. Table 18 defines the signal grouping “Static object entity status”. It defines this status LSG of the main sign and redefines the signal grouping “Generic object level entity status” (see Table 8).

— **Main sign information:** the main sign information describes the semantic of the main sign.

— **Main sign colour tone:** the main sign colour tone describes visual properties of the main sign’s message text and the background.

— **Main sign lane relevance:** the main sign lane relevance describes the lanes, which are relevant for the main sign and its supplementary signs.

— **Main sign position:** the main sign position describes the geometric position and orientation of the main sign.

— **Main sign bounding box:** the main sign bounding box describes the 3D rectangular hull that encloses the recognised main sign.

— A list of supplementary signs assigned to the main sign:

  — **Supplementary sign status:** the supplementary sign status describes general information of the tracked supplementary sign. This information is based on history of the object tracking and is associated to the main sign. A supplementary sign uses a subset of signals of the signal grouping “Static object entity status” (Table 18) for this LSG.

  — **Supplementary sign information:** the supplementary sign information describes the supplementary sign type and confidence.

  — **Supplementary sign colour tone:** the supplementary sign colour tone describes visual properties of the supplementary sign’s message text and the background.

  — **Supplementary sign position:** the supplementary sign position describes the qualitative position of the supplementary sign with respect to the main sign and other supplementary signs.

A traffic sign board is described by the following LSGs (see key 1 in Figure 15).

— **Traffic sign board status:** the sign board status describes general information of the tracked traffic sign board. This information is based on history of the object tracking. Table 18 defines the signal grouping “Static object entity status”. It defines this status LSG of the sign board and redefines the signal grouping “Generic object level entity status” (see Table 8).

— **Traffic sign board information:** the sign board information describes the general information of the traffic sign board.

— **Traffic sign board colour tone:** the sign board colour tone describes visual properties of the traffic sign board.

— **Traffic sign board position:** the position describes the rectangular shape of the tracked traffic sign board. It defines the affine coordinate system of the traffic sign board.

A traffic sign board entity uses multiple traffic sign board entity types as regions, guiding graphs, text, icons and symbols, referenced object entities and occlusions.

— A list of traffic sign board regions which are assigned to the traffic sign board (see key 2 in Figure 15 and Figure 16):

  — **Region status:** the region status describes general information of the tracked region. The region is associated to a sign board type entity or the sign board. A region uses a subset of signals of the signal grouping “Static object entity status” (Table 18) for this LSG and extends signals for a hierarchical association of traffic sign board type entities.

  — **Region information:** the region information describes the information of the region on the traffic sign board.

  — **Region colour tone:** the region colour tone describes visual properties of the region on the traffic sign board.

  — **Region vertex points:** the region vertex points describe the region with a list of relative 2D vertex points for the region by affine coordinates of the traffic sign board object coordinate system.

— A list of traffic sign board guiding graphs which are assigned to the traffic sign board (see key 3 in Figure 15 and Figure 17):

  — **Guiding graph status:** the guiding graph status describes general information of the tracked guiding graph. The guiding graph is associated to a sign board type entity or the sign board. A symbol uses a subset of signals of the signal grouping “Static object entity status” (Table 18) for this LSG and extends signals for a hierarchical association of traffic sign board type entities.

  — **Guiding graph information:** the guiding graph information describes the information of the guiding graph on the traffic sign board.

  — **Guiding graph vertex points:** the guiding graph vertex points describe the guiding graph with a list of relative 2D vertex points by affine coordinates of the traffic sign board object coordinate system.

  — **Guiding graph edges:** the guiding graph edges describe the edges of the guiding graph on the traffic sign board and references vertex points for each edge.

  — **Guiding graph edge colour tone:** the guiding graph edge colour tone describes visual properties of a guiding graph edge on the traffic sign board.

— A list of traffic sign board text strings which are assigned to the traffic sign board (see key 4 in Figure 15), which is no referenced traffic sign (some text strings on the traffic sign board may be recognised as a referenced traffic sign main or supplementary sign object [see LSG “Traffic sign board object references”]):

  — **Text status:** the text status describes general information of the tracked text. The text string is associated to a sign board type entity or the sign board. A text string uses a subset of signals of the signal grouping “Static object entity status” (Table 18) for this LSG and extends signals for a hierarchical association of traffic sign board type entities.

  — **Text information:** the text information describes the text string on the traffic sign board.

  — **Text colour tone:** the text colour tone describes visual properties of the text string on the traffic sign board.

  — **Text bounding box:** the text bounding box describes the bounding box of the text string by affine coordinates of the traffic sign board object coordinate system.

— A list of traffic sign board icons and symbols which are assigned to the traffic sign board (see key 5 in Figure 15):

  — **Icon or symbol status:** the icon or symbol status describes general information of the tracked icon or symbol. The icon or symbol is associated to a sign board type entity or the sign board. An icon or symbol uses a subset of signals of the signal grouping "Static object entity status" (Table 18) for this LSG and extends signals for a hierarchical association of traffic sign board type entities.

  — **Icon or symbol information:** the icon or symbol information describes the recognised icon or symbol on the traffic sign board.

  — **Icon or symbol bounding box:** the icon or symbol bounding box describes the bounding box of the icon or the symbol by affine coordinates of the traffic sign board object coordinate system.

— A list of traffic sign board object references for object entities which are assigned to the traffic sign board (for example, traffic sign or traffic light). Due to the possibility of insufficient separability of traffic signs or traffic lights and traffic sign boards that are too close to the traffic sign board, the traffic sign board related object entities are always referenced (see key 6a, 6b and 6c in Figure 15). The possible lack of accuracy in the separation of traffic sign board and traffic signs or traffic lights may link traffic signs or traffic lights to the traffic sign board as object references (see Figure 18):

  — **Object reference status:** the object reference status describes general information of the tracked referenced object entity. The object entity is associated to a sign board type entity or the sign board. An object reference uses a subset of signals of the signal grouping "Static object entity status" (Table 18) for this LSG and extends signals for a hierarchical association of traffic sign board type entities.

  — **Object reference information:** the object reference information describes the semantic of the referenced object entity on the traffic sign board.

  — **Object reference bounding box:** the object reference bounding box describes the bounding box of the referenced object entity by affine coordinates of the traffic sign board object coordinate system.

— A list of traffic sign board occlusion areas which are assigned to the traffic sign board (for example, occlusion by graffiti, a heavy truck, a tree branch) (see key 7 in Figure 15):

  — **Occlusion status:** the occlusion status describes general information of the tracked occlusion area on the traffic sign board. The occlusion is associated to a sign board type entity or the sign board. An occlusion uses a subset of signals of the signal grouping "Static object entity status" (Table 18) for this LSG and extends signals for a hierarchical association of traffic sign board type entities.

  — **Occlusion information:** the occlusion information describes the semantic of the occlusion area on the traffic sign board.

  — **Occlusion vertex points:** the occlusion vertex points describe the occlusion with a list of relative 2D vertex points for the shape of the occlusion by affine coordinates of the traffic sign board object coordinate system.

A traffic light is described by the following LSGs.

— **Light status:** the traffic light status describes general information of the tracked traffic light. This information is based on history of the object tracking. Table 18 defines the signal grouping “Static object entity status”. It defines this status LSG of the traffic light and redefines the signal grouping “Generic object level entity status” (see Table 8).

— **Light information:** the information describes the certainty and the type of the tracked traffic light.

— **Light position:** the position describes the position information of the tracked traffic light.

— **Light bounding box:** the bounding box describes the 3D rectangular hull that encloses the tracked traffic light.

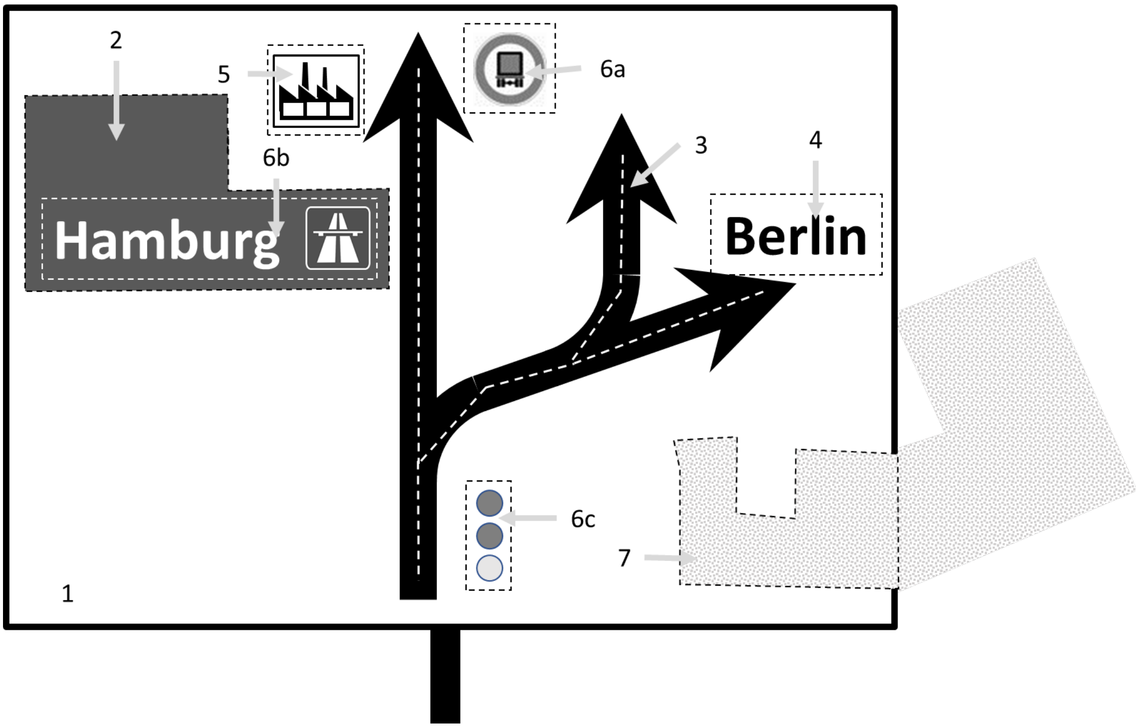
— A list of traffic light spots assigned to the traffic light:

  — **Spot status:** the traffic light spot status describes general information of the tracked light spot. This information is based on history of the object tracking and is associated to the traffic light. A traffic light spot uses a subset of signals of the signal grouping “Static object entity status” (Table 18) for this LSG.

  — **Spot information:** the traffic light spot information describes the semantic of the tracked light spot.

  — **Spot colour:** the traffic light spot colour describes the basic light colour of the tracked light spot.

  — **Spot position:** the traffic light spot position describes the position of the tracked light spot which is relative to the vehicle coordinate system [see signal “Vehicle coordinate system type – header” (A.1.20)]. All traffic light spots are inside the traffic light’s bounding box [see signal “Bounding box extent {length, width, height}” (A.2.20)].



Key

1 traffic sign board
described by an affine coordinate system

2 region on the traffic sign board – region for motorway information
described by a shape with vertex points

3 guiding graph on the traffic sign board
described by vertex points and connecting edges

4 text string on the traffic sign board – text string “Berlin”
described by a bounding box

5 icon or symbol on the traffic sign board – icon for industrial park
described by a bounding box

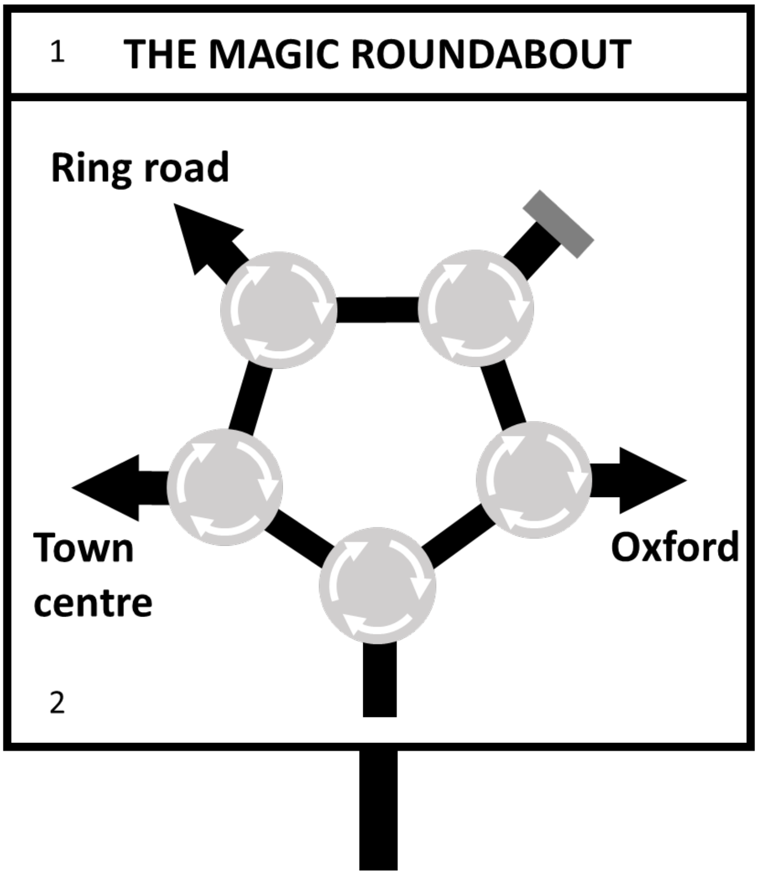
6a referenced object entity on the traffic sign board – traffic sign as traffic main sign
described by a bounding box

6b referenced object entity on the traffic sign board – traffic sign as traffic main sign including text string “Hamburg”
described by a bounding box

6c referenced object entity on the traffic sign board – traffic light
described by a bounding box

7 occlusion area of the traffic sign board – for example, graffiti or vegetation
described by a shape with vertex points, which is relevant for the traffic sign board

Figure 15 — Example for a traffic sign board and its specific entities including their bounding box, graph or shape



Key

1 region 1 – title

2 region 2 – guiding graph, text and traffic signs, which are referenced traffic sign entities

Figure 16 — Example of a traffic sign board with regions with borderlines

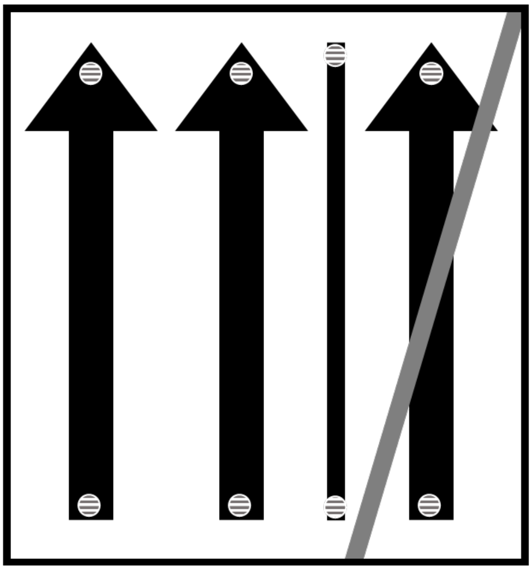
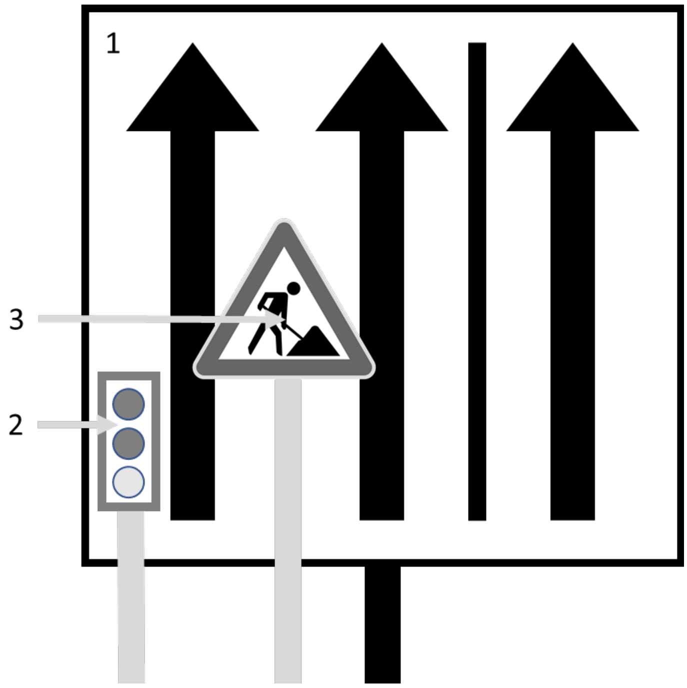


Figure 17 — Example for a traffic sign board with guiding graph and "Entity state" (A.2.99) ≔ enumerator "ES_PartlyOutOfService"



Key

1 traffic sign board

2 traffic light which may be a referenced traffic sign entity of the traffic sign board (see key 1)

3 traffic sign which may be a referenced traffic sign entity of the traffic sign board (see key 1)

Figure 18 — Example of a traffic sign board, traffic sign and traffic light which may not be separated exactly

Table 18 — Specific signal grouping: Static object entity status

Signal	RL signal	Option
Existence probability – object level (A.2.1)	Mandatory	
Object ID (A.2.2)	Mandatory	Alternative A2I (B.3.2)
Object grouping ID (A.2.3)	Optional	
Age (A.2.4)	Mandatory	
Number of valid observations – object level (A.2.5)	Optional	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
Time stamp reference – object level (A.2.6)	Mandatory	Alternative VRO (B.1.3)
Observation status – object level (A.2.7)	Mandatory	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
Track quality (A.2.8)	Optional	
Measurement status – object level (A.2.9)	Mandatory	Default enumerators (B.1.7)

7.5.3 Profile: Colour model for SOI

The profile is relevant for camera sensor technology (B.2.1). The signal "Colour model type" (A.1.14) defines the colour model for the interface. Depending on the colour model, each colour is described by a fixed number of colour values [see signal "Colour value – object level" (A.2.100)] to define the colour tone. The confidence of the colour tone is provided by the signal "Colour tone – confidence – object level" (A.2.101).

The interface provides colour tones for traffic main signs, supplementary signs and traffic sign board entity types.

7.5.4 Profile: Detection references for 3D detections

As the different sensor types have different strength, some of them are very precise in a coordinate system closer to its nature. To enable the fusion unit to make use of it, a mechanism is provided to map detection of the detection level to entities of the object level.

The profile is relevant, if, for example, a fusion unit benefits from additional information of detections (for example, detections defined in sensor coordinates), which the sensor cluster has used to generate signals on object level.

The confidence of the position (in cartesian coordinates) of a traffic sign board [see signal "Position uv_origin {x, y, z}" (A.2.142)] and the confidence of the extension of the traffic sign board [see signals "Position u_end {x, y, z}" (A.2.144) and "Position v_end {x, y, z}" (A.2.146)] may be low and a fusion unit may combine detections from different sensor technologies. Logical interfaces may extent the signals according to the cross-interface optimisation (see B.3.4) to reference detections to add the additional information of detections (see Table 19). Additionally, the fusion unit may combine detections from different sensor technologies to reduce the corresponding error signals ["Position uv_origin {x, y, z} – error" (A.2.143), "Position uv_origin {x, y, z} – error" (A.2.143) and "Position v_end {x, y, z} – error" (A.2.147)].

Table 19 — Signal grouping: Exemplary detection references for traffic sign board affine coordinates

Traffic sign board position	M		Position uv_origin {x, y, z} (A.2.142)	M	Profile: Detection references for 3D detections (7.5.4)
			Position uv_origin {x, y, z} – error (A.2.143)	M	Profile: Detection references for 3D detections (7.5.4) …
			Position u_end {x, y, z} (A.2.144)	M	Profile: Detection references for 3D detections (7.5.4)
			Position u_end {x, y, z} – error (A.2.145)	M	Profile: Detection references for 3D detections (7.5.4) …
			Position v_end {x, y, z} (A.2.146)	M	Profile: Detection references for 3D detections (7.5.4)

		Position v_end {x, y, z} – error (A.2.147)	M	Profile: Detection references for 3D detections (7.5.4) …
		…		
Detections to generate signals "Position uv_origin {x, y, z}" (A.2.142) and "Position uv_origin {x, y, z} – error" (A.2.143)	O	Number of valid sensing elements which generate the signal "xxx" – Annex B.3.4 (Table B.2) for signals "Position uv_origin {x, y, z}" (A.2.142) and "Position uv_origin {x, y, z} – error" (A.2.143)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Number of valid serving sensors – Annex B.3.4 (Table B.3), Sensor ID reference – Annex B.3.4 (Table B.4)
		Size type: dynamic/fixed Size #: Number of valid sensing elements which generate the signal "xxx" – Annex B.3.4 (Table B.2) for signal "Position uv_origin {x, y, z}" (A.2.142)		
		Number of valid serving sensors – Annex B.3.4 (Table B.3)	O	Alternative VRO (B.1.3) [a]
		Size type: dynamic/fixed Size #: Number of valid serving sensors – Annex B.3.4 (Table B.3)		
		Sensor ID reference – Annex B.3.4 (Table B.4)	M	[a]
		Time stamp – measurement (A.1.5.2)	O	[b]
		Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2) [b]
		Detection ID reference – Annex B.3.4 (Table B.5)	M	
Detections to generate signals "Position u_end {x, y, z}" (A.2.144) and "Position u_end {x, y, z} – error" (A.2.145)	O	Number of valid sensing elements which generate the signal "xxx" – Annex B.3.4 (Table B.2) for signals "Position u_end {x, y, z}" (A.2.144) and "Position u_end {x, y, z} – error" (A.2.145)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Number of valid serving sensors – Annex B.3.4 (Table B.3), Sensor ID reference – Annex B.3.4 (Table B.4)

		Size type: dynamic/fixed Size #: Number of valid sensing elements which generate the signal “xxx” – Annex B.3.4 (Table B.2) for signal “Position u_end {x, y, z}” (A.2.144)		
		Number of valid serving sensors – Annex B.3.4 (Table B.3)	O	Alternative VRO (B.1.3) [a]
		Size type: dynamic/fixed Size #: Number of valid serving sensors – Annex B.3.4 (Table B.3)		
		Sensor ID reference – Annex B.3.4 (Table B.4)	M	[a]
		Time stamp – measurement (A.1.5.2)	O	[b]
		Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2) [b]
		Detection ID reference – Annex B.3.4 (Table B.5)	M	
Detections to generate signals “Position v_end {x, y, z}” (A.2.142) and “Position v_end {x, y, z} – error” (A.2.147)	O	Number of valid sensing elements which generate the signal “xxx” – Annex B.3.4 (Table B.2) for signals “Position v_end {x, y, z}” (A.2.142) and “Position v_end {x, y, z} – error” (A.2.147)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Number of valid serving sensors – Annex B.3.4 (Table B.3), Sensor ID reference – Annex B.3.4 (Table B.4)
		Size type: dynamic/fixed Size #: Number of valid sensing elements which generate the signal “xxx” – Annex B.3.4 (Table B.2) for signal “Position v_end {x, y, z}” (A.2.142)		
		Number of valid serving sensors – Annex B.3.4 (Table B.3)	O	Alternative VRO (B.1.3) [a]
		Size type: dynamic/fixed Size #: Number of valid serving sensors – Annex B.3.4 (Table B.3)		
		Sensor ID reference – Annex B.3.4 (Table B.4)	M	[a]

				Signal	RL signal M/C/O	Option
				Time stamp – measurement (A.1.5.2)	O	[b]
				Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2) [b]
				Detection ID reference – Annex B.3.4 (Table B.5)	M	

[a] Signals are required, if the signal "Detection ID" (A.4.2) is not unique for different DLIs of the sensor cluster.

[b] Signals are required, if the signal "Detection ID" (A.4.2) is not unique for different measurement cycles of the DLI.

The mechanism of the profile based on a traffic sign board definition, but can also be used for traffic light, landmarks, lane markings, static or potentially moving objects.

7.6 Free space area object interface

The free space area object interface (FSAOI) consists of one type of areas: free space area (see Figure 19). Table 20 defines the logical structure of the free space area object interface.

Table 20 — Free space area object interface

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning (6.4)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
		Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning (6.4) Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Sensor ID (A.1.4)

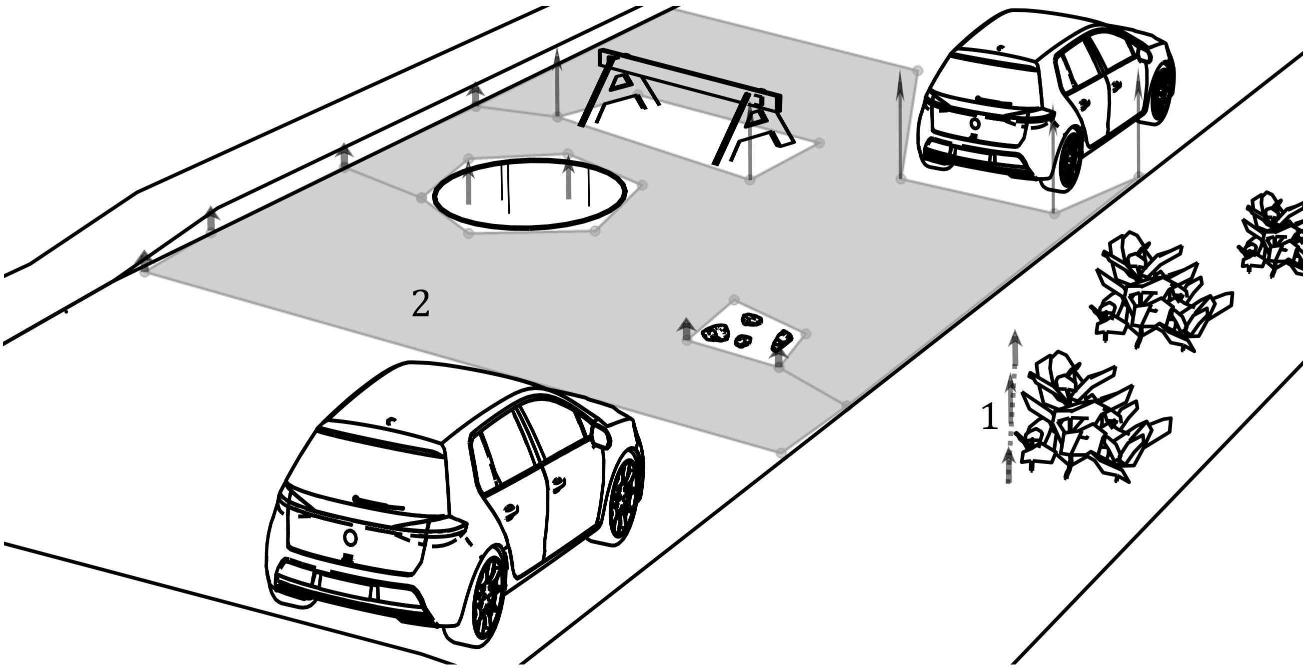
LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Size type: dynamic/fixed Size #: Number of valid serving sensors (A.1.3)		
		Sensor ID (A.1.4)	M	Profile: Uniqueness of interface versioning (6.4) Alternative VRO (B.1.3)
		Time stamp – prediction (A.1.5.1)	M	
		Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – prediction (A.1.5.1)
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	
		Data qualifier (A.1.9)	M	Default enumerators (B.1.7)
Free space areas	C (B.2.3) multiple entity types	Recognised free space areas – capability (A.1.10.8)	O	
		Recognised free space areas – status (A.1.11.8)	O	Redundancy (B.1.2) Signal: Recognised free space areas – capability (A.1.10.8) Default enumerators (B.1.7)
		Number of valid free space areas (A.1.12.8)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid free space areas (A.1.12.8)		
Free space area status	M	Existence probability – object level (A.2.1)	M	
		Object ID (A.2.2)	M	Alternative A2I (B.3.2)
		Object grouping ID (A.2.3)	O	
		Age (A.2.4)	M	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Number of valid observations – object level (A.2.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see “Time stamp reference – object level”(A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – object level (A.2.5)		
		Time stamp reference – object level (A.2.6)	M	Alternative VRO (B.1.3)
		Observation status – object level (A.2.7)	M	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
		Track quality (A.2.8)	O	
		Measurement status – object level (A.2.9)	M	Default enumerators (B.1.7)
Free space area information	M	Free space type (A.2.201)	M	
		Polyline interpolation method (A.2.120)	M	Default enumerators (B.1.7)
		Number of valid free space area shapes (A.2.202)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid free space area shapes (A.2.202)		
Free space area road surface	O	Road type – object level (A.2.73)	M	Default enumerators (B.1.7)
		Road type – confidence (A.2.74)	M	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Number of valid road surface classifications (A.2.75)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Road surface classification type – object level (A.2.76)
		Size type: dynamic/fixed Size #: Number of valid road surface classifications (A.2.75)		
		Road surface classification type – object level (A.2.76)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Road surface classification type – confidence (A.2.77)	M	
		Road surface roughness – object level (A.2.78)	O	
		Road surface texture – object level" (A.2.79)	O	
		Number of valid road surface condition classifications (A.2.80)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Road surface condition classification type – object level (A.2.81)
		Size type: dynamic/fixed Size #: Number of valid road surface condition classifications (A.2.80)		
		Road surface condition classification type – object level (A.2.81)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Road surface condition classification type – confidence (A.2.82)	M	
⊆ ⊆ Free space area shape	M	Limitation geometry type (A.2.203)	M	
		Shape type – object level (A.2.204)	M	Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Sector common vertex point {x, y, z} (A.2.205)	{C (B.2.2), C (B.2.2), O} * The signal "Shape type – object level" (A.2.204) has "ST_Sector" or a similar enumerator defined during the system design phase.	
		Sector common vertex point {x, y, z} – error (A.2.206)	{C (B.2.2), C (B.2.2), O} * The signal "Shape type – object level" (A.2.204) has "ST_Sector" or a similar enumerator defined during the system design phase.	Implementation EM (B.4.1)
		Sector common vertex point – confidence {x, y, z} (A.2.207)	O	
		Number of valid vertices (A.2.122)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid vertices (A.2.122)		
Free space area vertex	M	Vertex point {x, y, z} (A.2.105)	{M, M, O}	
		Vertex point {x, y, z} – error (A.2.106)	{M, M, O}	Implementation EM (B.4.1)
		Vertex point – confidence {x, y, z} (A.2.107)	O	
Free space area vertex limitation	M	Limitation reason (A.2.208)	M	Default enumerators (B.1.7)
		Limitation moving probability (A.2.209)	C	
		Limitation {radial extent, height} (A.2.210)	O	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Limitation {radial extent, height} – error (A.2.211)	O	Implementation EM (B.4.1)
		Limitation– confidence {radial extent, height} (A.2.212)	O	
		Clearance {height} (A.2.213)	O	
		Clearance {height} – error (A.2.214)	O	Implementation EM (B.4.1)
		Clearance – confidence {height} (A.2.215)	O	
		Object ID reference – object level (A.2.179)	O	



Key

1 limitation edge

2 free space area shape – signal “Free space type” (A.2.201) ≔ enumerator “FST_PerceivedLimitedByStaticAndDynamic”

↑ limitation {height} information of the height of the limitation

Figure 19 — Example for free space area objects

7.6.1 Free space area object header

Table 21 defines the interface header in subclause “Free space area object header” (7.6.1) and the changes due to the adaptation in comparison to the generic interface header in 7.2.1.

Table 21 — Specific signal grouping: Free space area object header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
Time stamp – prediction (A.1.5.1)	Mandatory	
Cycle counter (A.1.6.1)	Optional	Redundancy (B.1.2) Signal: Time stamp – prediction (A.1.5.1)
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)
Recognised free space areas – capability (A.1.10.8)	Optional	
Recognised free space areas – status (A.1.11.8)	Optional	Redundancy (B.1.2) Signal: Recognised free space areas – capability (A.1.10.8) Default enumerators (B.1.7)
Number of valid free space areas (A.1.12.8)	Mandatory	Optimise LL (B.1.1)

The following LSGs, which normally shall be provided by the sensor cluster in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor cluster (see B.3.3):

— interface: SPI; LSG “Information: vehicle coordinate system” (see Table 51);

— interface: SHII; LSG “Calibration” (see Table 53);

— interface: SHII; LSG “Sensor cluster” (see Table 53).

7.6.2 Free space area object entity

Each free space area object describes a recognised free space area and, additionally, its limitation. It consists of several LSGs.

A free space area and, additionally, its limitation is described by the following LSGs for free space area.

— **Status:** the status describes the general information of a tracked free space area or limitation. This information is based on history of the object tracking. Table 22 defines the signal grouping “Free space area object entity status”. It defines this status LSG of the free space area and redefines the signal grouping “Generic object level entity status” (see Table 8).

— **Information:** the information describes the free space type and the geometric specification method.

— **Road surface:** the road surface describes the surface of the road inside the defined shape (only for free space area shape and not for the limitation).

— **Shape:** the shape specifies the shape's properties of the defined sector or the closed polyline.

— **Vertex:** the vertex describes the geometric free space area shape or the boundary.

— **Vertex limitation:** the vertex limitation (as reference of an object entity {see signal "Object ID reference – object level" (A.2.179)]} describes the limitation at the geometric boundary of the vertex of the free space area, for example, of a limitation or an underdriveable structure.

Table 22 — Specific signal grouping: Free space area object entity status

Signal	RL signal	Option
Existence probability – object level (A.2.1)	Mandatory	
Object ID (A.2.2)	Mandatory	Alternative A2I (B.3.2)
Object grouping ID (A.2.3)	Optional	
Age (A.2.4)	Mandatory	
Number of valid observations – object level (A.2.5)	Optional	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – object level (A.2.6) * n recent messages of the interface [see "Time stamp reference – object level" (A.2.6)]
Time stamp reference – object level (A.2.6)	Mandatory	Alternative VRO (B.1.3)
Observation status – object level (A.2.7)	Mandatory	Redundancy (B.1.2) Signal: Object ID (A.2.2), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
Track quality (A.2.8)	Optional	
Measurement status – object level (A.2.9)	Mandatory	Default enumerators (B.1.7)

8 Feature level

8.1 General

The feature level interfaces (FLI) originate from several sensors of a sensor cluster. Therefore, at feature level, the term sensor cluster is always used, even if a single sensor is serving the interface. The FLIs provide recognised features, where recognition is based on multiple sensors of the sensor cluster, a small amount of historical data or no historical data at all. The sensor cluster refers its recognised features to one of two predefined vehicle coordinate systems [see signal "Vehicle coordinate system type – header" (A.1.20)]. The feature properties depend on the sensor technology of the sensor cluster. To bring recognised features in relation to entities of other interface levels, each recognised feature has a unique signal's "Feature ID" (A.3.2) value. The uniqueness of the signal's "Feature ID" (A.3.2) value is only guaranteed within the sensor cluster's interfaces.

Wrong link-relations between detections or objects and features shall be prevented. Specifically, the reuse of the signal's "Feature ID" (A.3.2) values shall not lead to a misinterpretation of the link-relation between entities of the sensor cluster's interfaces.

On feature level the following interfaces are available:

— Camera feature interface (8.3);

— Ultrasonic feature interface (8.4).

There is no FLI for radar or lidar sensor clusters defined.

8.2 Generic sensor cluster feature interface

Table 23 defines the generic structure of an FLI.

Table 23 — Generic sensor feature interface

Structure	Multiplicity	Option
Generic sensor cluster feature header (8.2.1)	1	
Generic sensor cluster feature entity (8.2.2), specifically an individual feature list interface entity	Multiple	Size type: dynamic/fixed

8.2.1 Generic sensor cluster feature header

Table 24 defines the interface header in subclause "Generic sensor cluster feature header" (8.2.1) and the changes due to the adaptation in comparison to the generic interface header in 6.2.

Table 24 — Specific signal grouping: Generic sensor cluster feature header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO(B.1.3)
Time stamp – prediction (A.1.5.1)	Mandatory	
Cycle counter (A.1.6.1)	Optional	Redundancy (B.1.2) Signal: Time stamp – prediction (A.1.5.1)
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)
FLI sensor technology specific header extensions		
Recognised features – capability (A.1.10.9)	Optional	
Recognised features – status (A.1.11.9)	Optional	Redundancy (B.1.2) Signal: Recognised features – capability (A.1.10.9) Default enumerators (B.1.7)
Number of valid features (A.1.12.9)	Mandatory	Optimise LL (B.1.1)

The following LSGs, which normally shall be provided by the sensor cluster in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor cluster (see B.3.3):

— interface: SPI; LSG “Information: vehicle coordinate system” (see Table 51);

— interface: SHII; LSG “Calibration” (see Table 53);

— interface: SHII; LSG “Sensor cluster” (see Table 53).

8.2.2 Generic sensor cluster feature entity

Table 25 defines the generic signal grouping “Generic sensor cluster feature entity status” for each FLI and defines the status of a feature [see also Table 8 (7.2.2) for generic object level entities].

Table 25 — Specific signal grouping: Generic sensor cluster feature entity status

Signal	RL signal	Option
Existence probability – feature level (A.3.1)	Mandatory	
Feature ID (A.3.2)	Conditional (B.3.1) Exist: DLI	Alternative A2I (B.3.2)
Object ID reference – feature level (A.3.3)	Conditional (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
Time stamp difference – feature level (A.3.4)	Mandatory	Optimise IV (B.1.5)
Number of valid observations – feature level (A.3.5)	Optional	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – feature level (A.3.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
Time stamp reference – feature level (A.3.6)	Mandatory	Alternative VRO (B.1.3)
Observation status – feature level (A.3.7)	Mandatory	Redundancy (B.1.2) Signal: Feature ID (A.3.2) (if unique over time), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)

Each interface type adds individual properties to the interface entity type. Geometric information of the feature references the vehicle coordinate system [see signal “Vehicle coordinate system type – header” (A.1.20)]. Features reference objects of the sensor cluster. Likewise, detections from individual sensors of a sensor cluster are referencing features.

8.3 Camera feature interface

Table 26 defines the logical structure of the camera feature interface (CFI).

Table 26 — Camera feature interface

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning (6.4)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
		Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
		Time stamp – prediction (A.1.5.1)	M	
		Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – prediction (A.1.5.1)
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	
		Data qualifier (A.1.9)	M	Default enumerators (B.1.7)
		Colour model type (A.1.14)	M	Profile: Colour model for CFI (8.3.3) 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)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Features	M	Recognised features – capability (A.1.10.9)	O	
		Recognised features – status (A.1.11.9)	O	Redundancy (B.1.2) Signal: Recognised features – capability (A.1.10.9) Default enumerators (B.1.7)
		Number of valid features (A.1.12.9)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid features (A.1.12.9)		
Status	M	Existence probability – feature level (A.3.1)	M	
		Feature ID (A.3.2)	C (B.3.1) Exist: DLI	Alternative A2I (B.3.2)
		Feature grouping ID (A.3.8)	O	
		Object ID reference – feature level (A.3.3)	C (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
		Time stamp difference – feature level (A.3.4)	M	Optimise IV (B.1.5)
		Number of valid observations – feature level (A.3.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – feature level (A.3.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – feature level (A.3.5)		
		Time stamp reference – feature level (A.3.6)	M	Alternative VRO (B.1.3)
		Observation status – feature level (A.3.7)	M	Redundancy (B.1.2) Signal: Feature ID (A.3.2) (if unique over time), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Shape information	M	Number of valid shape classifications – feature level (A.3.9)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Shape classification type – feature level (A.3.10)
		Size type: dynamic/fixed Size #: Number of valid shape classifications – feature level (A.3.9)		
		Shape classification type – feature level (A.3.10)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Shape classification type – confidence – feature level (A.3.11)	M	
Shape colour tone	M	Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – feature level (A.3.12)	M	Profile: Colour model for CFI (8.3.3)
		Colour tone – confidence – feature level (A.3.13)	O	Profile: Colour model for CFI (8.3.3)
Shape points	M	Shape type – feature level (A.3.14)	M	Default enumerators (B.1.7)
		Number of valid shape points – feature level (A.3.15)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid shape points – feature level (A.3.15)		
		Point existence probability – feature level (A.3.16)	M	
		Position – feature level {x, y, z} (A.3.17)	M	
		Position – feature level {x, y, z} – error (A.3.18)	M	Implementation EM (B.4.1)
Shape reference points	O	Number of valid shape reference points – feature level (A.3.19)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid shape reference points – feature level (A.3.19)		
		Point existence probability – feature level (A.3.16)	M	
		Position – feature level {x, y, z} (A.3.17)	M	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Position – feature level {x, y, z} – error (A.3.18)	M	Implementation EM (B.4.1)
		Shape surface normal {x, y, z} (A.3.20)	O	
		Shape surface normal {x, y, z} – error (A.3.21)	O	Implementation EM (B.4.1)
		Translation rate {x, y, z} – feature level (A.3.22)	O	
		Translation rate {x, y, z} – feature level – error (A.3.23)	O	Implementation EM (B.4.1)
		Rotation rate {yaw, pitch, roll} – feature level (A.3.24)	O	
		Rotation rate {yaw, pitch, roll} – error – feature level (A.3.25)	O	Implementation EM (B.4.1)
		Scale change – feature level (A.3.26)	O	
		Scale change – feature level – error (A.3.27)	O	Implementation EM (B.4.1)

8.3.1 Camera feature header

Table 27 defines the interface header in subclause "Camera feature header" (8.3.1) and the changes due to the adaptation in comparison to the generic interface header in 8.2.1. The header of the CFI can contain a list of valid camera feature entities (see 8.3.2).

Table 27 — Specific signal grouping: Camera feature header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
Time stamp – prediction (A.1.5.1)	Mandatory	
Cycle counter (A.1.6.1)	Optional	Redundancy (B.1.2) Signal: Time stamp – prediction (A.1.5.1)
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)

Colour model type (A.1.14)	Mandatory	Profile: Colour model for CFI (8.3.3) 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)
Recognised features – capability (A.1.10.9)	Optional	
Recognised features – status (A.1.11.9)	Optional	Redundancy (B.1.2) Signal: Recognised features – capability (A.1.10.9) Default enumerators (B.1.7)
Number of valid features (A.1.12.9)	Mandatory	Optimise LL (B.1.1)

The following LSGs, which normally shall be provided by the sensor cluster in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor cluster (see B.3.3):

— interface: SPI; LSG “Information: vehicle coordinate system” (see Table 51);

— interface: SHII; LSG “Calibration” (see Table 53);

— interface: SHII; LSG “Sensor cluster” (see Table 53).

8.3.2 Camera feature entity

For the camera, features are understood as shapes extracted from camera images. The shapes describe regions with the same semantic content (see Figure 20).

Each feature of a camera sensor cluster describes a recognised feature and consists of several LSGs.

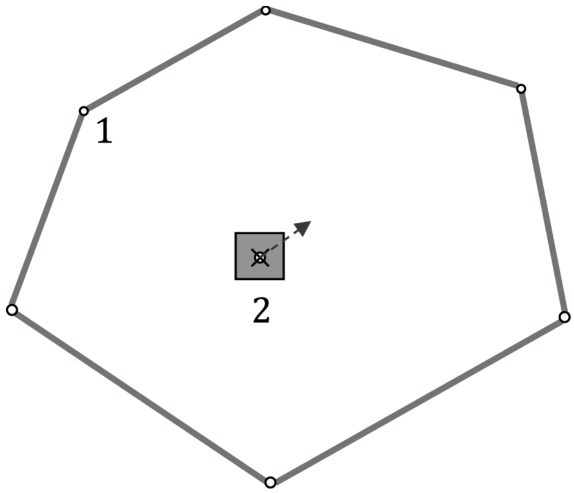
— **Status:** the status describes general information of the feature and provides an additional grouping ID to group interconnected camera features. This information is based on basic feature history information. Table 28 defines the signal grouping “Camera feature entity status”. It defines this status LSG of the feature and redefines the signal grouping “Generic sensor cluster feature entity status” (see Table 25).

— **Shape information:** the shape information describes the attributes of the tracked shape.

— **Shape colour tone:** the colour tone describes visual properties of the shape.

— **Shape points:** the shape points describe the geometric vertices of the hull for the feature shape.

— **Shape reference points:** the shape reference points are small distinctive trackable segments which are part of the feature’s shape.



Key

1 shape with shape points

2 shape reference point with approximated tangential plane and orientation normal

Figure 20 — Example for a camera feature shape

Table 28 — Specific signal grouping: Camera feature entity status

Signal	RL signal	Option
Existence probability – feature level (A.3.1)	Mandatory	
Feature ID (A.3.2)	Conditional (B.3.1) Exist: DLI	Alternative A2I (B.3.2)
Feature grouping ID (A.3.8)	Optional	
Object ID reference – feature level (A.3.3)	Conditional (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
Time stamp difference – feature level (A.3.4)	Mandatory	Optimise IV (B.1.5)
Number of valid observations – feature level (A.3.5)	Optional	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – feature level (A.3.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
Time stamp reference – feature level (A.3.6)	Mandatory	Alternative VRO (B.1.3)
Observation status – feature level (A.3.7)	Mandatory	Redundancy (B.1.2) Signal: Feature ID (A.3.2) (if unique over time), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)

8.3.3 Profile: Colour model for CFI

The signal “Colour model type” (A.1.14) defines the colour model for the interface. Depending on the colour model, each colour is described by a fixed number of colour values [see signal “Colour value –

feature level" (A.3.12)] to define the colour tone. The confidence of the colour tone is provided by the signal "Colour tone – confidence – feature level" (A.3.13).

The interface provides colour tones for features.

8.4 Ultrasonic feature interface

Table 29 defines the logical structure of the ultrasonic feature interface (UFI).

Table 29 — Ultrasonic feature interface

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning (6.4)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
		Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
		Time stamp – prediction (A.1.5.1)	M	
		Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – prediction (A.1.5.1)
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Data qualifier (A.1.9)	M	Default enumerators (B.1.7)
Features	M	Recognised features – capability (A.1.10.9)	O	
		Recognised features – status (A.1.11.9)	O	Redundancy (B.1.2) Signal: Recognised features – capability (A.1.10.9) Default enumerators (B.1.7)
		Number of valid features (A.1.12.9)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid features (A.1.12.9)		
Status	M	Existence probability – feature level (A.3.1)	M	
		Feature ID (A.3.2)	C (B.3.1) Exist: DLI	Alternative A2I (B.3.2)
		Object ID reference – feature level (A.3.3)	C (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
		Time stamp difference – feature level (A.3.4)	M	Optimise IV (B.1.5)
		Number of valid observations – feature level (A.3.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – feature level (A.3.6) * n recent messages of the interface [see “Time stamp reference – object level” (A.2.6)]
		Size type: dynamic/fixed Size #: Number of valid observations – feature level (A.3.5)		
		Time stamp reference – feature level (A.3.6)	M	Alternative VRO (B.1.3)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Observation status – feature level (A.3.7)	M	Redundancy (B.1.2) Signal: Feature ID (A.3.2) (if unique over time), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)
⊆ Segment information	M	Number of valid ultrasonic feature classifications (A.3.28)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Ultrasonic feature classification type (A.3.29)
		Size type: dynamic/fixed Size #: Number of valid ultrasonic feature classifications (A.3.28)		
		Ultrasonic feature classification type (A.3.29)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Ultrasonic feature classification type – confidence (A.3.30)	M	
⊆ Segment points	M	Number of valid points (A.3.31)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid points (A.3.31)		
		Position – feature level {x, y, z} (A.3.17)	{M, M, O}	
		Position – feature level {x, y, z} – error (A.3.18)	{M, M, O}	Implementation EM (B.4.1)
		Orientation – feature level {pitch} (A.3.32)	O	
		Orientation – feature level {pitch} – error (A.3.33)	O	Implementation EM (B.4.1)
		Extent {height} – feature level (A.3.34)	O	
		Extent {height} – feature level – error (A.3.35)	O	Implementation EM (B.4.1)
		Velocity {x, y} – feature level (A.3.36)	O	

LSG	RL LSG M/C/O	Signal			RL signal M/C/O	Option
				Velocity {x, y} – feature level – error (A.3.37)	O	Implementation EM (B.4.1)
				Trilateration status (A.3.38)	M	Default enumerators (B.1.7)
				Measurement status – feature level (A.3.39)	O	Default enumerators (B.1.7)

8.4.1 Ultrasonic feature header

Table 30 defines the interface header in subclause “Ultrasonic feature header” (8.4.1) and the changes due to the adaptation in comparison to the generic interface header in 8.2.1. The header of the UFI can contain a list of valid ultrasonic feature entities (see 8.4.2).

Table 30 — Specific signal grouping: Ultrasonic feature header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
Time stamp – prediction (A.1.5.1)	Mandatory	
Cycle counter (A.1.6.1)	Optional	Redundancy (B.1.2) Signal: Time stamp – prediction (A.1.5.1)
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)
Recognised features – capability (A.1.10.9)	Optional	
Recognised features – status (A.1.11.9)	Optional	Redundancy (B.1.2) Signal: Recognised features – capability (A.1.10.9) Default enumerators (B.1.7)
Number of valid features (A.1.12.9)	Mandatory	Optimise LL (B.1.1)

The following LSGs, which normally shall be provided by the sensor cluster in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor cluster (see B.3.3):

— interface: SPI; LSG "Information: vehicle coordinate system" (see Table 51);

— interface: SHII; LSG "Calibration" (see Table 53);

— interface: SHII; LSG "Sensor cluster" (see Table 53).

8.4.2 Ultrasonic feature entity

Each feature of an ultrasonic sensor cluster describes a recognised feature and consists of several LSGs.

— **Status:** the status describes general information of the feature. This information is based on basic feature history information. Table 31 defines the signal grouping "Ultrasonic feature entity status". It defines this status LSG of the feature and redefines the signal grouping "Generic sensor cluster feature entity status" (see Table 25).

— **Segment information:** the segment information describes the attributes of the tracked segment.

— **Segment points:** the segment points describe the geometric vertices of the hull for the feature segment.

Table 31 — Specific signal grouping: Ultrasonic feature entity status

Signal	RL signal	Option
Existence probability – feature level (A.3.1)	Mandatory	
Feature ID (A.3.2)	Conditional (B.3.1) Exist: DLI	Alternative A2I (B.3.2)
Object ID reference – feature level (A.3.3)	Conditional (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
Time stamp difference – feature level (A.3.4)	Mandatory	Optimise IV (B.1.5)
Number of valid observations – feature level (A.3.5)	Optional	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Time stamp reference – feature level (A.3.6) * n recent messages of the interface [see "Time stamp reference – object level" (A.2.6)]
⊆ Time stamp reference – feature level (A.3.6)	Mandatory	Alternative VRO (B.1.3)
⊆ Observation status – feature level (A.3.7)	Mandatory	Redundancy (B.1.2) Signal: Feature ID (A.3.2) (if unique over time), Time stamp – prediction (A.1.5.1) Default enumerators (B.1.7)

9 Detection level

9.1 General

Normally the detection level interfaces (DLI) originate from one sensing element. Therefore, at detection level, the term sensor is always used, even if, for example, a combination of emitting as well as sensing elements are serving the interface. The DLIs provide recognised detections. The detections may be based on limited historical data and are rated with individual existence probability values. Detections are defined in the individual sensor coordinate system of the sensor's sensing element. The properties of the detections depend on the sensor technology. The uniqueness of the signal's "Feature ID" (A.3.2) values as well as the signal's "Object ID" (A.2.2) values is only guaranteed within the sensor cluster's interfaces of the sensor. To bring recognised detections in relation to entities of other interface levels, each recognised detections has an optional, unique signal's "Detection ID" (A.4.2) value. The uniqueness of the signal's "Detection ID" (A.4.2) value is only guaranteed within the sensor cluster's interfaces.

Wrong link-relations between features or objects and detections shall be prevented. Specifically, the reuse of the signal's "Detection ID" (A.4.2) values shall not lead to a misinterpretation of the link-relation between entities of the sensor cluster's interfaces.

On detection level the following interfaces are available:

— Radar detection interface (9.3);

— Lidar detection interface (9.4);

— Camera detection interface (9.5);

— Ultrasonic detection interface (9.6).

9.2 Generic sensor detection interface

Table 32 defines the generic structure of a DLI.

Table 32 — Generic sensor detection interface

Structure	Multiplicity	Option
Generic sensor detections header (9.2.1)	1	
Generic sensor detections entity (9.2.2), specifically an individual detection list interface entity	Multiple	Size type: dynamic/fixed

9.2.1 Generic sensor detections header

Table 33 defines the interface header in subclause "Generic sensor detections header" (9.2.1) and the changes due to the adaptation in comparison to the generic interface header in 6.2.

Table 33 — Specific signal grouping: Generic sensor detections header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
Time stamp – measurement (A.1.5.2)	Mandatory	
Cycle counter (A.1.6.1)	Optional	Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2)
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)
DLI sensor technology specific header extensions		
Recognised detections – capability (A.1.10.10)	Optional	
Recognised detections – status (A.1.11.10)	Optional	Redundancy (B.1.2) Signal: Recognised detections – capability (A.1.10.10) Default enumerators (B.1.7)
Number of valid detections (A.1.12.10)	Mandatory	Optimise LL (B.1.1) Optimise AER (B.1.4)

The following LSGs, which normally shall be provided by the sensor in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor (see B.3.3):

— interface: SPI; LSG “Information: vehicle coordinate system” (see Table 51);

— interface: SPI; LSG “Information: sensor pose” (see Table 51);

— interface: SHII; LSG “Calibration” (see Table 53);

— interface: SHII; LSG “Sensor cluster” (see Table 53).

9.2.2 Generic sensor detections entity

Table 34 defines the sensor grouping “Generic sensor detections entity status” for each DLI and defines the status of the detection [see also Table 8 (7.2.2) for generic object level entities and Table 25 (8.2.2) for generic sensor cluster feature entities].

Table 34 — Specific signal grouping: Generic sensor detections entity status

Signal	RL signal	Option
Existence probability – detection level (A.4.1)	Mandatory	
Detection ID (A.4.2)	Optional	Alternative A2I (B.3.2)
Object ID reference – detection level (A.4.3)	Conditional (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
Feature ID reference (A.4.4)	Conditional (B.3.1) Exist: FLI	Alternative A2I (B.3.2)
Time stamp difference – detection level (A.4.5)	Mandatory	Optimise IV (B.1.5)

Each interface type adds individual properties to the interface entity type. Detections are described in the sensor coordinate system. Detections reference entities of the OLI and FLI of the sensor or the sensor cluster of the sensor.

9.3 Radar detection interface

Table 35 defines the logical structure of the radar detection interface (RDI).

Table 35 — Radar detection interface

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning (6.4)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
		Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
		Time stamp – measurement (A.1.5.2)	M	
		Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2)
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	
		Data qualifier (A.1.9)	M	Default enumerators (B.1.7)
Information: ambiguity domain	M	Radial velocity ambiguity domain {begin, end} (A.1.15)	C (B.2.1) Relevant: technology specific	Profile: Radar ambiguity (9.3.3)
		Range ambiguity domain {begin, end} (A.1.16)	C (B.2.1) Relevant: technology specific	Profile: Radar ambiguity (9.3.3)
		Angle azimuth ambiguity domain {begin, end} (A.1.17)	C (B.2.1) Relevant: technology specific	Profile: Radar ambiguity (9.3.3)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Angle elevation ambiguity domain {begin, end} (A.1.18)	C (B.2.1) Relevant: technology specific	Profile: Radar ambiguity (9.3.3)
Detections	M	Recognised detections – capability (A.1.10.10)	O	
		Recognised detections – status (A.1.11.10)	O	Redundancy (B.1.2) Signal: Recognised detections – capability (A.1.10.10) Default enumerators (B.1.7)
		Number of valid detections (A.1.12.10)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Position {radial distance, azimuth, elevation} (A.4.17) identifiers {azimuth, elevation} Optimise AER (B.1.4)
		Size type: dynamic/fixed Size #: Number of valid detections (A.1.12.10)		
Status	M	Existence probability – detection level (A.4.1)	M	
		Detection ID (A.4.2)	O	Alternative A2I (B.3.2)
		Object ID reference – detection level (A.4.3)	C (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
		Time stamp difference – detection level (A.4.5)	M	Optimise IV (B.1.5)
Information	M	Radar cross section (A.4.6)	M	
		Radar cross section – error (A.4.7)	O	Implementation EM (B.4.1)
		Signal to noise ratio – detection level (A.4.8)	M	
		Signal to noise ratio – detection level – error (A.4.9)	O	Implementation EM (B.4.1)
		Multi target probability (A.4.10)	O	
		Ambiguity grouping ID (A.4.11)	C (B.2.1) Relevant: ambiguity	Profile: Radar ambiguity (9.3.3)
		Detection ambiguity probability (A.4.12)	C (B.2.1) Relevant: ambiguity	Profile: Radar ambiguity (9.3.3)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Free space probability (A.4.13)	O	
		Number of valid detection classifications (A.4.14)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Detection classification type (A.4.15)
		Size type: dynamic/fixed Size #: Number of valid detection classifications (A.4.14)		
		Detection classification type (A.4.15)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Detection classification type – confidence (A.4.16)	M	
Position	M	Position {radial distance, azimuth, elevation} (A.4.17)	{M, M, O}	Alternative VRO (B.1.3) Signal: {azimuth, elevation}
		Position {radial distance, azimuth, elevation} – error (A.4.18)	{M, M, O}	Implementation EM (B.4.1)
Dynamics	M	Relative velocity {radial distance} (A.4.19)	M	
		Relative velocity {radial distance} – error (A.4.20)	O	Implementation EM (B.4.1)

9.3.1 Radar detections header

Table 36 defines the interface header in subclause “Radar detections header” (9.3.1) and the changes due to the adaptation in comparison to the generic interface header in 9.2.1. The header of the RDI can contain a list of valid radar detection entities (see 9.3.2).

Table 36 — Specific signal grouping: Radar detections header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Sensor ID (A.1.4)

Signal	RL signal		Option
Sensor ID (A.1.4)	Mandatory		Profile: Uniqueness of interface versioning (6.4) Alternative VRO (B.1.3)
Time stamp – measurement (A.1.5.2)	Mandatory		
Cycle counter (A.1.6.1)	Optional		Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2)
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)
Radial velocity ambiguity domain {begin, end} (A.1.15)	RL LSG mandatory	Conditional (B.2.1) Relevant: technology specific	Profile: Radar ambiguity (9.3.3)
Range ambiguity domain {begin, end} (A.1.16)		Conditional (B.2.1) Relevant: technology specific	Profile: Radar ambiguity (9.3.3)
Angle azimuth ambiguity domain {begin, end} (A.1.17)		Conditional (B.2.1) Relevant: technology specific	Profile: Radar ambiguity (9.3.3)
Angle elevation ambiguity domain {begin, end} (A.1.18)		Conditional (B.2.1) Relevant: technology specific	Profile: Radar ambiguity (9.3.3)
Recognised detections – capability (A.1.10.10)	Optional		
Recognised detections – status (A.1.11.10)	Optional		Redundancy (B.1.2) Signal: Recognised detections – capability (A.1.10.10) Default enumerators (B.1.7)
Number of valid detections (A.1.12.10)	Mandatory		Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Position {radial distance, azimuth, elevation} (A.4.17) identifiers {azimuth, elevation} Optimise AER (B.1.4)

The following LSGs, which normally shall be provided by the sensor in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor (see B.3.3):

— interface: SPI; LSG “Information: vehicle coordinate system” (see Table 51);

— interface: SPI; LSG “Information: sensor pose” (see Table 51);

— interface: SHII; LSG “Calibration” (see Table 53);

— interface: SHII; LSG “Sensor cluster” (see Table 53).

9.3.2 Radar detections entity

Each detection of a radar sensor describes a measured detection and consists of several LSGs.

— **Status:** the status describes general information of the detection. It is based on current information and does not include historical information. Table 37 defines the signal grouping "Radar detections entity status". It defines this status LSG of the detection and redefines the signal grouping "Generic sensor detections entity status" (see Table 34). There is no radar feature interface defined and therefore radar detections cannot reference radar features.

— **Information:** the information describes the radar specific information of the detection.

— **Position:** the position describes the position information of the detection in the sensor coordinate system of the detection.

— **Dynamics:** the dynamics describe the dynamic information of the detection in the sensor coordinate system of the detection.

Table 37 — Specific signal grouping: Radar detections entity status

Signal	RL signal	Option
Existence probability – detection level (A.4.1)	Mandatory	
Detection ID (A.4.2)	Optional	Alternative A2I (B.3.2)
Object ID reference – detection level (A.4.3)	Conditional (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
Time stamp difference – detection level (A.4.5)	Mandatory	Optimise IV (B.1.5)

9.3.3 Profile: Radar ambiguity

The signal "Ambiguity grouping ID" (A.4.11) and the signal "Detection ambiguity probability" (A.4.12) are mandatory, if the radar sensor technology has one or more technology depending ambiguities. The signals corresponding to the following domains of the signal are mandatory, if the sensor technology has the specific ambiguity: ambiguity corresponding to signal "Radial velocity ambiguity domain {begin, end}" (A.1.15), signal "Range ambiguity domain {begin, end}" (A.1.16), signal "Angle azimuth ambiguity domain {begin, end}" (A.1.17) and/or signal "Angle elevation ambiguity domain {begin, end}" (A.1.18).

9.4 Lidar detection interface

Table 38 defines the logical structure of the lidar detection interface (LDI).

Table 38 — Lidar detection interface

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning (6.4)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
		Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
		Time stamp – measurement (A.1.5.2)	M	
		Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2)
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	
		Data qualifier (A.1.9)	M	Default enumerators (B.1.7)
Detections	M	Recognised detections – capability (A.1.10.10)	O	
		Recognised detections – status (A.1.11.10)	O	Redundancy (B.1.2) Signal: Recognised detections – capability (A.1.10.10) Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
		Number of valid detections (A.1.12.10)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Position {radial distance, azimuth, elevation} (A.4.17) identifiers {azimuth, elevation} Optimise AER (B.1.4)
		Size type: dynamic/fixed Size #: Number of valid detections (A.1.12.10)		
Status	M	Existence probability – detection level (A.4.1)	M	
		Detection ID (A.4.2)	O	Alternative A2I (B.3.2)
		Object ID reference – detection level (A.4.3)	C (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
		Time stamp difference – detection level (A.4.5)	M	Optimise IV (B.1.5)
Information	M	Reflectivity (A.4.21)	M	
		Reflectivity – error (A.4.22)	O	Implementation EM (B.4.1)
		Free space probability (A.4.13)	O	
		Number of valid detection classifications (A.4.14)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Detection classification type (A.4.15)
		Size type: dynamic/fixed Size #: Number of valid detection classifications (A.4.14)		
		Detection classification type (A.4.15)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Detection classification type – confidence (A.4.16)	M	

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
Position	M	Position {radial distance, azimuth, elevation} (A.4.17)	M	Alternative VRO (B.1.3) Signal: {azimuth, elevation}
		Position {radial distance, azimuth, elevation} – error (A.4.18)	M	Implementation EM (B.4.1)
		Extent {height} – lidar (A.4.23)	O	
		Extent {height} – lidar – error (A.4.24)	C (B.2.2) Signal: Extent {height} – lidar (A.4.23)	Implementation EM (B.4.1)
Dynamics	O	Relative velocity {radial distance} (A.4.19)	M	
		Relative velocity {radial distance} – error (A.4.20)	O	Implementation EM (B.4.1)

9.4.1 Lidar detection header

Table 39 defines the interface header in subclause “Lidar detection header” (9.4.1) and the changes due to the adaptation in comparison to the generic interface header in 9.2.1. The header of the LDI can contain a list of valid lidar detection entities (see 9.4.2).

Table 39 — Specific signal grouping: Lidar detection header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
Time stamp – measurement (A.1.5.2)	Mandatory	
Cycle counter (A.1.6.1)	Optional	Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2)
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)
Recognised detections – capability (A.1.10.10)	Optional	

Signal	RL signal	Option
Recognised detections – status (A.1.11.10)	Optional	Redundancy (B.1.2) Signal: Recognised detections – capability (A.1.10.10) Default enumerators (B.1.7)
Number of valid detections (A.1.12.10)	Mandatory	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Position {radial distance, azimuth, elevation} (A.4.17) identifiers {azimuth, elevation} Optimise AER (B.1.4)

The following LSGs, which normally shall be provided by the sensor in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor (see B.3.3):

— interface: SPI; LSG "Information: vehicle coordinate system" (see Table 51);

— interface: SPI; LSG "Information: sensor pose" (see Table 51);

— interface: SHII; LSG "Calibration" (see Table 53);

— interface: SHII; LSG "Sensor cluster" (see Table 53).

9.4.2 Lidar detection entity

Each detection of a lidar sensor describes a measured detection and consists of several LSGs.

— **Status:** the status describes general information of the detection. It is based on current information and does not include historical information. Table 40 defines the signal grouping "Lidar detection entity status". It defines this status LSG of the detection and redefines the signal grouping "Generic sensor detections entity status" (see Table 34). There is no lidar feature interface defined and therefore lidar detections cannot reference lidar features.

— **Information:** the information describes the lidar specific information of the detection.

— **Position:** the position describes the position information of the detection in the sensor coordinate system of the detection.

— **Dynamics:** the dynamics describe the dynamic information of the detection in the sensor coordinate system of the detection.

Table 40 — Specific signal grouping: Lidar detection entity status

Signal	RL signal	Option
Existence probability – detection level (A.4.1)	Mandatory	
Detection ID (A.4.2)	Optional	Alternative A2I (B.3.2)
Object ID reference – detection level (A.4.3)	Conditional (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
Time stamp difference – detection level (A.4.5)	Mandatory	Optimise IV (B.1.5)

9.5 Camera detection interface

Table 41 defines the logical structure of the camera detection interface (CDI). Camera detections use shapes and points to define detections.

Table 41 — Camera detection interface

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning (6.4)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
		Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
		Time stamp – measurement (A.1.5.2)	M	
		Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2)
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	
		Data qualifier (A.1.9)	M	Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
		Colour model type (A.1.14)	M	Profile: Colour model for CDI (9.5.3) 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)
Shapes	C (B.2.3) multiple entity types	Recognised shapes – capability (A.1.10.11)	O	
		Recognised shapes – status (A.1.11.11)	O	Redundancy (B.1.2) Signal: Recognised shapes – capability (A.1.10.11) Default enumerators (B.1.7)
		Number of valid shapes (A.1.12.11)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid shapes (A.1.12.11)		
Shape status	M	Existence probability – detection level (A.4.1)	M	
		Detection ID (A.4.2)	O	Alternative A2I (B.3.2)
		Object ID reference – detection level (A.4.3)	C (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
		Feature ID reference (A.4.4)	C (B.3.1) Exist: FLI	Alternative A2I (B.3.2)
		Time stamp difference – detection level (A.4.5)	M	Optimise IV (B.1.5)
Shape	M	Free space probability (A.4.13)	O	

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
information		Number of valid shape classifications – detection level (A.4.25)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Shape classification type – detection level (A.4.26)
		Size type: dynamic/fixed Size #: Number of valid shape classifications – detection level (A.4.25)		
		Shape classification type – detection level (A.4.26)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Shape classification type – confidence – detection level (A.4.27)	M	Default enumerators (B.1.7)
		Shape ambiguity grouping ID (A.4.28)	C (B.2.1) Relevant: ambiguity	
Shape colour tone	M	Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – detection level (A.4.29)	M	Profile: Colour model for CDI (9.5.3)
		Colour tone – confidence – detection level (A.4.30)	O	Profile: Colour model for CDI (9.5.3)
Shape points	M	Shape type – detection level (A.4.31)	M	Default enumerators (B.1.7)
		Number of valid shape points – detection level (A.4.32)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid shape points – detection level (A.4.32)		
		Point existence probability – detection level (A.4.33)	M	
		Position {radial distance, azimuth, elevation} (A.4.17)	{O, M, M}	
		Position {radial distance, azimuth, elevation} – error (A.4.18)	{C (B.2.2) Signal: Position {radial distance} (A.4.17), M, M}	Implementation EM (B.4.1)

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
Shape reference points	O	Number of valid shape reference points – detection level (A.4.34)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid shape reference points – detection level (A.4.34)		
		Detection ID reference – detection level (A.4.35)	M	[a]
Points	C (B.2.3) multiple entity types	Recognised detections – capability (A.1.10.10)	O	
		Recognised detections – status (A.1.11.10)	O	Redundancy (B.1.2) Signal: Recognised detections – capability (A.1.10.10) Default enumerators (B.1.7)
		Number of valid detections (A.1.12.10)	M	Optimise LL (B.1.1)
		Size type: dynamic/fixed Size #: Number of valid detections (A.1.12.10)		
Point status	M	Existence probability – detection level (A.4.1)	M	
		Detection ID (A.4.2)	O	Alternative A2I (B.3.2)
		Object ID reference – detection level (A.4.3)	C (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
		Feature ID reference (A.4.4)	C (B.3.1) Exist: FLI	Alternative A2I (B.3.2)
		Time stamp difference – detection level (A.4.5)	M	Optimise IV (B.1.5)
Point information	M	Position {radial distance, azimuth, elevation} (A.4.17)	{O, M, M}	
		Position {radial distance, azimuth, elevation} – error (A.4.18)	{C (B.2.2) Signal: Position {radial distance} (A.4.17), M, M}	Implementation EM (B.4.1)
		Point existence probability – detection level (A.4.33)	M	
		Extent {azimuth, elevation} (A.4.36)	O	
		Extent {azimuth, elevation} – error (A.4.37)	O	Implementation EM (B.4.1)

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
Point colour tone	M	Size type: dynamic/fixed Size # * Implicit list length – Optimise LL (B.1.1): depends on Colour model type (A.1.14)		
		Colour value – detection level (A.4.29)	M	Profile: Colour model for CDI (9.5.3)
		Colour tone – confidence – detection level (A.4.30)	O	Profile: Colour model for CDI (9.5.3)
Point dynamics	O	Translation rate {radial distance, azimuth, elevation} – detection level (A.4.38)	M	
		Translation rate {radial distance, azimuth, elevation} – detection level – error (A.4.39)	O	Implementation EM (B.4.1)

[a] Reference only CDI points detections.

9.5.1 Camera detection header

Table 42 defines the interface header in subclause "Camera detection header" (9.5.1) and the changes due to the adaptation in comparison to the generic interface header in 9.2.1. The header of the CDI can contain a list of valid camera detection entities (see 9.5.2).

Table 42 — Specific signal grouping: Camera detection header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
Time stamp – measurement (A.1.5.2)	Mandatory	
Cycle counter (A.1.6.1)	Optional	Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2)
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)

Signal	RL signal	Option
Colour model type (A.1.14)	Mandatory	Profile: Colour model for CDI (9.5.3) 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)
Recognised shapes – capability (A.1.10.11)	Optional	
Recognised shapes – status (A.1.11.11)	Optional	Redundancy (B.1.2) Signal: Recognised shapes – capability (A.1.10.11) Default enumerators (B.1.7)
Number of valid shapes (A.1.12.11)	Mandatory	Optimise LL (B.1.1)
Recognised detections – capability (A.1.10.10)	Optional	
Recognised detections – status (A.1.11.10)	Optional	Redundancy (B.1.2) Signal: Recognised detections – capability (A.1.10.10) Default enumerators (B.1.7)
Number of valid detections (A.1.12.10)	Mandatory	Optimise LL (B.1.1)

The following LSGs, which normally shall be provided by the sensor in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor (see B.3.3):

— interface: SPI; LSG “Information: vehicle coordinate system” (see Table 51);

— interface: SPI; LSG “Information: sensor pose” (see Table 51);

— interface: SHII; LSG “Calibration” (see Table 53);

— interface: SHII; LSG “Sensor cluster” (see Table 53).

9.5.2 Camera detection entity

Each detection of a camera sensor describes a measured shape- or point detection and consists of several LSGs.

A shape is described by the following LSGs for shape.

— **Shape status:** the shape status describes general information of the detection of a shape. It is based on current information and does not include historical information. Table 43 defines the signal grouping “Camera detection entity status”. It defines this status LSG of the detection and redefines the signal grouping “Generic sensor detections entity status” (see Table 34).

— **Shape information:** the information describes the camera specific information of the detection shape.

— **Shape colour tone:** the colour tone describes visual properties of the shape detection.

— **Shape points:** the shape points describe the geometric vertices of the hull for the shape detection in the sensor coordinate system.

— **Shape reference points:** the shape reference points are small distinctive segments which are part of the detection's shape.

A point is described by the following LSGs for point.

— **Point status:** the point status describes general information of the detection of a point. It is based on current information and does not include historical information. Table 43 defines the signal grouping “Camera detection entity status”. It defines this status LSG of the detection and redefines the signal grouping “Generic sensor detections entity status” (see Table 34).

— **Point information:** the information describes the geometric information of the detection point in the sensor coordinate system.

— **Point colour tone:** the colour tone describes visual properties of the point detection.

— **Point dynamics:** the point dynamic describes information of the point detection in the sensor coordinate system.

Table 43 — Specific signal grouping: Camera detection entity status

Signal	RL signal	Option
Existence probability – detection level (A.4.1)	Mandatory	
Detection ID (A.4.2)	Optional	Alternative A2I (B.3.2)
Object ID reference – detection level (A.4.3)	Conditional (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
Feature ID reference (A.4.4)	Conditional (B.3.1) Exist: FLI	Alternative A2I (B.3.2)
Time stamp difference – detection level (A.4.5)	Mandatory	Optimise IV (B.1.5)

9.5.3 Profile: Colour model for CDI

The signal “Colour model type” (A.1.14) defines the colour model for the interface. Depending on the colour model, each colour is described by a fixed number of colour values [see signal “Colour value – detection level” (A.4.29)] to define the colour tone. The confidence of the colour tone is provided by the signal “Colour tone – confidence – detection level” (A.4.30).

The interface provides colour tones for shape- and point detections.

9.6 Ultrasonic detection interface

Table 44 defines the logical structure of the ultrasonic detection interface (UDI).

Table 44 — Ultrasonic detection interface

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning (6.4)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
		Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning (6.4) Profile: Ultrasonic sensor cluster (9.6.3) 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 (6.4) Profile: Ultrasonic sensor cluster (9.6.3) Alternative VRO (B.1.3)
		Time stamp – measurement (A.1.5.2)	M	
		Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2)
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
		Data qualifier (A.1.9)	M	Default enumerators (B.1.7)
Detections	M	Recognised detections – capability (A.1.10.10)	O	
		Recognised detections – status (A.1.11.10)	O	Redundancy (B.1.2) Signal: Recognised detections – capability (A.1.10.10) Default enumerators (B.1.7)
		Number of valid detections (A.1.12.10)	M	Optimise LL (B.1.1) Optimise AER (B.1.4)
		Size type: dynamic/fixed Size #: Number of valid detections (A.1.12.10)		
Status	M	Existence probability – detection level (A.4.1)	M	
		Detection ID (A.4.2)	O	Alternative A2I (B.3.2)
		Object ID reference – detection level (A.4.3)	C (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
		Feature ID reference (A.4.4)	C (B.3.1) Exist: FLI	Alternative A2I (B.3.2)
		Time stamp difference – detection level (A.4.5)	M	Profile: Ultrasonic sensor cluster (9.6.3) Optimise IV (B.1.5)
Information	M	Second sensor ID reference (A.4.40)	C Profile: Ultrasonic sensor cluster (9.6.3)	Profile: Ultrasonic sensor cluster (9.6.3)
		Reflectivity (A.4.21)	O	
Position	M	Distance (A.4.41)	M	
		Distance – error (A.4.42)	M	Implementation EM (B.4.1)

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
		Extent {height} – ultrasonic (A.4.43)	C (B.2.1) Relevant: technology specific	
		Extent {height} – ultrasonic – error (A.4.44)	O	Implementation EM (B.4.1)

9.6.1 Ultrasonic detection header

Table 45 defines the interface header in subclause “Ultrasonic detection header” (9.6.1) and the changes due to the adaptation in comparison to the generic interface header in 9.2.1. The header of the UDI can contain a list of valid ultrasonic detection entities (see 9.6.2).

Table 45 — Specific signal grouping: Ultrasonic detection header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) Profile: Ultrasonic sensor cluster (9.6.3) 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 (6.4) Profile: Ultrasonic sensor cluster (9.6.3) Alternative VRO (B.1.3)
Time stamp – measurement (A.1.5.2)	Mandatory	
Cycle counter (A.1.6.1)	Optional	Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2)
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)
Recognised detections – capability (A.1.10.10)	Optional	
Recognised detections – status (A.1.11.10)	Optional	Redundancy (B.1.2) Signal: Recognised detections – capability (A.1.10.10) Default enumerators (B.1.7)
Number of valid detections (A.1.12.10)	Mandatory	Optimise LL (B.1.1) Optimise AER (B.1.4)

The UDI may provide all detections of either the emitting or the sensing ultrasonic sensor. Each detection will provide the corresponding sensor by the signal “Second sensor ID reference” (A.4.40). If the UDI provides detections for a sensor-sub-cluster, the first signal “Sensor ID” (A.1.4) provides the emitting sensor and the following signal “Sensor ID” (A.1.4) provides the sensing sensor. In case of a concurrent emitting and sensing sensor element the signal "Sensor ID" (A.1.4) provides only one ID for both elements (see 9.6.3).

The following LSGs, which normally shall be provided by the sensor in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor (see B.3.3):

— interface: SPI; LSG "Information: vehicle coordinate system" (see Table 51);

— interface: SPI; LSG "Information: sensor pose" (see Table 51);

— interface: SHII; LSG "Calibration" (see Table 53);

— interface: SHII; LSG "Sensor cluster" (see Table 53).

9.6.2 Ultrasonic detection entity

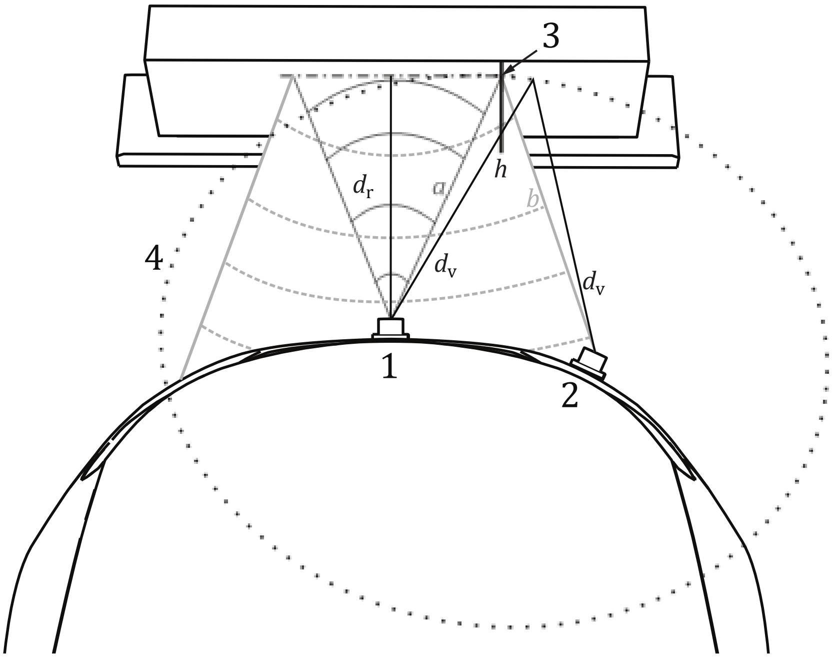
Each detection of an ultrasonic sensor describes a measured detection and consists of several LSGs.

— **Status:** the status describes general information of the detection. It is based on current information and does not include historical information. Table 46 defines the signal grouping "Ultrasonic detection entity status". It defines this status LSG of the detection and redefines the signal grouping "Generic sensor detections entity status" (see Table 34).

— **Information:** The information describes the ultrasonic specific information of the echo (see Figure 21).

Table 46 — Specific signal grouping: Ultrasonic detection entity status

Signal	RL signal	Option
Existence probability – detection level (A.4.1)	Mandatory	
Detection ID (A.4.2)	Optional	Alternative A2I (B.3.2)
Object ID reference – detection level (A.4.3)	Conditional (B.3.1) Exist: OLI	Alternative A2I (B.3.2)
Feature ID reference (A.4.4)	Conditional (B.3.1) Exist: FLI	Alternative A2I (B.3.2)
Time stamp difference – detection level (A.4.5)	Mandatory	Optimise IV (B.1.5)



Key

1 ultrasonic sender $\overrightarrow{(S)}$ – emitting ultrasonic element

2 ultrasonic receiver $\overrightarrow{(R)}$ – sensing ultrasonic element

3 obstacle's reflection point $\overrightarrow{(O)}$

4 ellipse (theoretically possible points of an obstacle's reflection)

a distance from the emitting ultrasonic element to the obstacle's reflection point $\coloneqq \left|\overrightarrow{(O)} - \overrightarrow{(S)}\right|$

b distance from the obstacle's reflection point to the sensing ultrasonic element $\coloneqq \left|\overrightarrow{(R)} - \overrightarrow{(O)}\right|$

d_v mean distance of the echo of a reflection between emitting ultrasonic element (see key 1), obstacle's reflection point (see key 3) and sensing ultrasonic element (see key 2) $\coloneqq (a + b)/2$

d_r distance of a direct reflection between obstacle and the emitting and sensing ultrasonic element (see key 1)

h height of the obstacle

Figure 21 — Example for an ultrasonic sensor cluster with separate emitting and sensing elements on the example of two received echoes of one emitted pulse

9.6.3 Profile: Ultrasonic sensor cluster

An ultrasonic sensor cluster (see Figure 22) may serve this interface in different ways (see Table 47).

1. Each virtual sensor (which is based on two different real sensors, one for emitting and one for sensing) and real sensor (which is based on one real sensors, which is emitting and sensing its emitted pulse) provide a separate interface. The emitting and sensing sensors are defined in the header of the interface message. Real sensors, which emit and sense their own echo, provide a DLI with the signal "Sensor ID" (A.1.4) of the sensor (one ID). Virtual sensors provide a DLI with the first signal "Sensor ID" (A.1.4) of the emitting sensor and the second of the sensing sensor (two IDs). The RL of the signal "Second sensor ID reference" (A.4.40) is optional and the signal would be redundant.

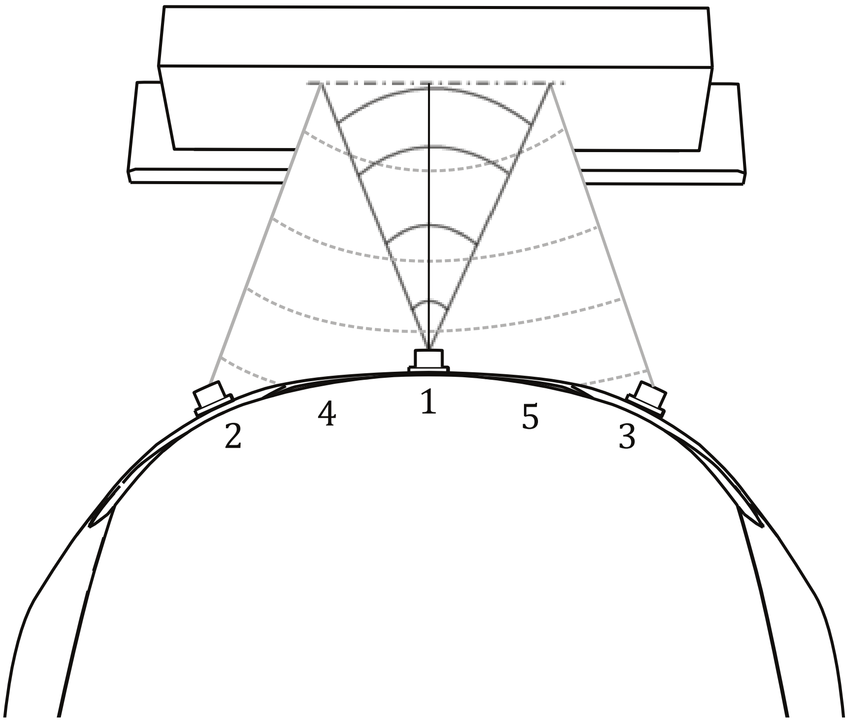
2. Each real sensor provides a separate interface, including all detections of the virtual sensors. Virtual sensors may serve no interface.

   a. The signal "Sensor ID" (A.1.4) provides the ID of the emitting sensor. The sensing sensor of the detection is referenced by the signal "Second sensor ID reference" (A.4.40), which is mandatory for a sensor cluster. The measurement cycle of the sensor cluster's UDIs may not overlap in time.

b. The signal "Sensor ID" (A.1.4) provides the ID of the sensing sensor. The emitting sensor of the detection is referenced by the signal "Second sensor ID reference" (A.4.40), which is mandatory for a sensor cluster. The measurement cycle of the sensor cluster's UDIs may overlap in time.

The signal "Second sensor ID reference" (A.4.40) is optional for a single ultrasonic sensor.

All emitting and/or sensing ultrasonic sensors may provide the SPI sensor origin point and sensor axis system, in detail the LSG "Information: sensor pose" (see Table 51). Even if the ultrasonic detections are clustered in the interface (see Profile: Ultrasonic sensor cluster (9.6.3) – option 2a or 2b) or the origin point and sensor axis system of a virtual sensor is calculated of the sensor poses of the real sensors' SPIs.



Key

1 ultrasonic sender and receiver (SR)
real sensor {SR} origin
2 ultrasonic receiver (R1)
3 ultrasonic receiver (R2)
4 virtual sensor {SR, R1} origin
5 virtual sensor {SR, R2} origin

Figure 22 — Example for an ultrasonic sensor cluster of 3 ultrasonic elements for one echo and the resulting sensor origins

Table 47 — Example of UDIs for 3 emitting and sensing elements; one echo – Profile relevant signals

Profile: Ultrasonic sensor cluster (9.6.3) – option 1 (9 UDI)	Profile: Ultrasonic sensor cluster (9.6.3) – option 2a (3 UDI)	Profile: Ultrasonic sensor cluster (9.6.3) – option 2b (3 UDI)

UDI {
{Sensor ID = SR}
Detection {}
}
	UDI {
	{Sensor ID = SR}
	Detection {
	Second sensor ID reference = SR
	Time stamp difference = dt_{SRSR}
	}
	Detection {
	Second sensor ID reference = R1
	Time stamp difference = dt_{SRR1}
	}
	Detection {
	Second sensor ID reference = R2
	Time stamp difference = dt_{SRR2}
	}
	}
		UDI {
		{Sensor ID = SR}
		...
		Detection {
		Second sensor ID reference = SR
		Time stamp difference = dt_{SR}+ dt_{SRSR}
		}
		...
		}

UDI {
{Sensor ID = {SR, R1}}
Detection {}
}
		UDI {
		{Sensor ID = R1}
		...
		Detection {
		Second sensor ID reference = SR
		Time stamp difference = dt_{SR}+ dt_{SRR1}
		}
		...
		}

UDI {
{Sensor ID = {SR, R2}}
Detection {}
}
	...	UDI {
		{Sensor ID = R2}
		...
		Detection {
		Second sensor ID reference = SR
		Time stamp difference = dt_{SR}+ dt_{SRR2}
		}
		...
		}

...		

10 Supportive sensor interfaces

10.1 General

Sensors and sensor clusters serve supportive sensor interfaces (SSI). A fusion unit may derive the sensor cluster's SSI's information of the sensors' SSIs of the sensor cluster. Therefore, in this clause for SSI, the term sensor is always used, even if a sensor cluster is serving the interface. The SSIs provide additional, general information of a sensor's or sensor cluster's health and performance. Table 48 provides an overview over the differences and boundaries between the SSIs.

Table 48 — Brief overview over the differences and boundaries between the SSIs

Sensor performance		Sensor health information
Impairment on observed field	Impairment on sensor surface	Sensor internal
— rain, fog — snow — particles (air) — and so forth	— dirt, dust — condensation — scratch — and so forth	— operation — diagnosis — defects — cleaning — position calibration — and so forth
Classification into several measurement ranges Relevant for safety concept		Global information for the complete sensor Misalignment: hardware and software calibration Relevant E/E information

The following supportive sensor interfaces are available:

— Sensor performance interface (10.3);

— Sensor health information interface (10.4).

Supportive sensor interface messages (see 10.3 and 10.4) may be required to correctly interpret information from object-, feature- and detection level interface. Data consistency over the sensor's interfaces shall be assured. Supportive sensor interfaces have LSGs which the sensor shall provide. If an SSI is not provided, the SSI relevant LSG will be provided by other interfaces as defined (see B.3.3).

10.2 Generic supportive sensor interface

Table 49 defines the generic structure of an SSI.

Table 49 — Generic supportive sensor interface

Structure	Multiplicity	Option
Generic supportive sensor header (10.2.1)	1	
Generic supportive sensor entity (10.2.2), specifically an individual supportive sensor entity (list)	SPI: multiple as well as SHII: 1	Size type: dynamic/fixed

The multiplicity of the individual supportive sensor interface entity list depends on the individual SSI interface.

The geometric information of the SSIs references the vehicle coordinate system (see signal "Vehicle coordinate system type – header" (A.1.20)] as well as the sensor coordinate system.

10.2.1 Generic supportive sensor header

Table 50 defines the interface header in subclause "Generic supportive sensor header" (10.2.1) and the changes due to the adaptation in comparison to the generic interface header in 6.2. Each individual SSI may define the signal "Time stamp – <…>" (A.1.5) during the system design phase.

Table 50 — Specific signal grouping: Generic supportive sensor header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)

Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
Time stamp – <…> (A.1.5)	Mandatory	
Message counter (A.1.6.2)	Optional	
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)
SSI specific header extensions		
Number of valid <…> (A.1.12)	Mandatory	Optimise LL (B.1.1)

The LSGs, which normally shall be provided by the sensor as well as the sensor cluster in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor or sensor cluster (see B.3.3). For each SSI these LSGs are individual.

10.2.2 Generic supportive sensor entity

No generic LSG is defined for the interface entity types of all SSIs.

10.3 Sensor performance interface

Table 51 defines the logical structure of the sensor performance interface (SPI).

Table 51 — Sensor performance interface

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning of SPIs (10.3.3)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning of SPIs (10.3.3) Default enumerators (B.1.7)
		Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning of SPIs (10.3.3) Optimise LL

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
				(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 of SPIs (10.3.3) Alternative VRO (B.1.3)
		Time stamp – <...> (A.1.5)	M	
		Message counter (A.1.6.2)	O	
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	
		Data qualifier (A.1.9)	M	Default enumerators (B.1.7)
		Interface applicability (A.1.19)	O	Profile: Uniqueness of interface versioning of SPIs (10.3.3) Default enumerators (B.1.7)
Information: vehicle coordinate system	M Need of logical signal group (B.3.3) 1. SHII Header, 2. Redundant on OLI, FLI and DLI Header	Vehicle coordinate system type – header (A.1.20)	M	Optimise IV (B.1.5)
Information: sensor pose	M Need of logical signal group (B.3.3) 1. SHII Header, 2. DLI Header	Sensor origin point {x, y, z} – header (A.1.21)	M	
		Sensor origin point {x, y, z} – error (A.1.22)	O	Implementation EM (B.4.1)
		Sensor orientation {yaw, pitch, roll} – header (A.1.23)	M	
		Sensor orientation {yaw, pitch, roll} – error (A.1.24)	O	Implementation EM (B.4.1)
Information: sensor	O	Vanishing point {azimuth, elevation} (A.1.25)	M	

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
surrounding		Vanishing point {azimuth, elevation} – error (A.1.26)	O	Implementation EM (B.4.1)
Segments	M	Number of valid field-of-view segments (A.1.12.12)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Segment azimuth – supportive sensor level {begin, end} (A.5.1) and Segment elevation – supportive sensor level {begin, end} (A.5.2)
		Size type: Dynamic/fixed Size #: Number of valid field-of-view segments (A.1.12.12)		
Status	M	Segment azimuth – supportive sensor level {begin, end} (A.5.1)	M	Alternative VRO (B.1.3)
		Segment elevation – supportive sensor level {begin, end} (A.5.2)	O	Alternative VRO (B.1.3)
		Measurement grid resolution {radial distance, azimuth, elevation} (A.5.3)	O	
		Beam divergence {azimuth, elevation} (A.5.4)	O	
		Range gain (A.5.5)	O	
		Blockage status (A.5.6)	M	Default enumerators (B.1.7)
Field-of-view reduction	O	Number of valid field-of-view reduction reasons (A.5.7)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Field-of-view reduction reason type (A.5.8)
		Size type: Dynamic/fixed Size #: Number of valid field-of-view reduction reasons (A.5.7)		
		Field-of-view reduction reason type (A.5.8)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
		Field-of-view reduction reason type – confidence (A.5.9)	M	
Real-world object recognition capabilities	C (B.3.1) Exist: OLI and in scope of signal “Interface applicability” (A.1.19)	Number of valid recognisable object types (A.5.10)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Recognised object type (A.5.11)
		Size type: Dynamic/fixed Size #: Number of valid recognisable object types (A.5.10)		
		Recognised object type (A.5.11)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Detection range radial distance {begin, end} (A.5.12)	M	
		True positive rate (A.5.13)	O	
		False positive rate (A.5.14)	O	
		Positive predictive value (A.5.15)	O	
Reference target recognition capabilities	C (B.3.1) Exist: FLI, DLI and in scope of signal “Interface applicability” (A.1.19)	Number of valid reference target types (A.5.16)	M	Optimise LL (B.1.1)
		Size type: Dynamic/fixed Size #: Number of valid reference target types (A.5.16)		
		Reference target type (A.5.17)	C (B.2.1) Relevant: camera	Default enumerators (B.1.7)
		Radar cross section reference target (A.5.18)	C (B.2.1) Relevant: radar	
		Reflectivity reference target (A.5.19)	C (B.2.1) Relevant: lidar, ultrasonic	
		Detection range radial distance {begin, end} (A.5.12)	M	
		True positive rate (A.5.13)	O	
		Relative radial velocity	O	

LSG	RL LSG M/C/O	Signal			RL Signal M/C/O	Option
				range {begin, end} (A.5.20)		
				Signal to noise ratio – supportive level (A.5.21)	M	Optimise IV (B.1.5)
				Spatial separability {radial distance, azimuth, elevation} (A.5.22)	O	
				Velocity separability {radial distance, azimuth, elevation} (A.5.23)	O	

The signals referring to angles as well as distances in the segments always refer to the sensor coordinate system and its origin. This affects the signals:

— Segment azimuth – supportive sensor level {begin, end} (A.5.1);

— Segment elevation – supportive sensor level {begin, end} (A.5.2);

— Measurement grid resolution {radial distance, azimuth, elevation} (A.5.3);

— Detection range radial distance {begin, end} (A.5.12);

— Relative radial velocity range {begin, end} (A.5.20);

— Spatial separability {radial distance, azimuth, elevation} (A.5.22);

— Velocity separability {radial distance, azimuth, elevation} (A.5.23).

The correlation between vehicle- and sensor coordinate system is determined by the sensor origin point and the sensor orientation of the sensor (LSG "Information: sensor pose" – see Table 51).

10.3.1 Sensor performance header

Table 52 defines the interface header in subclause "Sensor performance header" (10.3.1) and the changes due to the adaptation in comparison to the generic interface header in 10.2.1. The header of the SPI can contain a list of valid FOV segment entities (see 10.3.2).

Table 52 — Specific signal grouping: Sensor performance header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning of SPIs (10.3.3)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning of SPIs (10.3.3) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning of SPIs (10.3.3) Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Sensor ID (A.1.4)

Signal	RL signal		Option
Sensor ID (A.1.4)	Mandatory		Profile: Uniqueness of interface versioning of SPIs (10.3.3) Alternative VRO(B.1.3)
Time stamp – <…> (A.1.5)	Mandatory		
Message counter (A.1.6.2)	Optional		
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)
Interface applicability (A.1.19)	Optional		Profile: Uniqueness of interface versioning of SPIs (10.3.3) Default enumerators (B.1.7)
Vehicle coordinate system type – header (A.1.20)	RL LSG mandatory Need of logical signal group (B.3.3) 1. SHII Header, 2. Redundant on OLI, FLI and DLI Header	Mandatory	Optimise IV (B.1.5)
Sensor origin point {x, y, z} – header (A.1.21)	RL LSG mandatory Need of logical signal group (B.3.3) 1. SHII Header, 2. DLI Header	Mandatory	
Sensor origin point {x, y, z} – error (A.1.22)		Optional	Implementation EM (B.4.1)
Sensor orientation {yaw, pitch, roll} – header (A.1.23)		Mandatory	
Sensor orientation {yaw, pitch, roll} – error (A.1.24)		Optional	Implementation EM (B.4.1)
Vanishing point {azimuth, elevation} (A.1.25)	RL LSG optional	Mandatory	
Vanishing point {azimuth, elevation} – error (A.1.26)		Optional	Implementation EM (B.4.1)
Number of valid field-of-view segments (A.1.12.12)	Mandatory		Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Segment azimuth – supportive sensor level {begin, end} (A.5.1) and Segment elevation – supportive sensor level {begin, end} (A.5.2)

The following LSGs, which normally shall be provided by the sensor as well as the sensor cluster in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor or sensor cluster (see B.3.3):

— interface: SHII; LSG “Calibration” (see Table 53);

— interface: SHII; LSG “Sensor cluster” (see Table 53).

The following LSGs, which shall be provided by the sensor as well as the sensor cluster in this interface, may be added to another header (see B.3.3):

— interface: SPI; LSG “Information: vehicle coordinate system” (see Table 51);

— interface: SPI; LSG “Information: sensor pose” (see Table 51).

10.3.2 Sensor performance entity

Each sensor performance segment for FOV of a sensor describes the performance in this segment and consists of several LSGs.

— **Status:** the status describes the geometry of the FOV segment.

— **Field-of-view reduction causes:** the FOV reduction causes describe the causes (for example, extrinsic or intrinsic) for an FOV reduction.

— **Real-world object recognition rates:** the real-world object recognition rates describe the estimated recognition rates for real-world recognition of different real-world objects.

— **Reference target recognition rates:** the reference target recognition rates describe the estimated recognition rates for synthetic, well-defined recognition of different synthetic, well-defined objects.

For two valid but geometric overlapping FOV segments (azimuth-, elevation range), the values for the earlier defined segment in the list will always stay valid. So typically, the segments will be defined from the inside to the outside (due to timing reasons, special regions of interest are more important than the general FOV segments and the special regions of interest need to be known to be subtracted from the general FOV segment).

10.3.3 Profile: Uniqueness of interface versioning of SPIs

This profile extends the profile of 6.4. A sensor cluster may provide this interface more than once for the sensor. To identify the different interface implementations of the SPI the signal “Interface applicability” (A.1.19) is additionally used to define uniqueness.

10.4 Sensor health information interface

The subclause “Sensor health information interface” (10.4) (SHII) provides a qualitive statement of the sensor’s health status. More detailed information of sensor statuses can be provided via other interfaces.

Table 53 defines the logical structure of the sensor health information interface.

Table 53 — Sensor health information interface

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning (6.4)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
		Number of valid serving sensors (A.1.3)	M	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
		Time stamp – <…> (A.1.5)	M	
		Message counter (A.1.6.2)	O	
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	
		Data qualifier (A.1.9)	M	Default enumerators (B.1.7)
Status	M	Number of valid sensor operation modes (A.5.24)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Sensor operation mode (A.5.25)
		Size type: Dynamic/fixed Size #: Number of valid sensor operation modes (A.5.24)		
		Sensor operation mode (A.5.25)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Sensor defect recognised (A.5.26)	M	Default enumerators (B.1.7)
		Sensor defect reason (A.5.27)	M	Default enumerators (B.1.7)
		Supply voltage status (A.5.28)	M	Default enumerators (B.1.7)
		Sensor temperature status (A.5.29)	M	Default enumerators (B.1.7)
		Number of valid sensor input signal statuses (A.5.30)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Sensor input signal type (A.5.31)
		Size type: Dynamic/fixed Size #: Number of valid sensor input signal statuses (A.5.30)		
		Sensor input signal type (A.5.31)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
		Sensor input signal status (A.5.32)	M	Default enumerators (B.1.7)
		Sensor externally disturbed (A.5.33)	O	Default enumerators (B.1.7)
		Sensor transmit power reduced (A.5.34)	O	Default enumerators (B.1.7)
		Sensor heating status (A.5.35)	O	Default enumerators (B.1.7)
		Sensor cleaning status (A.5.36)	O	Default enumerators (B.1.7)
		Sensor time sync (A.5.37)	O	Default enumerators (B.1.7)
		Sensor time sync offset value (A.5.38)	C (B.2.2) * The signal "Sensor time sync" (A.5.37) has "STS_Offset" or a similar enumerator defined during the system design phase.	
Calibration	O Need of logical signal group (B.3.3) 1. SPI Header, 2. DLI Header, 3. FLI Header, 4. redundant on OLI Header	Number of valid sensor-calibratable components (A.5.39)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Sensor-calibratable component (A.5.40)
		Size type: Dynamic/fixed Size #: Number of valid sensor-calibratable components (A.5.39)		
		Sensor-calibratable component (A.5.40)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Sensor calibration status (A.5.41)	M	Default enumerators (B.1.7)
		Calibration process state (A.5.42)	O	Default enumerators (B.1.7)
		Sensor origin point – correction {x, y, z} (A.5.43)	O	
		Sensor origin point – correction {x, y, z} – error (A.5.44)	O	Implementation EM (B.4.1)

LSG	RL LSG M/C/O	Signal	RL Signal M/C/O	Option
		Sensor origin translation – correction limit {x_{begin}, x_{end}, y_{begin}, y_{end}, z_{begin}, z_{end}} (A.5.45)	O	
		Sensor orientation – correction {yaw, pitch, roll} (A.5.46)	O	
		Sensor orientation – correction {yaw, pitch, roll} – error (A.5.47)	O	Implementation EM (B.4.1)
		Sensor pose angle – correction limit {yaw_{begin}, yaw_{end}, $pitch_{begin}$, $pitch_{end}$, $roll_{begin}$, $roll_{end}$} (A.5.48)	O	
Sensor cluster	O Need of logical signal group (B.3.3) 1. SPI Header, 2. Redundant on OLI, FLI and DLI Header	Number of valid sensors (A.5.49)	M	
		Size type: Dynamic/fixed Size #: Number of valid sensors (A.5.49)		
		Sensor ID reference (A.5.50)	M	

10.4.1 Sensor health information header

Table 54 defines the interface header in subclause "Sensor health information header" (10.4.1) and the changes due to the adaptation in comparison to the generic interface header in 10.2.1. The header of the SHII contains only one sensor information entity (see 10.4.2).

Table 54 — Specific signal grouping: Sensor health information header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning (6.4)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning (6.4) Default enumerators (B.1.7)
Number of valid serving sensors (A.1.3)	Mandatory	Profile: Uniqueness of interface versioning (6.4) 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 (6.4) Alternative VRO (B.1.3)
Time stamp – <...> (A.1.5)	Mandatory	
Message counter (A.1.6.2)	Optional	
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)

There is only one global entity in the SHII. Therefore, the sensor provides no list of SHII entities and a signal “Number of valid <…>” (A.1.12) is additionally not provided.

The following LSGs, which normally shall be provided by the sensor as well as the sensor cluster in another interface, may be added to this header, if, for example, the other interface is not implemented by the sensor or sensor cluster (see B.3.3):

— interface: SPI; LSG “Information: vehicle coordinate system” (see Table 51);

— interface: SPI; LSG “Information: sensor pose” (see Table 51).

The following LSGs, which shall be provided by the sensor as well as the sensor cluster in this interface, may be added to another header (see B.3.3):

— interface: SHII; LSG “Calibration” (see Table 53);

— interface: SHII; LSG “Sensor cluster” (see Table 53).

10.4.2 Sensor health information entity

Sensor health information of a sensor describes global sensor statuses and consists of several LSGs. This interface provides only one sensor health information entity for the entire sensor and not a list of entities.

— **Status:** the status describes the global statuses of the sensor.

— **Calibration:** the status describes the statuses and information of the sensor calibration.

— **Sensor cluster:** the sensor cluster defines the set of sensors which defines the sensor cluster.

11 Sensor input interface

11.1 General

The sensor input interface (SII) provides information and parametrisation for a sensor or a sensor cluster. The sensor receives the SIIs via the in-vehicle communication. Each SII can be sent to the sensor or sensor cluster by different ECUs. Also, several ECUs can provide complementary parts of the interface (for example, one ECU provides weather information, and a second ECU provides road information of the CSII). During the system design phase, each received SIIs of a sensor or a sensor cluster and the ECUs that originate these interfaces shall be defined. The information source and the way how the signals are provided shall be defined during the system design phase to meet the safety and system design requirements (for example, that the fusion unit may provide certain SIIs).

11.2 Generic sensor input interface

Table 55 defines the generic structure of a SII.

Table 55 — Generic sensor input interface

Structure	Multiplicity	Option
Generic sensor inputs header (11.2.1)	1	
Generic sensor inputs entity (11.2.2)	1	

11.2.1 Generic sensor inputs header

Table 56 defines the interface header in subclause “Generic sensor inputs header” (11.2.1) and the changes due to the adaptation in comparison to the generic interface header in 6.2.

Table 56 — Specific signal grouping: Generic sensor detections header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning of SII (11.2.3)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning of SII (11.2.3) Default enumerators (B.1.7)
Sender ID (A.1.27)	Mandatory	Profile: Uniqueness of interface versioning of SII (11.2.3)
Time stamp – <...> (A.1.5)	Mandatory	
Message counter (A.1.6.2)	Optional	
Interface cycle time (A.1.7)	Optional	
Interface cycle time – variation (A.1.8)	Optional	
Data qualifier (A.1.9)	Optional	Default enumerators (B.1.7)

11.2.2 Generic sensor inputs entity

Each SII provides only one entity per interface. No generic LSG is defined for the interface entity types of all SIIs.

11.2.3 Profile: Uniqueness of interface versioning of SII

This profile adapts the profile of 6.4. A sensor or sensor cluster may receive this interface more than once (for example, different ECUs). To identify different senders of the SII a signal “Sender ID” (A.1.27) is used.

11.3 Common sensor input interface

The subclause “Common sensor input interface” (11.3) (CSII) provides the generic input of a sensor or sensor cluster.

Table 57 defines the logical structure of the common sensor input interface.

Table 57 — Common sensor input interface

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
Information: interface	M	Interface version ID {major, minor, patch} (A.1.1)	M	Profile: Uniqueness of interface versioning of SII (11.2.3)
		Interface ID (A.1.2)	O	Profile: Uniqueness of interface versioning of SII (11.2.3) Default enumerators (B.1.7)
		Sender ID (A.1.27)	M	Profile: Uniqueness of interface versioning of SII (11.2.3)
		Time stamp – <...> (A.1.5)	M	
		Message counter (A.1.6.2)	O	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Interface cycle time (A.1.7)	O	
		Interface cycle time – variation (A.1.8)	O	
		Data qualifier (A.1.9)	O	Default enumerators (B.1.7)
Sensor operation	O	Sensor operation mode command (A.6.1)	M	Default enumerators (B.1.7)
Environmental information: weather	O	Weather condition (A.6.2)	O	Default enumerators (B.1.7)
		Fog (A.6.3)	O	Default enumerators (B.1.7)
		Precipitation (A.6.4)	O	Default enumerators (B.1.7)
		Number of valid absorption models (A.6.5)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Absorption wavelength (A.6.7)
		Size type: Dynamic/fixed Size #: Number of valid absorption models (A.6.5)		
		Absorption coefficient (A.6.6)	M	
		Absorption wavelength (A.6.7)	M	Alternative VRO (B.1.3) Default enumerators (B.1.7)
		Ambient illumination (A.6.8)	O	Default enumerators (B.1.7)
		Air temperature (A.6.9)	M	
		Air temperature – error (A.6.10)	O	Implementation EM (B.4.1)
		Atmospheric pressure (A.6.11)	O	
		Atmospheric pressure – error (A.6.12)	O	Implementation EM (B.4.1)
		Relative humidity (A.6.13)	O	
		Relative humidity – error (A.6.14)	O	Implementation EM (B.4.1)
Environmental information: time	O	Global time stamp (A.6.15)	M	
Environmental information: road	O	Road type – input level (A.6.16)	M	Default enumerators (B.1.7)
		Road surface temperature (A.6.17)	O	
		Road surface water film (A.6.18)	O	
		Road surface freezing point (A.6.19)	O	
		Road surface ice coverage (A.6.20)	O	
		Road surface classification type – input level (A.6.21)	O	Default enumerators (B.1.7)
		Road surface roughness – input level (A.6.22)	O	

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Road surface condition classification type – input level (A.6.23)	O	Default enumerators (B.1.7)
		Road surface texture – input level (A.6.24)	O	
Vehicle state	O	Vehicle coordinate system type – input level (A.6.25)	M	Optimise IV (B.1.5)
		Vehicle state reference point type (A.6.26)	O	
		Velocity {x, y, z} – input level (A.6.27)	{M, M, O}	
		Velocity {x, y, z} – error – input level (A.6.28)	O	Implementation EM (B.4.1)
		Acceleration {x, y, z} – input level (A.6.29)	O	
		Acceleration {x, y, z} – error – input level (A.6.30)	O	Implementation EM (B.4.1)
		Jerk {x} (A.6.31)	O	
		Jerk {x} – error (A.6.32)	O	Implementation EM (B.4.1)
		Rotation rate {yaw, pitch, roll} – input level (A.6.33)	{M, O, O}	
		Rotation rate {yaw, pitch, roll} – error – input level (A.6.34)	O	Implementation EM (B.4.1)
		Angular wheel position {FLP, FRP, RLP, RRP} (A.6.35)	O	
		Angular wheel velocity {FLP, FRP, RLP, RRP} (A.6.36)	M	
		Angular wheel velocity {FLP, FRP, RLP, RRP} – error (A.6.37)	O	Implementation EM (B.4.1)
		Slip angle {FLP, FRP, RLP, RRP} (A.6.38)	O	
		Active suspension {FLP, FRP, RLP, RRP} (A.6.39)	O	
		Steering angle (A.6.40)	O	
		Steering angle – error (A.6.41)	O	Implementation EM (B.4.1)
		Vehicle global position {latitude, longitude, altitude} (A.6.42)	O	
		Vehicle global position {latitude, longitude, altitude} – error (A.6.43)	O	Implementation EM (B.4.1)
		Vehicle global orientation {yaw, pitch, roll} (A.6.44)	O	
		Wheel rotation direction {FLP, FRP, RLP, RRP} (A.6.45)	O	Default enumerators (B.1.7)

LSG	RL LSG M/C/O	Signal	RL signal M/C/O	Option
		Wheel tick count {FLP, FRP, RLP, RRP} (A.6.46)	O	Redundancy (B.1.2) Signal: Angular wheel position {FLP, FRP, RLP, RRP} (A.6.35) or Angular wheel velocity {FLP, FRP, RLP, RRP} (A.6.36)
		Gear position (A.6.47)	O	Default enumerators (B.1.7)
		Brake activation level (A.6.48)	O	Default enumerators (B.1.7)
		Vehicle motion state (A.6.49)	O	Default enumerators (B.1.7)
Region information	O	Current region (A.6.50)	M	Default enumerators (B.1.7)
		Current traffic flow type (A.6.51)	M	Default enumerators (B.1.7)
Vehicle configuration	O	Trailer type (A.6.52)	O	Default enumerators (B.1.7)
		Park brake state (A.6.53)	O	Default enumerators (B.1.7)
		Vehicle body position {z} (A.6.54)	M	Optimise IV (B.1.5)
		Vehicle body orientation {pitch, roll} (A.6.55)	O	
Sensor pose	O	Sensor origin point {x, y, z} – input level (A.6.56)	M	Optimise IV (B.1.5)
		Sensor orientation {yaw, pitch, roll} – input level (A.6.57)	M	Optimise IV (B.1.5)
PMOI operation	O	Reporting interface PMOI – command (A.6.58.1)	M	Default enumerators (B.1.7)
RDOI operation	O	Reporting interface RDOI – command (A.6.58.2)	M	Default enumerators (B.1.7)
SOI operation	O	Reporting interface SOI – command (A.6.58.3)	M	Default enumerators (B.1.7)
FSAOI operation	O	Reporting interface FSAOI – command (A.6.58.4)	M	Default enumerators (B.1.7)
FLI operation	O	Reporting interface FLI – command (A.6.58.5)	M	Default enumerators (B.1.7)
DLI operation	O	Reporting interface DLI – command (A.6.58.6)	M	Default enumerators (B.1.7)
SPI operation	O	Reporting interface SPI – command (A.6.58.7)	M	Default enumerators (B.1.7)
		Number of valid region-of-interest segments (A.6.59)	O	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Segment azimuth – input level {begin, end} (A.6.60) and Segment elevation – input level {begin, end} (A.6.61)
		Size type: Dynamic/fixed Size #: Number of valid region-of-interest segments (A.6.59)		

LSG	RL LSG M/C/O	Signal		RL signal M/C/O	Option
			Segment azimuth – input level {begin, end} (A.6.60)	O	Alternative VRO (B.1.3)
			Segment elevation – input level {begin, end} (A.6.61)	O	Alternative VRO (B.1.3)
			Resolution type {azimuth, elevation} (A.6.62)	M	Default enumerators (B.1.7)
SHII operation	O	Reporting interface SHII – command (A.6.58.8)		M	Default enumerators (B.1.7)

11.3.1 Common sensor input header

Table 58 defines the interface header in subclause "Common sensor input header" (11.3.1) and the changes due to the adaptation in comparison to the generic sensor inputs header in 11.2.1.

Table 58 — Specific signal grouping: Sensor input header

Signal	RL signal	Option
Interface version ID {major, minor, patch} (A.1.1)	Mandatory	Profile: Uniqueness of interface versioning of SII (11.2.3)
Interface ID (A.1.2)	Optional	Profile: Uniqueness of interface versioning of SII (11.2.3) Default enumerators (B.1.7)
Sender ID (A.1.27)	Mandatory	Profile: Uniqueness of interface versioning of SII (11.2.3)
Time stamp – <...> (A.1.5)	Mandatory	
Message counter (A.1.6.2)	Optional	
Interface cycle time (A.1.7)	Optional	
Interface cycle time – variation (A.1.8)	Optional	
Data qualifier (A.1.9)	Optional	Default enumerators (B.1.7)

The signal "Time stamp – <...>" (A.1.5) shall be defined during the system design phase.

11.3.2 Common sensor input entity

The common sensor input for a sensor describes global ego-vehicle information and requests sensor parameterisation for the interfaces and consists of several LSGs. This interface provides only one common sensor input entity for the entire sensor and not a list of entities.

— **Sensor operation:** the sensor operation defines the global operation mode for the sensor.

— **Environmental information:** the environmental information weather, time and road describe the dynamic environmental information for the ego-vehicle.

— **Vehicle state:** the vehicle state describes the dynamic states of the ego-vehicle.

— **Region information:** the region information describes the geographical region in which the ego-vehicle is currently driving.

— **Vehicle configuration:** the vehicle configuration describes the ego-vehicle and the attached trailer to the ego-vehicle.

— **Sensor pose:** the sensor pose describes the sensor coordinate system in the ego-vehicle coordinate system.

— **<Interface> operation:** the <interface> operation defines operation mode for each of the sensor's interfaces and provides additional parametrisations (for example, the LSG "SPI operation" defines the resolution type for field-of-view segments).

Annex A
(normative)

Interface signals

A.1 Header signals

Interface header specific signals are defined in this subclause (see Table A.1-Table A.67). If different definitions are required for different interfaces, the interface-specific signal is defined in a subclause, for example, the signal "Time stamp – <...>" (A.1.5) and the specific signal "Time stamp – prediction" (A.1.5.1).

A.1.1 Interface version ID {major, minor, patch}

Table A.1 — Signal: Interface version ID {major, minor, patch}

Name	Interface version ID {major, minor, patch}		
Description	The signal "Interface version ID {major, minor, patch}" (A.1.1) provides the version information of the interface. Requirement: The signal "Interface version ID {major, minor, patch}" (A.1.1) is assigned in the system design phase.		
Value type	3D vector value	**Unit**	(1, 1, 1)

A.1.2 Interface ID

Table A.2 — Signal: Interface ID

Name	Interface ID		
Description	The signal "Interface ID" (A.1.2) is used to uniquely identify the originated interface type of the message. Additional information: The enumerators may differentiate the sensor's sensor technology. The signal "Interface ID" (A.1.2) is necessary, for example, for a service-oriented architecture.		
Value type	enumeration	**Unit**	1

Table A.3 — Enumeration: Interface ID – Example enumerators

Name	**Description**	**RL enumerator**
IID_PotentiallyMovingObjects	The message was sent by PMOI.	"exemplary"
IID_RoadObjects	The message was sent by RDOI.	"exemplary"
IID_StaticObjects	The message was sent by SOI.	"exemplary"
IID_FreeSpaceAreaObjects	The message was sent by FSAOI.	"exemplary"
IID_CameraFeatures	The message was sent by the sensor technology specific FLI. The sensor or sensor cluster uses camera sensing elements.	"exemplary"

IID_UltrasonicFeatures	The message was sent by the sensor technology specific FLI. The sensor or sensor cluster uses ultrasonic sensing elements.	“exemplary”
IID_RadarDetections	The message was sent by the sensor technology specific DLI. The sensor or sensor cluster uses radar sensing elements.	“exemplary”
IID_LidarDetections	The message was sent by the sensor technology specific DLI. The sensor or sensor cluster uses lidar sensing elements.	“exemplary”
IID_CameraDetections	The message was sent by the sensor technology specific DLI. The sensor or sensor cluster uses camera sensing elements.	“exemplary”
IID_UltrasonicDetections	The message was sent by the sensor technology specific DLI. The sensor or sensor cluster uses ultrasonic sensing elements.	“exemplary”
IID_SensorPerformance	The message was sent by SPI.	“exemplary”
IID_SensorHealthInformation	The message was sent by SHII.	“exemplary”
IID_CommonSensorInput	The message is sent to the sensor or sensor cluster as input for the sensor.	“exemplary”

A.1.3 Number of valid serving sensors

Table A.4 — Signal: Number of valid serving sensors

Name	Number of valid serving sensors		
Description	The signal “Number of valid serving sensors” (A.1.3) provides the number of valid sensors serving the interface.		
Value type	[0…] integer value	**Unit**	1

A.1.4 Sensor ID

Table A.5 — Signal: Sensor ID

Name	Sensor ID		
Description	The signal “Sensor ID” (A.1.4) which uniquely identifies the sensor and link the data of different sensors’ interfaces. Additional information: It is required to associate the logical interfaces of one sensor or a sensor cluster with its sensors. Each signal “Sensor ID” (A.1.4) value shall serve independently at least one interface. The signal “Sensor ID” (A.1.4) is necessary, for example, for a service-oriented architecture. Requirement: The signal's “Sensor ID” (A.1.4) value is assigned during the system design phase.		
Value type	integer value	**Unit**	1

A.1.5 Time stamp – <...>

The time stamp is defined depending on the level of the interface. It is either the most consistent time of the measurement or the predicted time at which the message is consistent. An additional time stamp difference specifies an individual measurement point with a time offset of each entity relative to the time stamp of the message. The time stamps can also be used to link the data of different interfaces of a sensor cluster.

A.1.5.1 Time stamp – prediction

Table A.6 — Signal: Time stamp – prediction

Name	Time stamp – prediction		
Description	The signal "Time stamp – prediction" (A.1.5.1) provides the time stamp at which the entities of the interface are consistent (not the time at which it was processed or at which it is transmitted) in the vehicle-global synchronised time. Clock synchronisation shall be ensured, depending on bus technology. Additional information: The time stamp that was used for the prediction or tracking. Specifically, the time stamp can be the same as or differ from the base time stamp(s) of the, for example, underlying detection or feature's entity list(s). The signal is used for tracked or predicted quantity values. Time stamps are consistent for all vehicle electronic control units (ECUs).		
Value type	real value	**Unit**	s

A.1.5.2 Time stamp – measurement

Table A.7 — Signal: Time stamp – measurement

Name	Time stamp – measurement		
Description	The signal "Time stamp – measurement" (A.1.5.2) provides the time stamp at which the measurement was taken (not the time at which it was processed or at which it is transmitted) in the vehicle-global synchronised time. Clock synchronisation shall be ensured, depending on bus technology. Additional information: The signal's "Time stamp – measurement" (A.1.5.2) value shall be selected so that it is as consistent as possible with the measured entities and the associated time error is minimum. Each entity of a detection list may have, for example, the signal "Time stamp difference – detection level" (A.4.5) for its measurement (for example, for integrating sensor technologies). In case of a continuous or a subdivided measurement cycle, the signal "Time stamp difference – detection level" (A.4.5) shall be used to differentiate the real measured point in time of the entity acquisition. Time stamps are consistent for all vehicle electronic control units (ECUs).		
Value type	real value	**Unit**	s

A.1.6 <...> counter

A continuous value that defines the order of the logical interface's messages. The logical interface messages may be sent cyclically or non-cyclically, for example, event triggered.

A.1.6.1 Cycle counter

Table A.8 — Signal: Cycle counter

Name	Cycle counter		
Description	The signal “Cycle counter” (A.1.6.1) provides the continuous up counter to identify the message cycle of the interface. It counts up per every cycle of a complete prediction, tracking or a single measurement. Additional information: This information can be determined from signal’s “Time stamp – <…>” (A.1.5) value and the sensor’s cycle period [see the signal “Interface cycle time” (A.1.7) and “Interface cycle time – variation” (A.1.8)]. Each sensor as well as each sensor cluster uses a local sensor cycle counter per interface.		
Value type	[0…] integer value	**Unit**	1

A.1.6.2 Message counter

Table A.9 — Signal: Message counter

Name	Message counter		
Description	The signal “Message counter” (A.1.6.2) provides the continuous up counter to identify the message sequence of the interface. It counts up per every sent message. Additional information: Interfaces with a signal “Message counter” (A.1.6.2) may send messages non-cyclical, for example, event triggered. Each sensor as well as each sensor cluster uses a local sensor message counter per interface.		
Value type	[0…] integer value	**Unit**	1

A.1.7 Interface cycle time

Table A.10 — Signal: Interface cycle time

Name	Interface cycle time		
Description	The signal “Interface cycle time” (A.1.7) provides the representative cycle time of the interface’s messages. Normally, each interface sends the complete interface message cyclically. The period between two messages can vary. Each interface header defines the interface’s cycle time and the variation of the cycle time [see signal “Interface cycle time – variation” (A.1.8)]. Additional information: If the signal “Interface cycle time – variation” (A.1.8) is 100 %, the message is sent in the case one or several signals have changed their value.		
Value type	[0…] real value	**Unit**	s

A.1.8 Interface cycle time – variation

Table A.11 — Signal: Interface cycle time – variation

Name	Interface cycle time – variation

Description	The signal “Interface cycle time – variation” (A.1.8) provides the possible variation of the expected representative cycle time [see signal “Interface cycle time” (A.1.7)] of the interface’s messages. Additional information: If the signal “Interface cycle time – variation” (A.1.8) is 100 %, the message is sent in the case one or several signals have changed their value, for example, the possible, allowed cycle time for the next cycle: 0 s ≤ next cycle time ≤ infinity s. This may indicate that the next cycle is triggered by an event. EXAMPLE The duration between two sequentially sent messages of an interface is in the range [interface cycle time × (1 - interface cycle time variation / 100 %), interface cycle time / (1 - interface cycle time variation / 100 %)].		
Value type	[0…] real value	**Unit**	%

A.1.9 Data qualifier

Table A.12 — Signal: Data qualifier

Name	Data qualifier		
Description	The signal “Data qualifier” (A.1.9) expresses whether the content of the entity list(s) of the interface can be used or not. It can change dynamically over time and inform about temporal restrictions.		
Value type	enumeration	**Unit**	1

Table A.13 — Enumeration: Data qualifier – Example enumerators

Name	Description	RL enumerator
DQ_Normal	The entities and information of the interface can be used without restrictions.	“exemplary”
DQ_NotAvailable	The entities and information of the interface are not available.	“exemplary”
DQ_ReduceInCoverage	The entities are not complete due to a restricted coverage (for example, restricted view).	“exemplary”
DQ_ReduceInPerformance	The entities are not complete due to a restricted performance.	“exemplary”
DQ_ReduceInCoverageAndPerformance	The entities are not complete due to a restricted coverage and restricted performance.	“exemplary”
DQ_TestMode	The sensor or the sensor cluster is running in test mode and outputs differ from normal operation mode.	“exemplary”
DQ_Invalid	The measurement, tracking or prediction cycle was invalid, no predicted, tracked or measured entity will be transferred.	“exemplary”

A.1.10Recognised <...> – capability

The performance of the sensor as well as the sensor cluster determines how many entities the sensor cluster’s interface can recognise (except SHII), for example, at full load. For example, a value of 0 informs that the sensor may not recognise any object/feature/detection at the moment.

A.1.10.1 Recognised potentially moving objects – capability

Table A.14 — Signal: Recognised potentially moving objects – capability

Name	Recognised potentially moving objects – capability		
Description	The signal "Recognised potentially moving objects – capability" (A.1.10.1) provides the performance of the sensor cluster's interface. It determines how many entities the sensor cluster is guaranteed to recognise, for example, at full load with respect to the current scenario.		
Value type	[0…] integer value	**Unit**	1

A.1.10.2 Recognised road markings – capability

Table A.15 — Signal: Recognised road markings – capability

Name	Recognised road markings – capability		
Description	The signal "Recognised road markings – capability" (A.1.10.2) provides the performance of the sensor cluster's interface. It determines how many entities the sensor cluster is guaranteed to recognise, for example, at full load with respect to the current scenario.		
Value type	[0…] integer value	**Unit**	1

A.1.10.3 Recognised road boundaries – capability

Table A.16 — Signal: Recognised road boundaries – capability

Name	Recognised road boundaries – capability		
Description	The signal "Recognised road boundaries – capability" (A.1.10.3) provides the performance of the sensor cluster's interface. It determines how many entities the sensor cluster is guaranteed to recognise, for example, at full load with respect to the current scenario.		
Value type	[0…] integer value	**Unit**	1

A.1.10.4 Recognised general landmarks – capability

Table A.17 — Signal: Recognised general landmarks – capability

Name	Recognised general landmarks – capability		
Description	The signal "Recognised general landmarks – capability" (A.1.10.4) provides the performance of the sensor cluster's interface. It determines how many entities the sensor cluster is guaranteed to recognise, for example, at full load with respect to the current scenario.		
Value type	[0…] integer value	**Unit**	1

A.1.10.5 Recognised traffic signs – capability

Table A.18 — Signal: Recognised traffic signs – capability

Name	Recognised traffic signs – capability		
Description	The signal "Recognised traffic signs – capability" (A.1.10.5) provides the performance of the sensor cluster's interface. It determines how many entities the sensor cluster is guaranteed to recognise, for example, at full load with respect to the current scenario.		
Value type	[0…] integer value	**Unit**	1

A.1.10.6 Recognised traffic sign boards – capability

Table A.19 — Signal: Recognised traffic sign boards – capability

Name	Recognised traffic sign boards – capability		
Description	The signal “Recognised traffic sign boards – capability” (A.1.10.6) provides the performance of the sensor cluster’s interface. It determines how many entities the sensor cluster is guaranteed to recognise, for example, at full load with respect to the current scenario.		
Value type	[0…] integer value	**Unit**	1

A.1.10.7 Recognised traffic lights – capability

Table A.20 — Signal: Recognised traffic lights – capability

Name	Recognised traffic lights – capability		
Description	The signal “Recognised traffic lights – capability” (A.1.10.7) provides the performance of the sensor cluster’s interface. It determines how many entities the sensor cluster is guaranteed to recognise, for example, at full load with respect to the current scenario.		
Value type	[0…] integer value	**Unit**	1

A.1.10.8 Recognised free space areas – capability

Table A.21 — Signal: Recognised free space areas – capability

Name	Recognised free space areas – capability		
Description	The signal “Recognised free space areas – capability” (A.1.10.8) provides the performance of the sensor cluster’s interface. It determines how many entities the sensor cluster is guaranteed to recognise, for example, at full load with respect to the current scenario.		
Value type	[0…] integer value	**Unit**	1

A.1.10.9 Recognised features – capability

Table A.22 — Signal: Recognised features – capability

Name	Recognised features – capability		
Description	The signal “Recognised features – capability” (A.1.10.9) provides the performance of the sensor cluster’s interface. It determines how many entities the sensor cluster is guaranteed to recognise, for example, at full load with respect to the current scenario.		
Value type	[0…] integer value	**Unit**	1

A.1.10.10 Recognised detections – capability

Table A.23 — Signal: Recognised detections – capability

Name	Recognised detections – capability		
Description	The signal “Recognised detections – capability” (A.1.10.10) provides the performance of the sensor cluster’s interface. It determines how many entities the sensor cluster is guaranteed to recognise, for example, at full load with respect to the current scenario.		
Value type	[0…] integer value	**Unit**	1

A.1.10.11 Recognised shapes – capability

Table A.24 — Signal: Recognised shapes – capability

Name	Recognised shapes – capability		
Description	The signal “Recognised shapes – capability” (A.1.10.11) provides the performance of the sensor cluster’s interface. It determines how many entities the sensor cluster is guaranteed to recognise, for example, at full load with respect to the current scenario.		
Value type	[0…] integer value	**Unit**	1

A.1.11Recognised <…> – status

The performance of the sensor cluster’s interface determines a state of the recognition process under, for example, full load (except SHII).

All adaptions of the signal use the same list of example enumerators.

Table A.25 — Enumeration: Recognised <…> – status – Example enumerators

Name	Description	RL enumerator
R<…>S_Normal	The performance of the sensor’s or the sensor cluster’s interface is enough to process all recognised entities.	“exemplary”
R<…>S_PreLimits	The performance of the sensor’s or the sensor cluster’s interface is close to the limits to process all recognised entities.	“exemplary”
R<…>S_Limits	The performance of the sensor’s or the sensor cluster’s interface is not enough to process all recognised entities.	“exemplary”

A.1.11.1 Recognised potentially moving objects – status

Table A.26 — Signal: Recognised potentially moving objects – status

Name	Recognised potentially moving objects – status		
Description	The signal “Recognised potentially moving objects – status” (A.1.11.1) determines whether the sensor cluster’s interface can process all recognised entities or whether it works at the sensor cluster’s performance limits.		
Value type	enumeration	**Unit**	1

A.1.11.2 Recognised road markings – status

Table A.27 — Signal: Recognised road markings – status

Name	Recognised road markings – status		
Description	The signal “Recognised road markings – status” (A.1.11.2) determines whether the sensor cluster’s interface can process all recognised entities or whether it works at the sensor cluster’s performance limits.		
Value type	enumeration	**Unit**	1

A.1.11.3 Recognised road boundaries – status

Table A.28 — Signal: Recognised road boundaries – status

Name	Recognised road boundaries – status

Description	The signal "Recognised road boundaries – status" (A.1.11.3) determines whether the sensor cluster's interface can process all recognised entities or whether it works at the sensor cluster's performance limits.		
Value type	enumeration	**Unit**	1

A.1.11.4 Recognised general landmarks – status

Table A.29 — Signal: Recognised general landmarks – status

Name	Recognised general landmarks – status		
Description	The signal "Recognised general landmarks – status" (A.1.11.4) determines whether the sensor cluster's interface can process all recognised entities or whether it works at the sensor cluster's performance limits.		
Value type	enumeration	**Unit**	1

A.1.11.5 Recognised traffic signs – status

Table A.30 — Signal: Recognised traffic signs – status

Name	Recognised traffic signs – status		
Description	The signal "Recognised traffic signs – status" (A.1.11.5) determines whether the sensor cluster's interface can process all recognised entities or whether it works at the sensor cluster's performance limits.		
Value type	enumeration	**Unit**	1

A.1.11.6 Recognised traffic sign boards – status

Table A.31 — Signal: Recognised traffic sign boards – status

Name	Recognised traffic sign boards – status		
Description	The signal "Recognised traffic sign boards – status" (A.1.11.6) determines whether the sensor cluster's interface can process all recognised entities or whether it works at the sensor cluster's performance limits.		
Value type	enumeration	**Unit**	1

A.1.11.7 Recognised traffic lights – status

Table A.32 — Signal: Recognised traffic lights – status

Name	Recognised traffic lights – status		
Description	The signal "Recognised traffic lights – status" (A.1.11.7) determines whether the sensor cluster's interface can process all recognised entities or whether it works at the sensor cluster's performance limits.		
Value type	enumeration	**Unit**	1

A.1.11.8 Recognised free space areas – status

Table A.33 — Signal: Recognised free space areas – status

Name	Recognised free space areas – status
Description	The signal "Recognised free space areas – status" (A.1.11.8) determines whether the sensor cluster's interface can process all recognised entities or whether it works at the sensor cluster's performance limits.

Value type	enumeration	**Unit**	1

A.1.11.9 Recognised features – status

Table A.34 — Signal: Recognised features – status

Name	Recognised features – status		
Description	The signal "Recognised features – status" (A.1.11.9) determines whether the sensor cluster's interface can process all recognised entities or whether it works at the sensor cluster's performance limits.		
Value type	enumeration	**Unit**	1

A.1.11.10 Recognised detections – status

Table A.35 — Signal: Recognised detections – status

Name	Recognised detections – status		
Description	The signal "Recognised detections – status" (A.1.11.10) determines whether the sensor cluster's interface can process all recognised entities or whether it works at the sensor cluster's performance limits.		
Value type	enumeration	**Unit**	1

A.1.11.11 Recognised shapes – status

Table A.36 — Signal: Recognised shapes – status

Name	Recognised shapes – status		
Description	The signal "Recognised shapes – status" (A.1.11.11) determines whether the sensor cluster's interface can process all recognised entities or whether it works at the sensor cluster's performance limits.		
Value type	enumeration	**Unit**	1

A.1.12 Number of valid <...>

Each interface (except SHII) sends one or more lists of entities with defined entity types. For each list, the number of valid transferred entities is known.

A.1.12.1 Number of valid potentially moving objects

Table A.37 — Signal: Number of valid potentially moving objects

Name	Number of valid potentially moving objects		
Description	The signal's "Number of valid potentially moving objects" (A.1.12.1) value defines the number of valid entities in the potentially moving object list of the PMOI. Additional information: The entries in the list may or may not be sorted. All those entities of the list which can be used by the fusion unit are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal's "Time stamp – <...>" (A.1.5) value and not only a differential list between two sequential time stamps.		
Value type	[0...] integer value	**Unit**	1

A.1.12.2 Number of valid road markings

Table A.38 — Signal: Number of valid road markings

Name	Number of valid road markings		
Description	The signal’s “Number of valid road markings” (A.1.12.2) value defines the number of valid entities in the road marking list of the RDOI. Additional information: The entries in the list may or may not be sorted. All those entities of the list which can be used by the fusion unit are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal’s “Time stamp – <…>” (A.1.5) value and not only a differential list between two sequential time stamps. Each road marking has polynomial or polyline, for example, containing ≥ 2 vertices.		
Value type	[0…] integer value	**Unit**	1

A.1.12.3 Number of valid road boundaries

Table A.39 — Signal: Number of valid road boundaries

Name	Number of valid road boundaries		
Description	The signal’s “Number of valid road boundaries” (A.1.12.3) value defines the number of valid entities in the road boundary list of the RDOI. Additional information: The entries in the list may or may not be sorted. All those entities of the list which can be used by the fusion unit are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal’s “Time stamp – <…>” (A.1.5) value and not only a differential list between two sequential time stamps. Each road boundary has polynomial or polyline, for example, containing ≥ 2 vertices.		
Value type	[0…] integer value	**Unit**	1

A.1.12.4 Number of valid general landmarks

Table A.40 — Signal: Number of valid general landmarks

Name	Number of valid general landmarks		
Description	The signal’s “Number of valid general landmarks” (A.1.12.4) value defines the number of valid entities in the general landmark list of the SOI. Additional information: The entries in the list may or may not be sorted. All those entities of the list which can be used by the fusion unit are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal’s “Time stamp – <…>” (A.1.5) value and not only a differential list between two sequential time stamps.		
Value type	[0…] integer value	**Unit**	1

A.1.12.5 Number of valid traffic signs

Table A.41 — Signal: Number of valid traffic signs

Name	Number of valid traffic signs		
Description	The signal's "Number of valid traffic signs" (A.1.12.5) value defines the number of valid entities in the traffic sign list of the SOI. Additional information: The entries in the list may or may not be sorted. All those entities of the list which can be used by the fusion unit are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal's "Time stamp – <…>" (A.1.5) value and not only a differential list between two sequential time stamps.		
Value type	[0…] integer value	**Unit**	1

A.1.12.6 Number of valid traffic sign boards

Table A.42 — Signal: Number of valid traffic sign boards

Name	Number of valid traffic sign boards		
Description	The signal's "Number of valid traffic sign boards" (A.1.12.6) value defines the number of valid entities in the traffic sign board list of the SOI. Additional information: The entries in the list may or may not be sorted. All those entities of the list which can be used by the fusion unit are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal's "Time stamp – <…>" (A.1.5) value and not only a differential list between two sequential time stamps.		
Value type	[0…] integer value	**Unit**	1

A.1.12.7 Number of valid traffic lights

Table A.43 — Signal: Number of valid traffic lights

Name	Number of valid traffic lights		
Description	The signal's "Number of valid traffic lights" (A.1.12.7) value defines the number of valid entities in the traffic light list of the SOI. Additional information: The entries in the list may or may not be sorted. All those entities of the list which can be used by the fusion unit are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal's "Time stamp – <…>" (A.1.5) value and not only a differential list between two sequential time stamps.		
Value type	[0…] integer value	**Unit**	1

A.1.12.8 Number of valid free space areas

Table A.44 — Signal: Number of valid free space areas

Name	Number of valid free space areas

Description	The signal's "Number of valid free space areas" (A.1.12.8) value defines the number of valid entities in the free space area list of the FSAOI. Additional information: The entries in the list may or may not be sorted. All those entities of the list which can be used by the fusion unit are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal's "Time stamp – <…>" (A.1.5) value and not only a differential list between two sequential time stamps.		
Value type	[0…] integer value	**Unit**	1

A.1.12.9 Number of valid features

Table A.45 — Signal: Number of valid features

Name	Number of valid features		
Description	The signal's "Number of valid features" (A.1.12.9) value defines the number of valid entities in the feature list of an FLI. One measurement can generate not only unique features, if there are, for example, ambiguities in camera shape or colour classification. Additional information: The entries in the list may or may not be sorted. All those entities of the list which can be used by the fusion unit are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal's "Time stamp – <…>" (A.1.5) value and not only a differential list between two sequential time stamps.		
Value type	[0…] integer value	**Unit**	1

A.1.12.10 Number of valid detections

Table A.46 — Signal: Number of valid detections

Name	Number of valid detections		
Description	The signal's "Number of valid detections" (A.1.12.10) value defines the number of valid entities in the detection list of a DLI. One measurement can generate more than one similar detection, if there are ambiguities. Additional information: The entries in the list may or may not be sorted. All those entities of the list which can be used by the fusion unit are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal's "Time stamp – <…>" (A.1.5) value and not only a differential list between two sequential time stamps.		
Value type	[0…] integer value	**Unit**	1

A.1.12.11 Number of valid shapes

Table A.47 — Signal: Number of valid shapes

Name	Number of valid shapes

Description	The signal's "Number of valid shapes" (A.1.12.11) value defines the number of valid entities in the detection list of the CDI or CFI. Additional information: The entries in the list may or may not be sorted. All those entities of the list which can be used by the fusion unit are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal's "Time stamp – <...>" (A.1.5) value and not only a differential list between two sequential time stamps.		
Value type	[0…] integer value	**Unit**	1

A.1.12.12 Number of valid field-of-view segments

Table A.48 — Signal: Number of valid field-of-view segments

Name	Number of valid field-of-view segments		
Description	The signal's "Number of valid field-of-view segments" (A.1.12.12) value defines the number of FOVs sensor- or sensor cluster-segments of the SPI. Additional information: The entries in the list may or may not be sorted. All those entities of the list which can be used by the fusion unit are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal's "Time stamp – <...>" (A.1.5) value and not only a differential list between two sequential time stamps.		
Value type	[0…] integer value	**Unit**	1

A.1.13 Motion type

Table A.49 — Signal: Motion type

Name	Motion type		
Description	The signal "Motion type" (A.1.13) provides the applied motion type of the interface's motion signals.		
Value type	enumeration	**Unit**	1

Table A.50 — Enumeration: Motion type – Example enumerators

Name	Description	RL enumerator
MT_Relative	The interface sends relative motion values of the object described in ego-vehicle coordinate system {x, y, z}.	"exemplary"
MT_Absolute	The interface sends absolute motion values of the object in world coordinate reference system, using the ego-vehicle axis system {x, y, z}.	"exemplary"

A.1.14 Colour model type

Table A.51 — Signal: Colour model type

Name	Colour model type

Description	The signal “Colour model type” (A.1.14) provides the applied colour model for the colour signals of the interface. Additional information: The signal “Colour model type” (A.1.14) defines also the number of elements for the signal “Colour values” (see A.2.100, A.3.12, A.4.29).		
Value type	enumeration	**Unit**	1

Table A.52 — Enumeration: Colour model type – Example enumerators

Name	**Description**	**RL enumerator**
CMT_Grey	The colour type is grey scale, and 1 colour value is provided.	“exemplary”
CMT_RGB	The colour type is red, green, blue and 3 colour values are provided.	“exemplary”
CMT_HSV	The colour type is hue, saturation, value and 3 colour values are provided.	“exemplary”
CMT_LUV	The colour type is luminance and colour coordinates U, V and 3 colour values are provided.	“exemplary”
CMT_RGBIR	The colour type is red, green, blue, infrared and 4 colour values are provided.	“exemplary”
CMT_ColourList	Each value references a predefined colour and 1 colour value for reference values is provided. Requirement: By using the enumerator “CMT_ColourList” the signal’s “Colour values” (see A.2.100, A.3.12, A.4.29) values are defined during the system design phase.	“exemplary”

A.1.15 Radial velocity ambiguity domain {begin, end}

Table A.53 — Signal: Radial velocity ambiguity domain {begin, end}

Name	Radial velocity ambiguity domain {begin, end}		
Description	The signal “Radial velocity ambiguity domain {begin, end}” (A.1.15) provides a description of the Doppler ambiguity caused by under-sampling.		
Value type	2D vector real value	**Unit**	(m/s, m/s)

A.1.16 Range ambiguity domain {begin, end}

Table A.54 — Signal: Range ambiguity domain {begin, end}

Name	Range ambiguity domain {begin, end}		
Description	The range of the ambiguity domain is defined by {begin} and {end}. The defined range is only one possible solution for an ambiguous measurement method (for example, under-sampling).		
Value type	2D vector real value	**Unit**	(m, m)

A.1.17 Angle azimuth ambiguity domain {begin, end}

Table A.55 — Signal: Angle azimuth ambiguity domain {begin, end}

Name	Angle azimuth ambiguity domain {begin, end}		
Description	The azimuth angle of the ambiguity domain is defined by {begin} and {end}. The defined azimuth angle is only one possible solution for an ambiguous measurement method.		
Value type	2D vector real value	**Unit**	(rad, rad)

A.1.18 Angle elevation ambiguity domain {begin, end}

Table A.56 — Signal: Angle elevation ambiguity domain {begin, end}

Name	Angle elevation ambiguity domain {begin, end}		
Description	The elevation angle of the ambiguity domain is defined by {begin} and {end}. The defined elevation angle is only one possible solution for an ambiguous measurement method.		
Value type	2D vector real value	**Unit**	(rad, rad)

A.1.19 Interface applicability

Table A.57 — Signal: Interface applicability

Name	Interface applicability		
Description	The signal “Interface applicability” (A.1.19) defines the interface(s) for which the message is relevant for. The implementation of the interface may provide several interfaces with different signal’s “Interface applicability” (A.1.19) enumerators. Additional information: The signal “Interface applicability” (A.1.19) is necessary, for example, for a service-oriented architecture.		
Value type	enumeration	**Unit**	1

Table A.58 — Enumeration: Interface applicability – Example enumerators

Name	**Description**	**RL enumerator**
IA_OLI	The applicability of the interface is for all OLIs.	“exemplary”
IA_FLI	The applicability of the interface is for the FLI.	“exemplary”
IA_DLI	The applicability of the interface is for the DLI.	“exemplary”
IA_FLIAndDLI	The applicability of the interface is for FLI and DLI.	“exemplary”
IA_PMOI	The applicability of the interface is for the PMOI.	“exemplary”
IA_RDOI	The applicability of the interface is for the RDOI.	“exemplary”
IA_SOI	The applicability of the interface is for the SOI.	“exemplary”
IA_FSAOI	The applicability of the interface is for the FSAOI.	“exemplary”
IA_All	The applicability of the interface is for all provided interfaces.	“exemplary”

A.1.20 Vehicle coordinate system type – header

Table A.59 — Signal: Vehicle coordinate system type – header

Name	Vehicle coordinate system type – header

Description	The signal “Vehicle coordinate system type – header” (A.1.20) defines the reference vehicle coordinate system for the interfaces of the sensor cluster.		
Value type	enumeration	**Unit**	1

Table A.60 — Enumeration: Vehicle coordinate system type – header

Name	**Description**	**RL enumerator**
VCST_RearAxle	Use definition “vehicle rear-axle coordinate system” (3.7.12) for the ego-vehicle coordinate system of the sensor or sensor cluster.	Mandatory
VCST_RoadLevel	Use definition “vehicle road-level coordinate system” (3.7.15) for the ego-vehicle coordinate system of the sensor or sensor cluster.	Mandatory

A.1.21 Sensor origin point {x, y, z} – header

Table A.61 — Signal: Sensor origin point {x, y, z} – header

Name	Sensor origin point {x, y, z} – header		
Description	The signal “Sensor origin point {x, y, z} – header” (A.1.21) provides the position of the origin of the sensing element’s sensor coordinate system in the ego-vehicle coordinate system [see signal “Vehicle coordinate system type – header” (A.1.20)]. Additional information: The signal “Sensor origin point – correction {x, y, z}” (A.5.43) is already applied.		
Value type	3D vector real value	**Unit**	(m, m, m)

A.1.22 Sensor origin point {x, y, z} – error

Table A.62 — Signal: Sensor origin point {x, y, z} – error

Name	Sensor origin point {x, y, z} – error		
Description	The uncertainty of the sensor origin point calibration should be included in the interface {x, y, z}. Additional information: If only the trueness error [see "Error model implementation" (B.4.1) and "Multiple error value types" (B.4.1.3.2)] in the overall system is known, the sensor origin point error shall not be sent. No high dynamic motion of the ego-vehicle is compensated by the signal. The signal “Sensor origin point – correction {x, y, z} – error” (A.5.44) is already applied.		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Sensor origin point {x, y, z} – header” (A.1.21).

A.1.23 Sensor orientation {yaw, pitch, roll} – header

Table A.63 — Signal: Sensor orientation {yaw, pitch, roll} – header

Name	Sensor orientation {yaw, pitch, roll} – header

Description	The signal "Sensor orientation {yaw, pitch, roll} – header" (A.1.23) provides the relative orientation of the sensor axis system with respect to the ego-vehicle axis system [see signal "Vehicle coordinate system type – header" (A.1.20)]. The sensor orientation represents the current orientation of the sensor origin point to the best knowledge. It includes the pose estimation given by the calibration. The uncertainty of this estimation is given with the corresponding error. The estimation does not include effects due to short-time dynamics, such as pitch angle changes during braking, but can include long-time effects resulting from, for example, luggage in the trunk. Additional information: The signal "Sensor orientation {yaw, pitch, roll} – header" (A.1.23) is given with {yaw, pitch, roll} angles, which have to be separated in a defined procedure. For example, the rotations are to be performed yaw first (around the *Z*-axis), pitch second (around the new *Y*-axis) and roll third (around the new *X*-axis) following the definition according to ISO 8855:2011. The signal "Sensor orientation – correction {yaw, pitch, roll}" (A.5.46) is already applied.		
Value type	3D vector real value	**Unit**	(rad, rad, rad)

A.1.24 Sensor orientation {yaw, pitch, roll} – error

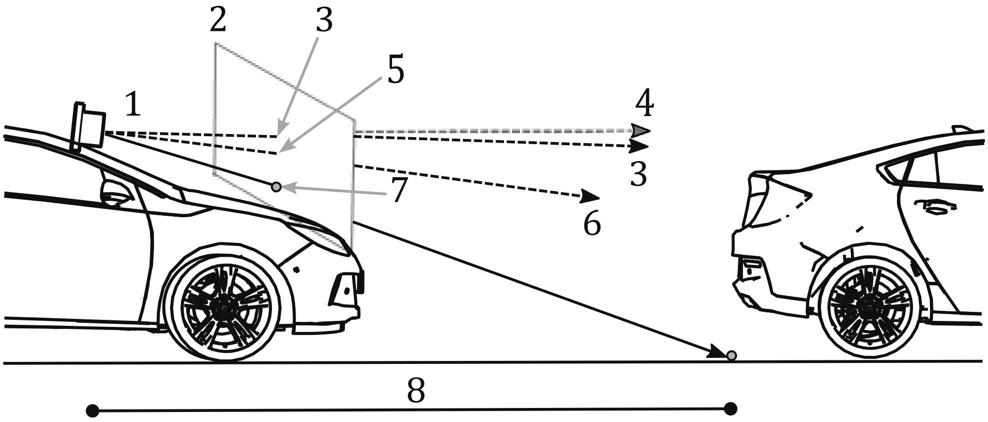
Table A.64 — Signal: Sensor orientation {yaw, pitch, roll} – error

Name	Sensor orientation {yaw, pitch, roll} – error		
Description	The uncertainty of the sensor orientation calibration should be included in the interface {yaw, pitch, roll}. Additional information: If only the trueness error in the overall system is known, the sensor orientation error shall not be sent. No high dynamic motion of the ego-vehicle is compensated by the signal. The signal "Sensor orientation – correction {yaw, pitch, roll} – error" (A.5.47) is already applied.		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Sensor orientation {yaw, pitch, roll} – header" (A.1.23).

A.1.25 Vanishing point {azimuth, elevation}

Table A.65 — Signal: Vanishing point {azimuth, elevation}

Name	Vanishing point {azimuth, elevation}		
Description	A set of lines in the image plane that corresponds to a set of parallel surface lines in the 3D world space converges to a common point in the image space, known as the signal "Vanishing point {azimuth, elevation}" (A.1.25). Additional information: Figure A.1 shows the distance estimation using the vanishing point.		
Value type	2D vector real value	**Unit**	(rad, rad)



Key

1 camera sensor
2 image plane (enlarged)
3 vanishing point
4 ego-vehicle *X*-axis direction
5 image centre of the camera sensor
6 optical axis of the camera
7 image of a point on road level of the camera sensor
8 distance of a recognised entity (in *X*-axis direction of the ego-vehicle coordinate system)

Figure A.1 — Example for distance estimation

A.1.26 Vanishing point {azimuth, elevation} – error

Table A.66 — Signal: Vanishing point {azimuth, elevation} – error

Name	Vanishing point {azimuth, elevation} – error		
Description	The signal “Vanishing point {azimuth, elevation} – error” (A.1.26) provides the uncertainty of the signal “Vanishing point {azimuth, elevation}” (A.1.25).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Vanishing point {azimuth, elevation}” (A.1.25).

A.1.27 Sender ID

Table A.67 — Signal: Sender ID

Name	Sender ID		
Description	The signal “Sender ID” (A.1.27) uniquely identifies the sender (for example, an ECU) and connects the data of different senders’ interfaces and merges the data.		
Value type	integer value	**Unit**	1

A.2 Object level entity signals

Signals are defined for the entities of subclauses 7.3-7.6 in this subclause (see Table A.68-Table A.336). These interfaces are located at OLI.

Normally, the OLI originates from several sensors. Therefore, at object level, the term sensor cluster is always used, even if a single sensor is serving the interface.

A.2.1 Existence probability – object level

Table A.68 — Signal: Existence probability – object level

Name	Existence probability – object level		
Description	The signal “Existence probability – object level” (A.2.1) represents the recognition quality and sensor’s certainty that the object exists. A higher value indicates an object which is more certain to exist while a lower value indicates a potential false positive object. Additional information: Low values may be possible in the first cycles of the object’s appearance. Use as confidence measure where a low value means less confidence and a high value indicates strong confidence.		
Value type	[0…100] real value	**Unit**	%

A.2.2 Object ID

Table A.69 — Signal: Object ID

Name	Object ID		
Description	The signal “Object ID” (A.2.2) provides the unique ID of the object within the object lists of the sensor cluster’s interfaces. Additional information: The signal’s “Object ID” (A.2.2) value is only unique for each sensor cluster's recognised entities of its OLIs. The signal’s “Object ID” (A.2.2) value is unique for the same entity in multiple cycles. Reuse of the signal’s “Object ID” (A.2.2) value is possible under defined conditions. Requirement: The reuse of the signal’s “Object ID” (A.2.2) value shall be well-defined.		
Value type	integer value	**Unit**	1

A.2.3 Object grouping ID

Table A.70 — Signal: Object grouping ID

Name	Object grouping ID

Description	A sensor cluster can group objects from the same object interface or different OLIs of the sensor cluster which are linked together. All objects from one real-world entity should have the same signal's "Object grouping ID" (A.2.3) value. The ID is unique considering all OLIs of a sensor cluster. In cases in which it is not clear, if it is, for example, a single traffic participant or multiple, the link can be used. EXAMPLE 1 Long vehicles (for example, a truck with a trailer) can be described by two potentially moving objects. In this case the same value for the signal "Object grouping ID" (A.2.3) logically connects or links one object with the other object. EXAMPLE 2 A construction site vehicle (as a potentially moving object) with a traffic sign (as static object) at the rear of the vehicle. Additional information: The signal "Object grouping ID" (A.2.3) ≔ 0 if object is not associated with another object. Requirement: The reuse of the signal's "Object grouping ID" (A.2.3) values shall be well defined.		
Value type	integer value	**Unit**	1

A.2.4 Age

Table A.71 — Signal: Age

Name	Age		
Description	The signal "Age" (A.2.4) provides the amount of time that this object has been currently tracked. Additional information: The signal "Age" (A.2.4) ≔ current time stamp − time stamp when the tracking or prediction for this object has been initiated.		
Value type	[0…] real value	**Unit**	s

A.2.5 Number of valid observations – object level

Table A.72 — Signal: Number of valid observations – object level

Name	Number of valid observations – object level		
Description	The signal "Number of valid observations – object level" (A.2.5) provides the current number of valid tuples [specifically the signal "Time stamp reference – object level" (A.2.6) and "Observation status – object level" (A.2.7)].		
Value type	[0…] integer value	**Unit**	1

A.2.6 Time stamp reference – object level

Table A.73 — Signal: Time stamp reference – object level

Name	Time stamp reference – object level
Description	The signal "Time stamp reference – object level" (A.2.6) provides a reference to a previously sent interface message with the referenced time stamp for signal "Time stamp – <…>" (A.1.5).

Value type	real value	**Unit**	s

A.2.7 Observation status – object level

Table A.74 — Signal: Observation status – object level

Name	Observation status – object level		
Description	The signal “Observation status – object level” (A.2.7) provides the observation status of the object, which was recognised in a previous cycle [see signal “Time stamp reference – object level” (A.2.6) which references the cycle].		
Value type	enumeration	**Unit**	1

Table A.75 — Enumeration: Observation status – object level – Example enumerators

Name	Description	RL enumerator
OS_True	The object was observed in the referenced cycle.	“exemplary”
OS_False	The object was not observed in the referenced cycle. It may be predicted in the referenced cycle.	“exemplary”

A.2.8 Track quality

Table A.76 — Signal: Track quality

Name	Track quality		
Description	The signal “Track quality” (A.2.8) value describes how well the track was predicted of the current observation. Usually there is a variety of signals which are used to set up a track. The quality of the track is changing gradually from a precise prediction, where all values met the prediction very close, down to a prediction which is based on less signals and where the deviation gets large. A value close to 100 % indicates that both the prediction is very precise and most of available signals are used to build the track. A very low value (near 0 %) means a very high deviation of the observation from the predicted track and that the availability of the signals is lower.		
Value type	[0...100] real value	**Unit**	%

A.2.9 Measurement status – object level

Table A.77 — Signal: Measurement status – object level

Name	Measurement status – object level		
Description	The signal “Measurement status – object level” (A.2.9) provides the current measurement status of the object. The objects should be sent out as fast as possible, even if not all statuses are observed, and the object’s signals might not be fully filled.		
Value type	enumeration	**Unit**	1

Table A.78 — Enumeration: Measurement status – object level – Example enumerators

Name	Description	RL enumerator
MS_Measured	The object was updated with new information from the sensor in the last update cycle of this object list.	“exemplary”
MS_New	This indicates the first occurrence of this particular object in the object list.	“exemplary”

MS_Predicted	The object was predicted without any new information with respect to the previous update cycle.	“exemplary”
MS_PartlyMeasured	The object was partly updated with new information from the sensor in the last update cycle of this object list. The measurement or tracking was incomplete and could, therefore, only partially update the signals of this object. The remaining signals of this object are unchanged or predicted for this update cycle.	“exemplary”
MS_Invalid	The object is invalid in this cycle.	“exemplary”
MS_PredictedOccluded	Tracked object is temporarily occluded by another entity.	“exemplary”

A.2.10 Tracking motion model

Table A.79 — Signal: Tracking motion model

Name	Tracking motion model		
Description	The signal “Tracking motion model” (A.2.10) provides the used motion model for tracking moving items.		
Value type	enumeration	**Unit**	1

Table A.80 — Enumeration: Tracking motion model – Example enumerators

Name	**Description**	**RL enumerator**
TMM_ConstantVelocity	The motion model uses constant velocity.	“exemplary”
TMM_ConstantAcceleration	The motion model uses constant acceleration.	“exemplary”
TMM_ConstantRotationRate	The motion model uses constant rotation rate.	“exemplary”

A.2.11 Number of valid potentially moving object classifications

Table A.81 — Signal: Number of valid potentially moving object classifications

Name	Number of valid potentially moving object classifications		
Description	The signal “Number of valid potentially moving object classifications” (A.2.11) provides the current number of valid tuples [specifically the signal “Potentially moving object classification type” (A.2.12) and the signal “Potentially moving object classification type – confidence” (A.2.13)] for classifying a potentially moving object.		
Value type	[0…] integer value	**Unit**	1

A.2.12 Potentially moving object classification type

Table A.82 — Signal: Potentially moving object classification type

Name	Potentially moving object classification type		
Description	The signal “Potentially moving object classification type” (A.2.12) provides a list of classification types for potentially moving objects.		
Value type	enumeration	**Unit**	1

Table A.83 — Enumeration: Potentially moving object classification type – Example enumerators

Name	**Description**	**RL enumerator**

PMOCT_Car	The potential moving object represents an object car.	“exemplary”
PMOCT_Truck	The potential moving object represents an object truck.	“exemplary”
PMOCT_HeavyTruck	The potential moving object represents an object heavy truck.	“exemplary”
PMOCT_Van	The potential moving object represents an object van.	“exemplary”
PMOCT_Bus	The potential moving object represents an object bus.	“exemplary”
PMOCT_Trailer	The potential moving object represents an object trailer.	“exemplary”
PMOCT_Train	The potential moving object represents an object train.	“exemplary”
PMOCT_OtherVehicle	The potential moving object represents an object unidentified vehicle.	“exemplary”
PMOCT_Motorbike	The potential moving object represents an object motorbike.	“exemplary”
PMOCT_Animal	The potential moving object represents an object animal.	“exemplary”
PMOCT_Bicycle	The potential moving object represents an object bicycle.	“exemplary”
PMOCT_Tricycle	The potential moving object represents an object tricycle.	“exemplary”
PMOCT_Pedestrian	The potential moving object represents an object pedestrian.	“exemplary”
PMOCT_Wheelchair	The potential moving object represents an object wheelchair.	“exemplary”
PMOCT_Ambulance	The potential moving object represents an object ambulance.	“exemplary”
PMOCT_FireEngine	The potential moving object represents an object fire engine.	“exemplary”
PMOCT_PoliceCar	The potential moving object represents an object police car.	“exemplary”
PMOCT_SanitationVehicle	The potential moving object represents an object sanitation vehicle.	“exemplary”
PMOCT_UtilityVehicle	The potential moving object represents an object utility vehicle.	“exemplary”
PMOCT_TrafficController	The potential moving object represents an object traffic controller (traffic authorised person).	“exemplary”

A.2.13 Potentially moving object classification type – confidence

Table A.84 — Signal: Potentially moving object classification type – confidence

Name	Potentially moving object classification type – confidence		
Description	The signal “Potentially moving object classification type – confidence” (A.2.13) provides the certainty for the corresponding signal “Potentially moving object classification type” (A.2.12).		
Value type	[0…100] real value	**Unit**	%

A.2.14 Reference point

Table A.85 — Signal: Reference point

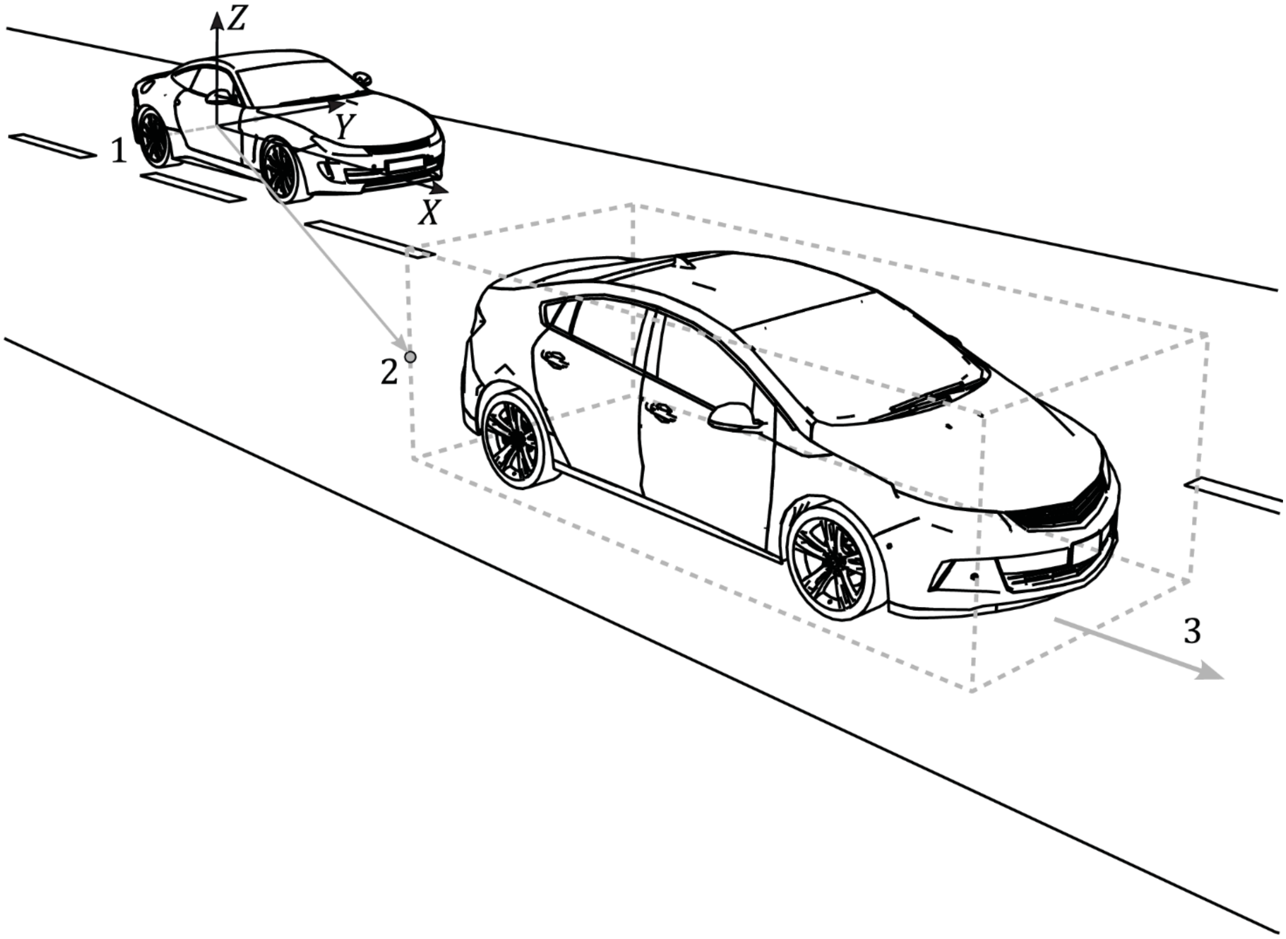
Name	Reference point

Description	The signal "Reference point" (A.2.14) provides the outer edges of the recognised object's bounding box (see Figure A.2). During tracking, this point can change in each cycle. Additional information: Only valid for cuboid model. The reference point is always on the outer edge with z value "middle" (middle height), if it is not defined in the enumeration. "middle" is the geometrical middle of the bounding box for each axis. If the signal is not part of the implemented interface, the reference point is located in the midside, midwidth, midheight of the object's bounding box (see enumerator "RP_MidsideMidwidthMidheight"). Front/rear, left/right, top/bottom are defined for the bounding box with respect to the object's orientation [see signal "Orientation {yaw, pitch, roll}" (A.2.17)]. Naming for enumerators: - *X*-axis of the bounding box: Rear – Midside – Front; - *Y*-axis of the bounding box: Right – Midwidth – Left; - *Z*-axis of the bounding box: Bottom – Midheight – Top.		
Value type	enumeration	**Unit**	1

Table A.86 — Enumeration: Reference point – Example enumerators

Name	Description	RL enumerator
RP_FrontLeftTop	The reference point of the object's bounding box is located at the front, left, top corner of the bounding box.	"exemplary"
RP_FrontMidwidthTop	The reference point of the object's bounding box is located in the middle of the front, top edge of the bounding box.	"exemplary"
RP_FrontRightTop	The reference point of the object's bounding box is located at the front, right, top corner of the bounding box.	"exemplary"
RP_MidsideLeftTop	The reference point of the object's bounding box is located in the middle of the left, top edge of the bounding box.	"exemplary"
RP_MidsideMidwidthTop	The reference point of the object's bounding box is located at the geometric centre of the bounding box's top plane.	"exemplary"
RP_MidsideRightTop	The reference point of the object's bounding box is located in the middle of the right, top edge of the bounding box.	"exemplary"
RP_RearLeftTop	The reference point of the object's bounding box is located at the rear, left, top corner of the bounding box.	"exemplary"
RP_RearMidwidthTop	The reference point of the object's bounding box is located in the middle of the rear, top edge of the bounding box.	"exemplary"
RP_RearRightTop	The reference point of the object's bounding box is located at the rear, right, top corner of the bounding box.	"exemplary"
RP_FrontLeftMidheight	The reference point of the object's bounding box is located in the middle of the front, left edge of the bounding box.	"exemplary"
RP_FrontMidwidthMidheight	The reference point of the object's bounding box is located at the geometric centre of the bounding box's front plane.	"exemplary"

Name	Description	RL enumerator
RP_FrontRightMidheight	The reference point of the object's bounding box is located in the middle of the front, right edge of the bounding box.	"exemplary"
RP_MidsideLeftMidheight	The reference point of the object's bounding box is located at the geometric centre of the bounding box's left-side plane.	"exemplary"
RP_MidsideMidwidthMidheight	The reference point of the object's bounding box is located at the geometric centre of the bounding box.	"exemplary"
RP_MidsideRightMidheight	The reference point is located at the geometric centre of the bounding box's right-side plane.	"exemplary"
RP_RearLeftMidheight	The reference point of the object's bounding box is located in the middle of the rear, left edge of the bounding box.	"exemplary"
RP_RearMidwidthMidheight	The reference point of the object's bounding box is located at the geometric centre of the bounding box's rear plane.	"exemplary"
RP_RearRightMidheight	The reference point of the object's bounding box is located in the middle of the rear, right edge of the bounding box.	"exemplary"
RP_FrontLeftBottom	The reference point of the object's bounding box is located at the front, left, bottom corner of the bounding box.	"exemplary"
RP_FrontMidwidthBottom	The reference point of the object's bounding box is located in the middle of the front, bottom edge of the bounding box.	"exemplary"
RP_FrontRightBottom	The reference point of the object's bounding box is located at the front, right, bottom corner of the bounding box.	"exemplary"
RP_MidsideLeftBottom	The reference point of the object's bounding box is located in the middle of the left, bottom edge of the bounding box.	"exemplary"
RP_MidsideMidwidthBottom	The reference point of the object's bounding box is located at the geometric centre of the bounding box's bottom plane.	"exemplary"
RP_MidsideRightBottom	The reference point of the object's bounding box is located in the middle of the right, bottom edge of the bounding box.	"exemplary"
RP_RearLeftBottom	The reference point of the object's bounding box is located at the rear, left, bottom corner of the bounding box.	"exemplary"
RP_RearMidwidthBottom	The reference point of the object's bounding box is located in the middle of the rear, bottom edge of the bounding box.	"exemplary"
RP_RearRightBottom	The reference point of the object's bounding box is located at the rear, right, bottom corner of the bounding box.	"exemplary"



Key

1 vehicle’s rear axle with ego-vehicle coordinate system

2 point of signal “Reference point” (A.2.14) with enumerator “RP_RearRightMidheight” refers to rear right midheight of the potentially moving object’s bounding box and orientation at this point [see signal “Orientation {yaw, pitch, roll}” (A.2.17) and signal “Position – object level {x, y, z}” (A.2.15)]

3 potentially moving object’s moving direction

Figure A.2 — Example for reference point of a potentially moving object's bounding box

A.2.15 Position – object level {x, y, z}

Table A.87 — Signal: Position – object level {x, y, z}

Name	Position – object level {x, y, z}		
Description	The signal “Position – object level {x, y, z}” (A.2.15) provides a position of the object. It is defined in the ego-vehicle coordinate system [see signal “Vehicle coordinate system type – header” (A.1.20)]. Additional information: The origin point of the object coordinate system is the ego-vehicle coordinate system (see Figure A.2).		
Value type	3D vector real value	**Unit**	(m, m, m)

A.2.16 Position – object level {x, y, z} – error

Table A.88 — Signal: Position – object level {x, y, z} – error

Name	Position – object level {x, y, z} – error		
Description	The signal “Position – object level {x, y, z} – error” (A.2.16) provides the error which represents the uncertainty of the state estimation of the signal’s “Position – object level {x, y, z}” (A.2.15) position (see Figure A.2).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Position – object level {x, y, z}” (A.2.15).

A.2.17 Orientation {yaw, pitch, roll}

Table A.89 — Signal: Orientation {yaw, pitch, roll}

Name	Orientation {yaw, pitch, roll}		
Description	The signal “Orientation {yaw, pitch, roll}” (A.2.17) provides the orientation of the object’s bounding box defined in the ego-vehicle coordinate system [see signal “Vehicle coordinate system type – header” (A.1.20)]. Additional information: A potentially moving object may move in another direction as the *X*-axis of the bounding box [see signal “Bounding box extent {length, width, height}” (A.2.20)]. The axis system of the bounding box and the object’s axis system may be different. The signal “Orientation {yaw, pitch, roll}” (A.2.17) is given with {yaw, pitch, roll} angles, which have to be separated in a defined procedure. For example, the rotations are to be performed yaw first (around the *Z*-axis), pitch second (around the new *Y*-axis) and roll third (around the new *X*-axis) following the definition according to ISO 8855:2011.		
Value type	3D vector real value	**Unit**	(rad, rad, rad)

A.2.18 Orientation {yaw, pitch, roll} – error

Table A.90 — Signal: Orientation {yaw, pitch, roll} – error

Name	Orientation {yaw, pitch, roll} – error		
Description	The signal “Orientation {yaw, pitch, roll} – error” (A.2.18) provides the error which represents the uncertainty of the state estimation of the signal’s “Orientation {yaw, pitch, roll}” (A.2.17) values for orientation (see Figure A.2).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Orientation {yaw, pitch, roll}” (A.2.17).

A.2.19 Road level

Table A.91 — Signal: Road level

Name	Road level

Description	The signal "Road level" (A.2.19) provides the information about relevance to ego-vehicle road level, for example, in case no {z} value for position can be given [see signal "Position – object level {x, y, z}" (A.2.15)]. Additional information: In situations it happens that a target vehicle is detected by the sensor, but the vehicle is on different road levels compared to the ego-vehicle (for example, motorway bridge ahead on which a vehicle is crossing the motorway). This signal indicates the relevance to the ego-vehicle road level.		
Value type	enumeration	**Unit**	1

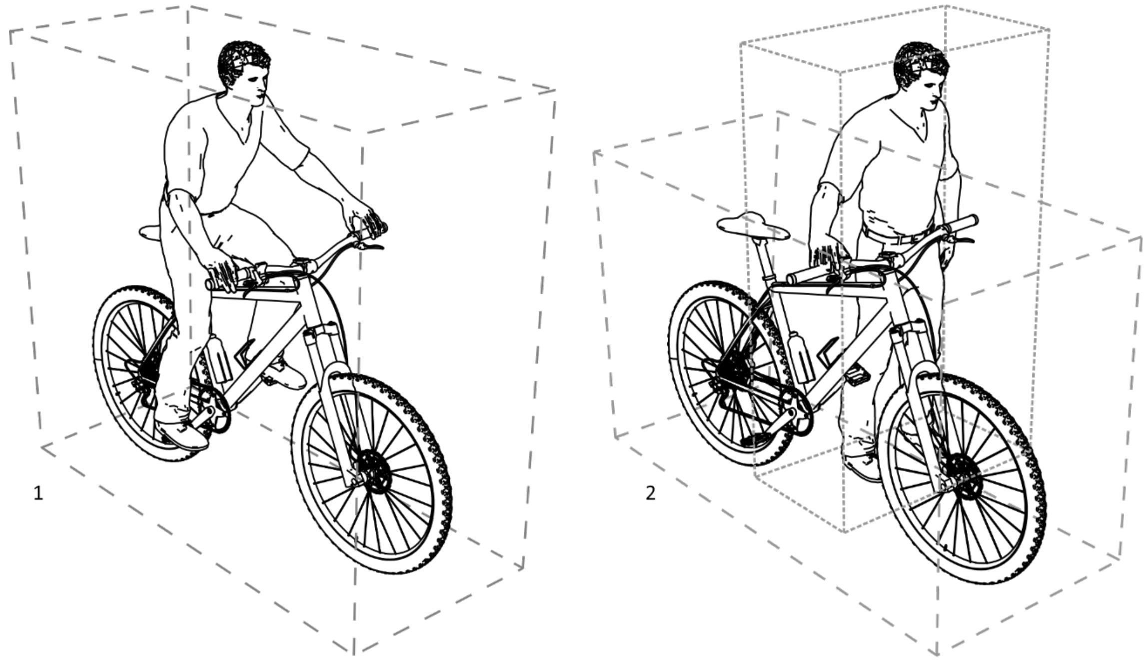
Table A.92 — Enumeration: Road level – Example enumerators

Name	**Description**	**RL enumerator**
RL_EgoRoadLevel	The object is on the same road level as the ego-vehicle.	"exemplary"
RL_RoadLevelAbove	The object is on a different road level as the ego-vehicle. It is on a road level above.	"exemplary"
RL_RoadLevelBelow	The object is on a different road level as the ego-vehicle. It is on a road level below.	"exemplary"

A.2.20 Bounding box extent {length, width, height}

Table A.93 — Signal: Bounding box extent {length, width, height}

Name	Bounding box extent {length, width, height}		
Description	The signal "Bounding box extent {length, width, height}" (A.2.20) provides the extent of an object (see Figure A.3). {length}: distance between the rear plane and the front plane of the bounding box. It is the object dimension along the *X*-axis of the bounding box axis system (see Table A.86). {width}: distance between the right-side plane and the left-side plane of the bounding box. It is the object dimension along the *Y*-axis of the bounding box axis system (see Table A.86). {height}: distance between the bottom plane and the top plane of the bounding box. It is the object dimension along the *Z*-axis of the bounding box axis system (see Table A.86). Additional information: The orientation of the bounding box is defined by the signal "Orientation {yaw, pitch, roll}" (A.2.17). Requirement: The degree to which small structures are part of the extent of the bounding box shall be defined by the sensor manufacturer during the system design phase [see signal "Included geometric structures" (A.2.23)].		
Value type	3D vector real value	**Unit**	(m, m, m)



Key

1 one bounding box of one potentially moving object

2 two bounding boxes of two potentially moving object which are connected [see signal "Accessory connection to person type" (A.2.62)]

Figure A.3 — Example for the signal "Bounding box extent {length, width, height}" (A.2.20)

A.2.21 Bounding box extent {length, width, height} – error

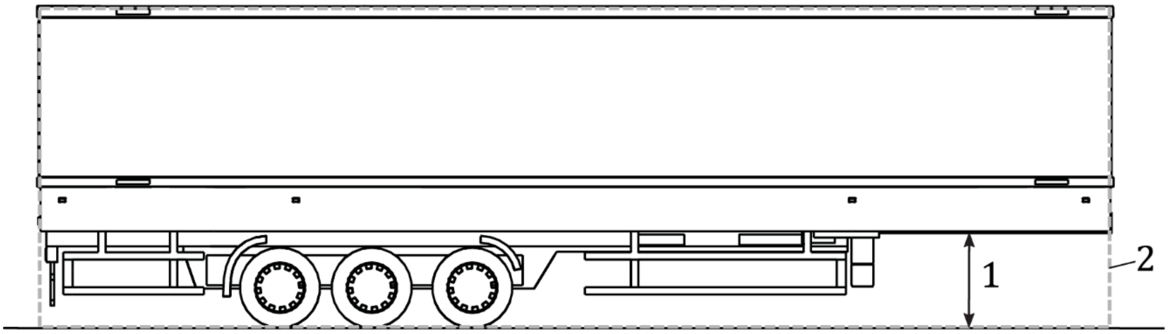
Table A.94 — Signal: Bounding box extent {length, width, height} – error

Name	Bounding box extent {length, width, height} – error		
Description	The signal "Bounding box extent {length, width, height} – error" (A.2.21) provides the error of the signal "Bounding box extent {length, width, height}" (A.2.20).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Bounding box extent {length, width, height}" (A.2.20).

A.2.22 Clearance of the object {height}

Table A.95 — Signal: Clearance of the object {height}

Name	Clearance of the object {height}		
Description	The signal "Clearance of the object {height}" (A.2.22) provides the maximum height of the clearance area between ground and object lower shape. The bounding box is indicated with the dashed box (see Figure A.4 and Figure A.5).		
Value type	[0…] real value	**Unit**	m

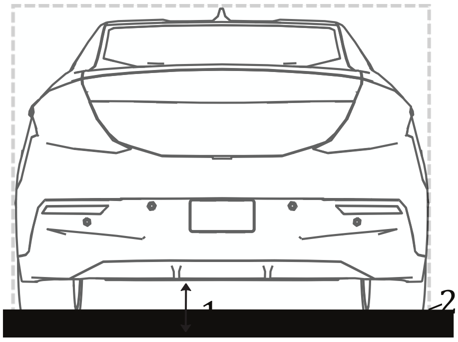


Key

1 signal "Clearance of the object {height}" (A.2.22)

2 bounding box

Figure A.4 — Example for the signal "Clearance of the object {height}" (A.2.22) of a trailer



Key

1 signal "Clearance of the object {height}" (A.2.22)

2 bounding box

Figure A.5 — Example for the signal "Clearance of the object {height}" (A.2.22) of a vehicle

A.2.23 Included geometric structures

Table A.96 — Signal: Included geometric structures

Name	Included geometric structures		
Description	The signal "Included geometric structures" (A.2.23) provides the geometrical structures that are taken into account in the bounding box [see signal "Bounding box extent {length, width, height}" (A.2.20)].		
Value type	enumeration	**Unit**	1

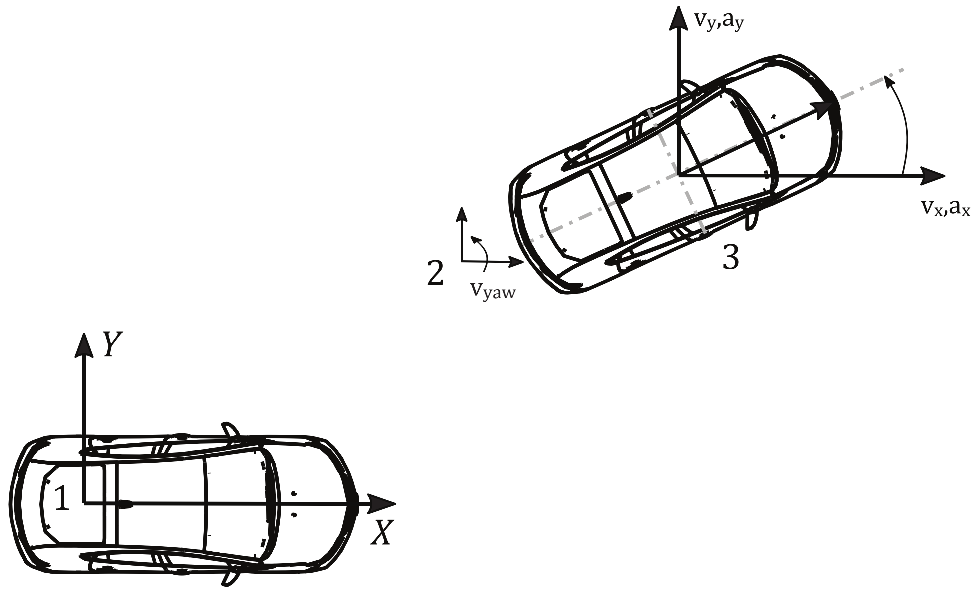
Table A.97 — Enumeration: Included geometric structures – Example enumerators

Name	**Description**	**RL enumerator**
IGS_WithoutMirrors	The bounding box dimensions exclude vehicle mirrors [see signal "Bounding box extent {length, width, height}" (A.2.20)].	"exemplary"
IGS_WithMirrors	The bounding box dimensions include vehicle mirrors [see signal "Bounding box extent {length, width, height}" (A.2.20)].	"exemplary"

A.2.24Velocity {x, y, z} – object level

Table A.98 — Signal: Velocity {x, y, z} – object level

Name	Velocity {x, y, z} – object level		
Description	The signal "Velocity {x, y, z} – object level" (A.2.24) provides the velocity of the object with respect to the signal "Motion type" (A.1.13) (see Figure A.6) in the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	3D vector real value	**Unit**	(m/s, m/s, m/s)



Key

1 ego-vehicle coordinate system

2 instantaneous centre of rotation of the potentially moving object

3 potentially moving object with ego-vehicle's axis system

Figure A.6 — Example for an ego-vehicle and object dynamics of a potentially moving object

A.2.25Velocity {x, y, z} – object level – error

Table A.99 — Signal: Velocity {x, y, z} – object level – error

Name	Velocity {x, y, z} – object level – error		
Description	The signal "Velocity {x, y, z} – object level – error" (A.2.25) provides the error which represents the uncertainty of the state estimation of {x, y, z} velocity with respect to the signal "Motion type" (A.1.13) (see Figure A.6) in the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Velocity {x, y, z} – object level" (A.2.24).

A.2.26Acceleration {x, y, z}

Table A.100 — Signal: Acceleration {x, y, z}

Name	Acceleration {x, y, z}

Description	The signal "Acceleration {x, y, z}" (A.2.26) provides the acceleration of the object with respect to the signal "Motion type" (A.1.13) (see Figure A.6) in the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	3D vector real value	**Unit**	(m/s^2, m/s^2, m/s^2)

A.2.27 Acceleration {x, y, z} – error

Table A.101 — Signal: Acceleration {x, y, z} – error

Name	Acceleration {x, y, z} – error		
Description	The signal "Acceleration {x, y, z} – error" (A.2.27) provides the error which represents the uncertainty of the state estimation of {x, y, z} acceleration with respect to the signal "Motion type" (A.1.13) (see Figure A.6) in the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Acceleration {x, y, z}" (A.2.26).

A.2.28 Instantaneous centre of rotation {x, y}

Table A.102 — Signal: Instantaneous centre of rotation {x, y}

Name	Instantaneous centre of rotation {x, y}		
Description	The signal "Instantaneous centre of rotation {x, y}" (A.2.28) provides the centre-point of the instantaneous rotation in the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)]. The centre can be located outside the object's bounding box (see Figure A.6). Additional information: The centre-point can be arbitrary for the object. The centre-point is the origin of the rotation rates [see signal "Rotation rate at instantaneous centre of rotation {yaw}" (A.2.30)] and it is defined in the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	2D vector real value	**Unit**	(m, m)

A.2.29 Instantaneous centre of rotation {x, y} – error

Table A.103 — Signal: Instantaneous centre of rotation {x, y} – error

Name	Instantaneous centre of rotation {x, y} – error		
Description	The signal "Instantaneous centre of rotation {x, y} – error" (A.2.29) provides the error of the state estimation of the signal "Instantaneous centre of rotation {x, y}" (A.2.28) (see Figure A.6) in the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Instantaneous centre of rotation {x, y}" (A.2.28).

A.2.30 Rotation rate at instantaneous centre of rotation {yaw}

Table A.104 — Signal: Rotation rate at instantaneous centre of rotation {yaw}

Name	Rotation rate at instantaneous centre of rotation {yaw}

Description	The signal "Rotation rate at instantaneous centre of rotation {yaw}" (A.2.30) provides the {yaw}-rate of the object at the signal "Instantaneous centre of rotation {x, y}" (A.2.28) with respect to the signal "Motion type" (A.1.13) (see Figure A.6) and with respect to the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	1D vector real value	**Unit**	rad/s

A.2.31 Rotation rate at instantaneous centre of rotation {yaw} – error

Table A.105 — Signal: Rotation rate at instantaneous centre of rotation {yaw} – error

Name	Rotation rate at instantaneous centre of rotation {yaw} – error		
Description	The signal "Rotation rate at instantaneous centre of rotation {yaw} – error" (A.2.31) provides the error of the {yaw}-rate at the object's signal "Instantaneous centre of rotation {x, y}" (A.2.28) with respect to the signal "Motion type" (A.1.13) (see Figure A.6) and with respect to the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Rotation rate at instantaneous centre of rotation {yaw}" (A.2.30).

A.2.32 Movement status

Table A.106 — Signal: Movement status

Name	Movement status		
Description	The signal "Movement status" (A.2.32) provides the information about a possible movement of the object during tracking.		
Value type	enumeration	**Unit**	1

Table A.107— Enumeration: Movement status – Example enumerators

Name	**Description**	**RL enumerator**
MS_Moving	The object is currently moving.	"exemplary"
MS_StoppedMoving	The object movement was detected in the tracking history of the object.	"exemplary"
MS_Stationary	Until now no object movement was detected in the tracking history of the object.	"exemplary"

A.2.33 Number of valid lights

Table A.108 — Signal: Number of valid lights

Name	Number of valid lights		
Description	The signal "Number of valid lights" (A.2.33) provides the current number of valid tuples [specifically the signal "Light type" (A.2.34) and the signal "Light status" (A.2.35) for a potentially moving object].		
Value type	[0…] integer value	**Unit**	1

A.2.34 Light type

Table A.109 — Signal: Light type

Name	Light type

Description	The signal “Light type” (A.2.34) provides a list of electric light classifications for a potentially moving object.		
Value type	enumeration	**Unit**	1

Table A.110— Enumeration: Light type – Example enumerators

Name	**Description**	**RL enumerator**
LT_LeftTurnIndicator	The light is the vehicle’s left turn indicator.	“exemplary”
LT_RightTurnIndicator	The light is the vehicle’s right turn indicator.	“exemplary”
LT_HazardFlashLight	The light is the vehicle’s hazard flash light.	“exemplary”
LT_LeftBrakeLight	The light is the vehicle’s left brake light.	“exemplary”
LT_RightBrakeLight	The light is the vehicle’s right brake light.	“exemplary”
LT_CentreBrakeLight	The light is the vehicle’s centre brake light.	“exemplary”
LT_LeftOtherLight	The light is the vehicle’s left light (no turn indicator, flash- or brake light).	“exemplary”
LT_RightOtherLight	The light is the vehicle’s right light (no turn indicator, flash- or brake light).	“exemplary”
LT_CentreOtherLight	The light is a vehicle’s light which is not on the left or right side (no turn indicator, flash- or brake light).	“exemplary”
LT_VehicleWarningLight	The light is the special vehicle’s warning light.	“exemplary”
LT_PoliceWarningLight	The light is the police’s warning light.	“exemplary”

A.2.35 Light status

Table A.111 — Signal: Light status

Name	Light status		
Description	The signal “Light status” (A.2.35) provides the status of a potentially moving object’s electric light [see signal “Light type” (A.2.34)]. Additional information: It is possible to have more than one active light signals (for example, low beam and blinker).		
Value type	enumeration	**Unit**	1

Table A.112— Enumeration: Light status – Example enumerators

Name	**Description**	**RL enumerator**
LS_Off	The light status is off.	“exemplary”
LS_On	The light status is on.	“exemplary”
LS_LowFrequencyFlash	The light status is cyclic flashing, for example, indicator.	“exemplary”
LS_HighFrequencyFlash	The light status indicates, for example, emergency full braking.	“exemplary”
LS_Warning	The light status indicates warning.	“exemplary”
LS_Other	The light status could not be determined.	“exemplary”

A.2.36Number of valid persons

Table A.113 — Signal: Number of valid persons

Name	Number of valid persons		
Description	The signal “Number of valid persons” (A.2.36) provides the current number of valid persons who are part of the potentially moving object.		
Value type	[0…] integer value	**Unit**	1

A.2.37Number of valid person type roles

Table A.114 — Signal: Number of valid person type roles

Name	Number of valid person type roles		
Description	The signal “Number of valid person type roles” (A.2.37) provides the current number of valid person type roles, which are classified for the potentially moving object.		
Value type	[0…] integer value	**Unit**	1

A.2.38Person type role

Table A.115 — Signal: Person type role

Name	Person type role		
Description	The signal “Person type role” (A.2.38) provides a classification of the person.		
Value type	enumeration	**Unit**	1

Table A.116— Enumeration: Person type role – Example enumerators

Name	**Description**	**RL enumerator**
PTR_Policeman	The person is a policeman.	“exemplary”
PTR_PolicemanInCar	The person is a policeman, who gestures out of a police car.	“exemplary”
PTR_PolicemanOnMotorcycle	The person is a policeman, who gestures on a police motorcycle.	“exemplary”
PTR_RoadWorker	The person is a road worker.	“exemplary”
PTR_PersonOfAuthority	The person has special authority for defined circumstances, for example, firefighter, rescue service.	“exemplary”
PTR_Person	The person is an arbitrary person without any identified special characteristics/authorities.	“exemplary”

A.2.39Person type role – confidence

Table A.117 — Signal: Person type role – confidence

Name	Person type role – confidence		
Description	The signal “Person type role – confidence” (A.2.39) provides the certainty for the corresponding signal “Person type role” (A.2.38).		
Value type	[0…100] real value	**Unit**	%

A.2.40 Number of valid person gestures

Table A.118 — Signal: Number of valid person gestures

Name	Number of valid person gestures		
Description	The signal “Number of valid person gestures” (A.2.40) provides the current number of valid person’s gestures.		
Value type	[0…] integer value	**Unit**	1

A.2.41 Person gesture indication type

Table A.119 — Signal: Person gesture indication type

Name	Person gesture indication type		
Description	The signal “Person gesture indication type” (A.2.41) provides the classification of the indication of a person’s gesture (for example, with hands). The gesture is made by a person defined in the signal “Person type role” (A.2.38).		
Value type	enumeration	**Unit**	1

Table A.120— Enumeration: Person gesture indication type – Example enumerators

Name	**Description**	**RL enumerator**
PGIT_ RepetitiveHandMoving	The person repeats a gesture with its hand. This might be interpreted as trivial waving to say “hello” or to call attention to the person with this gesture because of any reason.	“exemplary”
PGIT_BendArmThumbBackwards	The person bends one arm and stretches one thumb out of a fist. The forearm is moving back and forth. This gesture might be interpreted as a request for hitch hiking.	“exemplary”
PGIT_StretchedArmOpenHandToEgoVehicle	The person stretched one arm in the vehicle’s direction with open hand. This gesture might be interpreted as a request to the vehicle to stop.	“exemplary”
PGIT_StretchedArmAlongPedestrianShoulders	The person stretches its arm to the left or right of the person’s body. This gesture might be interpreted as a proposed guiding or to proceed with the current driving. It can also be interpreted to follow a preceding vehicle.	“exemplary”
PGIT_StretchedArmToRight	The person stretches its arm to the right with respect to the ego vehicle coordinate system. This gesture might be interpreted as a proposal or request to drive to the right. It can also be interpreted as a hint to the driver to consider a referred other traffic participant or a specific traffic scene for the ego vehicle driving. It can also be interpreted to change to the right neighbouring lane.	“exemplary”

PGIT_StretchedArmToLeft	The person stretches its arm to the left with respect to the ego vehicle coordinate system. This gesture might be interpreted as a proposal or request to drive to the left. It can also be interpreted as a hint to the driver to consider a referred other traffic participant or a specific traffic scene for the ego vehicle driving. It can also be interpreted to change to the left neighbouring lane.	“exemplary”
PGIT_StretchedArmOpenHandToGround	The person stretches one or two arms to the ground. The open hands are directed to the ground. This might be interpreted to slow down or to stop the vehicle.	“exemplary”

A.2.42 Person gesture indication type – confidence

Table A.121 — Signal: Person gesture direction type – confidence

Name	Person gesture direction type – confidence		
Description	The signal “Person gesture indication type – confidence” (A.2.42) provides the certainty for the corresponding signal “Person gesture indication type” (A.2.41).		
Value type	[0…100] real value	**Unit**	%

A.2.43 Person gesture direction type

Table A.122 — Signal: Person gesture direction type

Name	Person gesture direction type		
Description	The signal “Person gesture direction type” (A.2.43) provides the direction of an indicated request classification of a person’s gesture [see signal “Person gesture indication type” (A.2.41)] with respect to the ego vehicle.		
Value type	enumeration	**Unit**	1

Table A.123— Enumeration: Person gesture direction type – Example enumerators

Name	**Description**	**RL enumerator**
PGDT_Straight	The gesture is directed in driving direction of the ego vehicle. The direction of the person’s body does not matter.	“exemplary”
PGDT_Right	The gesture is directed to the right with respect to the ego vehicle driving direction. The direction of the person’s body does not matter.	“exemplary”
PGDT_Left	The gesture is directed to the left with respect to the ego vehicle driving direction. The direction of the person’s body does not matter.	“exemplary”
PGDT_StraightOpposite	The gesture is directed straight to the opposite direction with respect to the ego vehicle driving direction. The direction of the person’s body does not matter.	“exemplary”
PGDT_RightBottom	The gesture is directed to the bottom right with respect to the ego vehicle driving direction. The direction of the person’s body does not matter.	“exemplary”

PGDT_LeftBottom	The gesture is directed to the bottom left with respect to the ego vehicle driving direction. The direction of the person's body does not matter.	"exemplary"
PGDT_Unclear	The gesture direction meaning is unclear.	"exemplary"
PGDT_NoDirection	The persons gesture indicates no direction.	"exemplary"

A.2.44 Person gesture direction type – confidence

Table A.124 — Signal: Person gesture direction type – confidence

Name	Person gesture direction type – confidence		
Description	The signal "Person gesture direction type – confidence" (A.2.44) provides the certainty for the corresponding signal "Person gesture direction type" (A.2.43).		
Value type	[0…100] real value	**Unit**	%

A.2.45 Number of valid person's body part poses

Table A.125 — Signal: Number of valid person's body part poses

Name	Number of valid person's body part poses		
Description	The signal "Number of valid person's body part poses" (A.2.45) provides the current number of valid tuples [specifically the signal "Person body part" (A.2.46) and the signal "Person body part orientation {yaw, pitch, roll}" (A.2.47)] for a potentially moving object. All body part poses are related to one person (for example, the object is a pedestrian, the object is a vehicle with a driver).		
Value type	[0…] integer value	**Unit**	1

A.2.46 Person body part

Table A.126 — Signal: Person body part

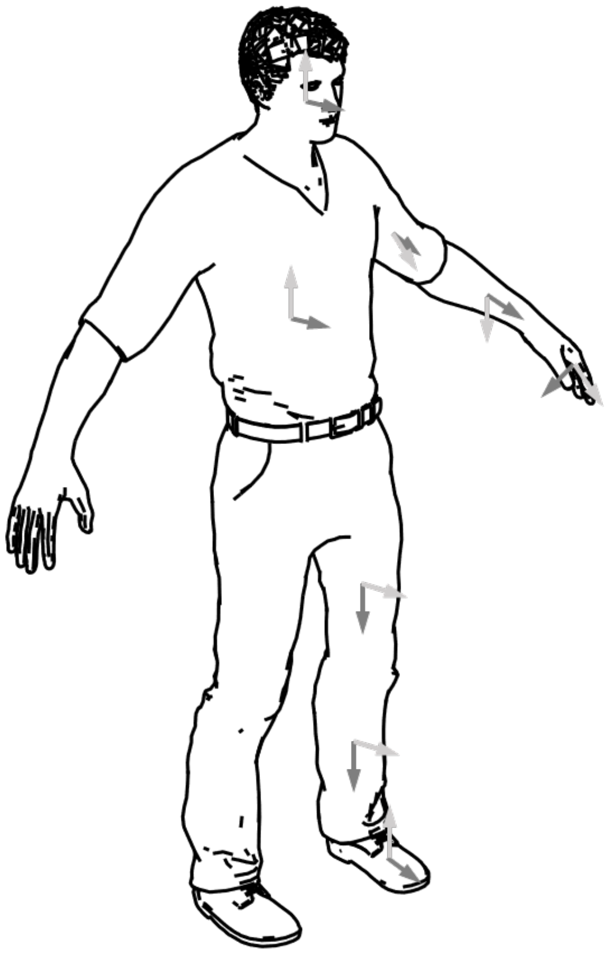
Name	Person body part		
Description	The signal "Person body part" (A.2.46) indicates a body part. It is described by the signals "Person body part orientation {yaw, pitch, roll}" (A.2.47) and "Person body part origin {x, y, z}" (A.2.49). Additional information: The defined axis (normal vector) is always frontal or distal and defines the *X*-axis. To define an axis system the second axis is the corresponding distal or frontal axis (or cranial axis) and defines the *Y*-axis.		
Value type	enumeration	**Unit**	1

Table A.127— Enumeration: Person body part – Example enumerators

Name	**Description**	**RL enumerator**
PBP_Head	The person's head (face director) is defined by the corresponding signal "Person body part orientation {yaw, pitch, roll}" (A.2.47). The normal vector to the face (eyes-nose plane) (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal "Vehicle coordinate system type – header" (A.1.20)].	"exemplary"

Name	Description	RL enumerator
PBP_UpperBody	The person's upper-body is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The normal vector of the chest’s front centre (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”
PBP_LeftHand	The person's left-hand is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The normal vector of the hand palm (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”
PBP_RightHand	The person's right-hand is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The normal vector of the hand palm (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”
PBP_LeftLowerArm	The person's left-lower arm is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The long axis of the body extremities (orientation towards the end of the extremity, that means distal) (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”
PBP_RightLowerArm	The person's right-lower arm is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The long axis of the body extremities (orientation towards the end of the extremity, that means distal) (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”
PBP_LeftUpperArm	The person's left-upper arm is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The long axis of the body extremities (orientation towards the end of the extremity, that means distal) (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”
PBP_RightUpperArm	The person's right-upper arm is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The long axis of the body extremities (orientation towards the end of the extremity, that means distal) (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”
PBP_LeftUpperLeg	The person's left-upper leg is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The long axis of the body extremities (orientation towards the end of the extremity, that means distal) (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”

Name	Description	RL enumerator
PBP_RightUpperLeg	The person's right-upper leg is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The long axis of the body extremities (orientation towards the end of the extremity, that means distal) (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”
PBP_LeftLowerLeg	The person's left-lower leg is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The long axis of the body extremities (orientation towards the end of the extremity, that means distal) (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”
PBP_RightLowerLeg	The person's right-lower leg is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The long axis of the body extremities (orientation towards the end of the extremity, that means distal) (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”
PBP_LeftFoot	The person's left-foot is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The foot sole direction towards the toe (frontal/distal) (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”
PBP_RightFoot	The person's right-foot is defined by the corresponding signal “Person body part orientation {yaw, pitch, roll}” (A.2.47). The foot sole direction towards the toe (frontal/distal) (see Figure A.7) is used to determine the pose relative to the ego-vehicle axis system [see signal “Vehicle coordinate system type – header” (A.1.20)].	“exemplary”
PBP_Chest	The upper body may be divided in chest and abdominal area.	“exemplary”
PBP_AbdominalArea	The upper body may be divided in abdominal area and chest.	“exemplary”
PBP_LowerBody	The legs may be covered by a skirt and could not be separated.	“exemplary”
PBP_UpperLegs	The upper legs may be covered by a miniskirt and could not be separated.	“exemplary”
PBP_LowerLegs	The legs may be covered by a skirt and the upper legs and lower legs may be divided in two parts (the person is wearing a skirt and is sitting on a bench), and the legs could not be separated.	“exemplary”



Key

X-axis of the body part's coordinate system

Y-axis of the body part's coordinate system

Figure A.7 — Example of person poses' coordinate systems

A.2.47 Person body part orientation {yaw, pitch, roll}

Table A.128 — Signal: Person body part orientation {yaw, pitch, roll}

Name	Person body part orientation {yaw, pitch, roll}

Description	The signal "Person body part orientation {yaw, pitch, roll}" (A.2.47) provides the orientation of the body part for behaviour prediction (see Figure A.7). Additional information: The signal "Person body part orientation {yaw, pitch, roll}" (A.2.47) describes the angles of the pose's orientation [defined by signal "Person body part" (A.2.46)] with respect to the ego-vehicle orientation, specifically the ego-vehicle axis system [see signal "Vehicle coordinate system type – header" (A.1.20)]. The signal "Person body part orientation {yaw, pitch, roll} – error" (A.2.48) is given with {yaw, pitch, roll} angles, which have to be separated in a defined procedure. For example, the rotations are to be performed yaw first (around the *Z*-axis), pitch second (around the new *Y*-axis) and roll third (around the new *X*-axis) following the definition according to ISO 8855:2011.		
Value type	3D vector real value	**Unit**	(rad, rad, rad)

A.2.48Person body part orientation {yaw, pitch, roll} – error

Table A.129 — Signal: Person body part orientation {yaw, pitch, roll} – error

Name	Person body part orientation {yaw, pitch, roll} – error		
Description	The signal "Person body part orientation {yaw, pitch, roll} – error" (A.2.48) provides the error of the orientation of the body part [see signal "Person body part orientation {yaw, pitch, roll} – error" (A.2.48)].		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Person body part orientation {yaw, pitch, roll} – error" (A.2.48).

A.2.49Person body part origin {x, y, z}

Table A.130 — Signal: Person body part origin {x, y, z}

Name	Person body part origin {x, y, z}		
Description	The signal "Person body part origin {x, y, z}" (A.2.49) provides the measured centre of the body part (midside, midwidth and midheight of the body part's theoretical bounding box) of the person pose [see signal "Person body part orientation {yaw, pitch, roll}" (A.2.47)].		
Value type	3D vector real value	**Unit**	(m, m, m)

A.2.50Person body part origin {x, y, z} – error

Table A.131 — Signal: Person body part origin {x, y, z} – error

Name	Person body part origin {x, y, z} – error		
Description	The signal "Person body part origin {x, y, z} – error" (A.2.50) provides the measured error of the signal "Person body part origin {x, y, z}" (A.2.49).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Person body part origin {x, y, z}" (A.2.49).

A.2.51Eye state

Table A.132 — Signal: Eye state

Name	Eye state		
Description	The signal “Eye state” (A.2.51) provides the classification of the person’s eyes.		
Value type	enumeration	**Unit**	1

Table A.133— Enumeration: Eye state – Example enumerators

Name	**Description**	**RL enumerator**
ES_Open	The person’s eyes are open.	“exemplary”
ES_Closed	The person’s eyes are closed.	“exemplary”
ES_OpenAndClosed	One eye of the person is open and the second is closed.	“exemplary”
ES_NotVisible	The person’s eyes are not visible. They may be hidden, for example, by a static object.	“exemplary”

A.2.52 Eye state – confidence

Table A.134 — Signal: Eye state – confidence

Name	Eye state – confidence		
Description	The signal “Eye state – confidence” (A.2.52) provides the certainty for the corresponding signal “Eye state” (A.2.51).		
Value type	[0…100] real value	**Unit**	%

A.2.53 Viewing fixation time

Table A.135 — Signal: Viewing fixation time

Name	Viewing fixation time		
Description	The signal “Viewing fixation time” (A.2.53) provides the fixation duration of the person to the ego-vehicle.		
Value type	real value	**Unit**	s

A.2.54 Viewing fixation time – error

Table A.136 — Signal: Viewing fixation time – error

Name	Viewing fixation time – error		
Description	The signal “Viewing fixation time – error” (A.2.54) provides the error of the signal “Viewing fixation time” (A.2.53).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Viewing fixation time” (A.2.53).

A.2.55 Viewing fixation direction

Table A.137 — Signal: Viewing fixation direction

Name	Viewing fixation direction
Description	The signal “Viewing fixation direction” (A.2.55) provides the fixation direction of the person to the ego-vehicle.

Value type	enumeration	**Unit**	1

Table A.138— Enumeration: Viewing fixation direction – Example enumerators

Name	Description	RL enumerator
VFD_EgoVehicleDirectFixation	The person is fixating the ego-vehicle.	“exemplary”
VFD_EgoVehiclePeripheralFixation	The person may have the ego-vehicle in the field of vision.	“exemplary”
VFD_EgoVehicleNoFixation	The person cannot have the ego-vehicle in the field of vision. The person’s viewing direction is, for example, in an opposite direction.	“exemplary”
VFD_EgoVehicleFixationEstimationNotPossible	The direction of the person’s gaze cannot be determined.	“exemplary”

A.2.56Viewing fixation direction – confidence

Table A.139 — Signal: Viewing fixation direction – confidence

Name	Viewing fixation direction – confidence		
Description	The signal “Viewing fixation direction – confidence” (A.2.56) provides the certainty for the corresponding signal “Viewing fixation direction” (A.2.55).		
Value type	[0…100] real value	**Unit**	%

A.2.57Action type

Table A.140 — Signal: Action type

Name	Action type		
Description	The signal “Action type” (A.2.57) provides the classification of a person’s action (action with the whole body) [see also “Person gesture indication type” (A.2.41)]. For detailed information for moving persons like direction or velocity refer to “Velocity {x, y, z} – object level” (A.2.24).		
Value type	enumeration	**Unit**	1

Table A.141— Enumeration: Action type – Example enumerators

Name	Description	RL enumerator
AT_Moving	The person is moving, for example, walking, running, jumping,	“exemplary”
AT_Bending	The person is bending.	“exemplary”
AT_Lying	The person is lying, for example, on the pavement.	“exemplary”
AT_Standstill	The person stands still and is not moving.	“exemplary”
AT_Sitting	The person is sitting, for example, on a bench.	“exemplary”
AT_Crawling	The person is crawling on the floor.	“exemplary”

A.2.58Action type – confidence

Table A.142 — Signal: Action type – confidence

Name	Action type – confidence		
Description	The signal “Action type – confidence” (A.2.58) provides the certainty for the corresponding signal “Action type” (A.2.57).		
Value type	[0…100] real value	**Unit**	%

A.2.59 Number of valid person accessories

Table A.143 — Signal: Number of valid person accessories

Name	Number of valid person accessories		
Description	The signal “Number of valid person accessories” (A.2.59) provides the current number of valid accessories of the person.		
Value type	[0…] integer value	**Unit**	1

A.2.60 Person accessory classification type

Table A.144 — Signal: Person accessory classification type

Name	Person accessory classification type		
Description	The signal “Person accessory classification type” (A.2.60) provides an accessory of the person. The accessory is not used for the motion of the potentially moving object [see signal “Potentially moving object classification type” (A.2.12)].		
Value type	enumeration	**Unit**	1

Table A.145— Enumeration: Person accessory classification type – Example enumerators

Name	**Description**	**RL enumerator**
PACT_AssociatedObjects	The associated object entities to this potentially moving object are passive [see signal “Object grouping ID” (A.2.3)]. This potentially moving object is responsible for the motion of all other grouped object entities.	“exemplary”
PACT_Suitcase	The person has a suitcase as an accessory (if not recognised as separate potentially moving object).	“exemplary”
PACT_Umbrella	The person has an umbrella as an accessory.	“exemplary”
PACT_Backpack	The person has a backpack as an accessory.	“exemplary”
PACT_Trolly	The person pulls a trolly as an accessory (if not recognised as separate potentially moving object).	“exemplary”
PACT_ShoppingCart	The person pushes a shopping cart as an accessory (if not recognised as separate potentially moving object).	“exemplary”
PACT_HandCart	The person pulls a hand cart as an accessory (if not recognised as separate potentially moving object).	“exemplary”
PACT_Ball	The person plays with a ball (if not recognised as separate potentially moving object).	“exemplary”
PACT_Headphones	The person is wearing headphones.	“exemplary”
PACT_FaceMask	The person is wearing a face mask.	“exemplary”
PACT_SunGlasses	The person is wearing sunglasses on its eyes.	“exemplary”
PACT_MealDrink	The person is holding a meal or a drink in its hands.	“exemplary”

Name	Description	RL enumerator
PACT_Helmet	The person is wearing a helmet.	“exemplary”
PACT_PolicemanSignallingDisk	The person uses a signalling disk to gesture.	“exemplary”
PACT_Sign	The person uses a sign to gesture.	“exemplary”

A.2.61 Person accessory classification type – confidence

Table A.146 — Signal: Person accessory classification type – confidence

Name	Person accessory classification type – confidence		
Description	The signal “Person accessory classification type – confidence” (A.2.61) provides the certainty for the corresponding signal “Person accessory classification type” (A.2.60).		
Value type	[0…100] real value	**Unit**	%

A.2.62 Accessory connection to person type

Table A.147 — Signal: Accessory connection to person type

Name	Accessory connection to person type		
Description	The signal “Accessory connection to person type" (A.2.62) provides the type of connection of the accessory to the person and the relative position with respect to the ego vehicle coordinate system. The signal “Person body part” (A.2.46) may provide the orientation of the referenced person poses [see signal “Person body part orientation {yaw, pitch, roll}” (A.2.47), “Person body part origin {x, y, z}” (A.2.49) and Figure A.8].		
Value type	enumeration	**Unit**	1

Table A.148— Enumeration: Accessory connection to person type – Example enumerators

Name	Description	RL enumerator
ACTPT_HandLeftSideOfPerson	The accessory is connected to the hand(s) of the person on the left side of the person with respect to the ego vehicle coordinate system.	“exemplary”
ACTPT_HandRightSideOfPerson	The accessory is connected to the hand(s) of the person on the right side of the person with respect to the ego vehicle coordinate system.	“exemplary”
ACTPT_HandInFrontOfPerson	The accessory is connected to the hand(s) in front of the person with respect to ego vehicle coordinate system X-axis direction.	“exemplary”
ACTPT_HandBehindOfPerson	The accessory is connected to the hand(s) behind the person with respect to ego vehicle coordinate system X-axis direction.	“exemplary”
ACTPT_UpperBody	The accessory is connected to the upper body of the person.	“exemplary”
ACTPT_FootLeftSideOfPerson	The accessory is connected to a foot of the person on the left side of the person with respect to the ego vehicle coordinate system.	“exemplary”
ACTPT_FootRightSideOfPerson	The accessory is connected to a foot of the person on the right side of the person with respect to the ego vehicle coordinate system.	“exemplary”

Name	Description	RL enumerator
ACTPT_FootInFrontOfPerson	The accessory is connected to a foot in front of the person with respect to the ego vehicle coordinate system.	“exemplary”
ACTPT_FootBehindOfPerson	The accessory is connected to a foot behind the person with respect to the ego vehicle coordinate system.	“exemplary”

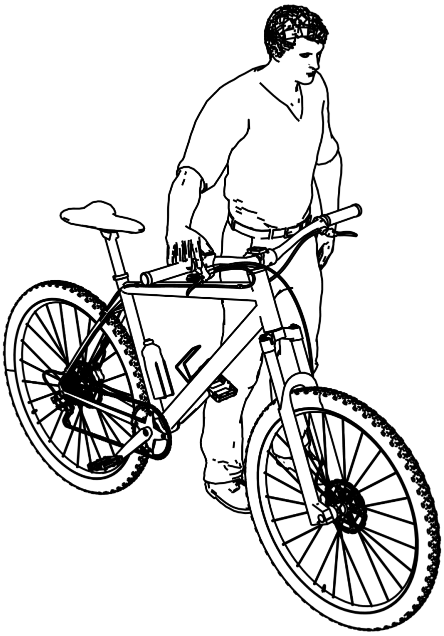


Figure A.8 — Example of the signal “Accessory connection to person type" (A.2.62) with enumerator “ACTPT_HandInFrontOfPerson”

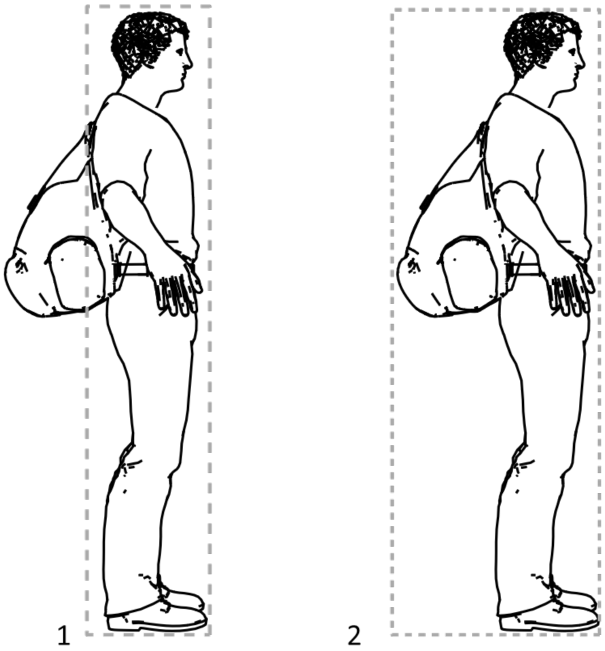
A.2.63 Included geometric structure of accessory

Table A.149 — Signal: Included geometric structure of accessory

Name	Included geometric structure of accessory		
Description	The signal “Included geometric structure of accessory” (A.2.63) provides the information if the geometrical structure of the accessory is taken into account in the bounding box of the potentially moving object [see signal “Bounding box extent {length, width, height}” (A.2.20), “Included geometric structures” (A.2.23) and Figure A.9].		
Value type	enumeration	**Unit**	1

Table A.150— Enumeration: Included geometric structure of accessory – Example enumerators

Name	Description	RL enumerator
IGSOA_WithoutAccessory	The bounding box extent of the potentially moving object excludes accessory [see signal “Bounding box extent {length, width, height}” (A.2.20)].	“exemplary”
IGSOA_WithAccessory	The bounding box extent of the potentially moving object includes accessory [see signal “Bounding box extent {length, width, height}” (A.2.20)].	“exemplary”



Key

1 person's bounding box with signal "Included geometric structure of accessory" (A.2.63) ≔ enumerator "IGSOA_WithoutAccessory"

2 person's bounding box with signal "Included geometric structure of accessory" (A.2.63) ≔ enumerator "IGSOA_WithAccessory"

Figure A.9 — Example of the signal "Included geometric structure of accessory" (A.2.63)

A.2.64 Object lane association

Table A.151 — Signal: Object lane association

Name	Object lane association		
Description	The signal "Object lane association" (A.2.64) provides an association of the object to neighbouring lanes with respect to the ego-vehicle's lane.		
Value type	enumeration	**Unit**	1

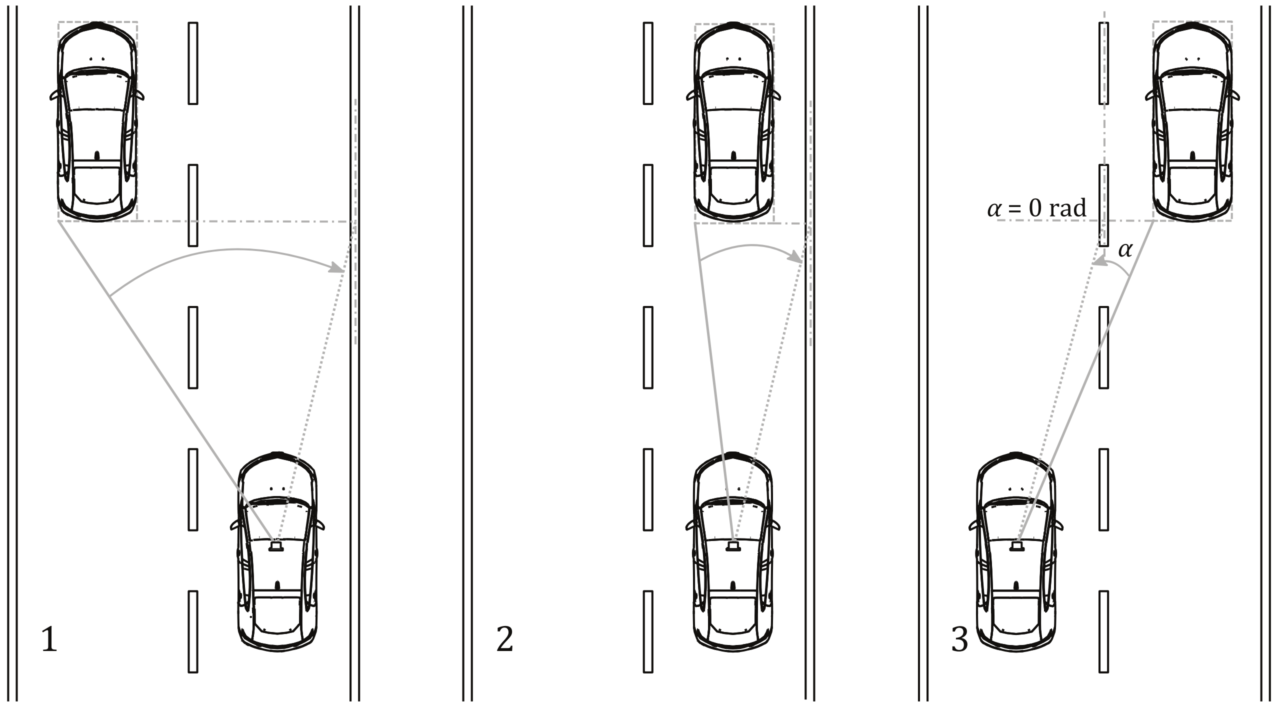
Table A.152— Enumeration: Object lane association – Example enumerators

Name	Description	RL enumerator
OLA_EgoLane	The object is in the ego lane.	"exemplary"
OLA_Left1Lane	The object is in the first-left neighbouring lane.	"exemplary"
OLA_Right1Lane	The object is in the first-right neighbouring lane.	"exemplary"
OLA_EgoRight1Lane	The object is located between the ego and right neighbouring lane.	"exemplary"
OLA_EgoLeft1Lane	The object is located between the ego and left neighbouring lane.	"exemplary"
OLA_Left2Lane	The object is in the second-left neighbouring lane.	"exemplary"
OLA_Right2Lane	The object is in the second-right neighbouring lane.	"exemplary"

A.2.65 Angle between object edge and lane {left edge right lane, right edge left lane}

Table A.153 — Signal: Angle between object edge and lane {left edge right lane, right edge left lane}

Name	Angle between object edge and lane {left edge right lane, right edge left lane}		
Description	{left edge right lane}: angle between the left edge of the object and the right centre of the ego-vehicle lane's road marking. {right edge left lane}: angle between the right edge of the object and the left centre of the ego-vehicle lane's road marking. Additional information: Signal, definition of 0 rad and positive angle is defined in Figure A.10 – key 3. The edge is always the nearest edge of the object's bounding box to the ego-vehicle. The centre of the road marking is the basis for the calculation.		
Value type	2D vector real value	**Unit**	(rad, rad)



Key

1 object is in the first-left neighbouring lane of the ego-vehicle

2 object is in the ego-vehicle lane

3 object is in the first-right neighbouring lane of the ego-vehicle

α position angle {left edge right lane}

Figure A.10 — Example for the signal: "Angle between object edge and lane {left edge right lane, right edge left lane}" (A.2.65) with left edge of the object and the right centre of the ego-vehicle lane's road marking

A.2.66 Angle between object edge and lane {left edge right lane, right edge left lane} – error

Table A.154 — Signal: Angle between object edge and lane {left edge right lane, right edge left lane} – error

Name	Angle between object edge and lane {left edge right lane, right edge left lane} – error		
Description	The signal “Angle between object edge and lane {left edge right lane, right edge left lane} – error” (A.2.66) provides the error of the signal “Angle between object edge and lane {left edge right lane, right edge left lane}” (A.2.65).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Angle between object edge and lane {left edge right lane, right edge left lane}” (A.2.65).

A.2.67 Percentage side lane {left, right}

Table A.155 — Signal: Percentage side lane {left, right}

Name	Percentage side lane {left, right}		
Description	The signal “Percentage side lane {left, right}” (A.2.67) provides the {left, right} assignment of the object to specified lane in percent. Additional information: The signal “Percentage side lane {left, right}” (A.2.67) provides the percentage value of the object width in the corresponding {left, right} lane. The centre of the road marking is the basis for the calculation.		
Value type	[0…100] 2D vector real value	**Unit**	(%, %)

A.2.68 Angular position {azimuth}

Table A.156 — Signal: Angular position {azimuth}

Name	Angular position {azimuth}		
Description	The signal “Angular position {azimuth}” (A.2.68) provides the lateral position of the bounding box centre (midside, midwidth, midheight) measured in the 2D image as {azimuth} angle in the sensor’s coordinate system. Additional information: It requires a calibrated sensor.		
Value type	1D vector real value	**Unit**	rad

A.2.69 Angular velocity {azimuth}

Table A.157 — Signal: Angular velocity {azimuth}

Name	Angular velocity {azimuth}
Description	The signal “Angular velocity {azimuth}” (A.2.69) provides the angular {azimuth} velocity of the bounding box centre (midside, midwidth, midheight) measured in the 2D image in the sensor's coordinate system. Additional information: It requires a calibrated sensor.

Value type	1D vector real value	**Unit**	rad/s

A.2.70 Scale change – object level

Table A.158 — Signal: Scale change – object level

Name	Scale change – object level		
Description	The signal “Scale change – object level” (A.2.70) provides the change in scale of the object in sensor’s projection plane. It indicates whether the object gets closer to the ego-vehicle (possible collision) or if it is departing from the ego-vehicle.		
Value type	real value	**Unit**	%/s

A.2.71 Entity radar cross section

Table A.159 — Signal: Entity radar cross section

Name	Entity radar cross section		
Description	The signal “Entity radar cross section” (A.2.71) provides the radar cross section (RCS) of the recognised object. Additional information: It is the representative RCS of the complete recognised object.		
Value type	real value	**Unit**	dB m^2

A.2.72 Entity lidar reflectivity

Table A.160 — Signal: Entity lidar reflectivity

Name	Entity lidar reflectivity		
Description	The signal “Entity lidar reflectivity” (A.2.72) provides the lidar reflectivity of the recognised object, assuming homogeneous Lambertian reflectivity for the used laser wavelength. Additional information: It is the representative lidar reflectivity of the complete recognised object.		
Value type	real value	**Unit**	%

A.2.73 Road type – object level

Table A.161 — Signal: Road type – object level

Name	Road type – object level		
Description	The signal “Road type – object level” (A.2.73) provides the relevant type of the road for the ego-vehicle.		
Value type	enumeration	**Unit**	1

Table A.162— Enumeration: Road type – object level – Example enumerators

Name	**Description**	**RL enumerator**
RT_Motorway	The road characteristics meet motorway/highway/expressway/dual carriageway conditions.	“exemplary”

Name	Description	RL enumerator
RT_Interurban	The road characteristics meet interurban road conditions.	“exemplary”
RT_Rural	The road characteristics meet rural conditions.	“exemplary”
RT_City	The road characteristics meet city/urban conditions.	“exemplary”
RT_Suburb	The road characteristics meet suburb conditions.	“exemplary”
RT_ParkingPlace	The road characteristics meet parking place conditions.	“exemplary”
RT_EnclosedPark	The road characteristics meet enclosed park conditions.	“exemplary”
RT_OffRoad	The road characteristics meet off road conditions.	“exemplary”

A.2.74Road type – confidence

Table A.163 — Signal: Road type – confidence

Name	Road type – confidence		
Description	The signal “Road type – confidence" (A.2.74) provides the certainty for the corresponding signal “Road type – object level” (A.2.73).		
Value type	[0…100] real value	**Unit**	%

A.2.75Number of valid road surface classifications

Table A.164 — Signal: Number of valid road surface classifications

Name	Number of valid road surface classifications		
Description	The signal “Number of valid road surface classifications” (A.2.75) provides the current number of valid tuples for road surface classifications. The tuples are defined by the signals “Road surface classification type – object level” (A.2.76) and “Road surface classification type – confidence” (A.2.77).		
Value type	[0…] integer value	**Unit**	1

A.2.76Road surface classification type – object level

Table A.165 — Signal: Road surface classification type – object level

Name	Road surface classification type – object level		
Description	The signal “Road surface classification type – object level” (A.2.76) provides the relevant type of the road surface for the ego-vehicle.		
Value type	enumeration	**Unit**	1

Table A.166— Enumeration: Road surface classification type – object level – Example enumerators

Name	Description	RL enumerator
RSCT_Flat	The road is a smooth-surface road.	“exemplary”
RSCT_Concrete	The road is a concrete road with a smooth surface.	“exemplary”
RSCT_Asphalt	The road is an asphalt road with a smooth surface.	“exemplary”
RSCT_Bumpy	The road is bumpy.	“exemplary”
RSCT_RomanRoad	The road is a cobblestone street.	“exemplary”

Name	Description	RL enumerator
RSCT_Gravel	The road has a gravel surface.	“exemplary”
RSCT_Soil	The road has a soil surface.	“exemplary”
RSCT_Sand	The road has a sand surface.	“exemplary”
RSCT_OffRoad	The road is an off-road road.	“exemplary”
RSCT_Vegetation	The road has a vegetation surface.	“exemplary”

A.2.77 Road surface classification type – confidence

Table A.167 — Signal: Road surface classification type – confidence

Name	Road surface classification type – confidence		
Description	The signal “Road surface classification type – confidence” (A.2.77) provides the certainty for the corresponding signal “Road surface classification type – object level” (A.2.76).		
Value type	[0…100] real value	**Unit**	%

A.2.78 Road surface roughness – object level

Table A.168 — Signal: Road surface roughness – object level

Name	Road surface roughness – object level		
Description	The signal “Road surface roughness – object level” (A.2.78) provides the relevant roughness or unevenness of the road surface for the ego-vehicle. Additional information: The international roughness index (IRI) has a value range from 0 = mm/m (smooth surface which is equivalent to driving on a plate of glass) up to 20 mm/m (a very rough road).		
Value type	[0…] real value	**Unit**	mm/m

A.2.79 Road surface texture – object level

Table A.169 — Signal: Road surface texture – object level

Name	Road surface texture – object level		
Description	The signal “Road surface texture – object level” (A.2.79) provides the surface texture or fine roughness [16] measures only wavelengths below 0,5 m, compared to the signal’s value “Road surface roughness – object level” (A.2.78) (0,5 m – 100 m).		
Value type	real value	**Unit**	m

A.2.80 Number of valid road surface condition classifications

Table A.170 — Signal: Number of valid road surface condition classifications

Name	Number of valid road surface condition classifications
Description	The signal “Number of valid road surface condition classifications” (A.2.80) provides the current number of valid tuples for road surface condition classifications. The tuples are defined by the signals “Road surface condition classification type – object level” (A.2.81) and “Road surface condition classification type – confidence” (A.2.82).

Value type	[0…] integer value	**Unit**	1

A.2.81 Road surface condition classification type – object level

Table A.171 — Signal: Road surface condition classification type – object level

Name	Road surface condition classification type – object level		
Description	The signal "Road surface condition classification type – object level" (A.2.81) provides the relevant condition of the road surface for the ego-vehicle.		
Value type	enumeration	**Unit**	1

Table A.172— Enumeration: Road surface condition classification type – object level – Example enumerators

Name	**Description**	**RL enumerator**
RSCCT_Dry	The road surface is dry.	"exemplary"
RSCCT_Wet	The road surface is wet.	"exemplary"
RSCCT_Water	The road surface is covered with water.	"exemplary"
RSCCT_Snow	The road surface is covered with snow.	"exemplary"
RSCCT_Ice	The road surface is covered with ice.	"exemplary"
RSCCT_Leaves	The road surface is covered with leaves.	"exemplary"
RSCCT_Dust	The road surface is covered with dust.	"exemplary"
RSCCT_Dirt	The road surface is covered with dirt.	"exemplary"

A.2.82 Road surface condition classification type – confidence

Table A.173 — Signal: Road surface condition classification type – confidence

Name	Road surface condition classification type – confidence		
Description	The signal "Road surface condition classification type – confidence" (A.2.82) provides the certainty for the corresponding signal "Road surface condition classification type – object level" (A.2.81).		
Value type	[0…100] real value	**Unit**	%

A.2.83 Number of valid road marking classifications

Table A.174 — Signal: Number of valid road marking classifications

Name	Number of valid road marking classifications		
Description	The signal "Number of valid road marking classifications" (A.2.83) provides the current number of valid tuples for road marking types. The tuples are defined by the signals "Road marking type" (A.2.84) and "Road marking type – confidence" (A.2.85).		
Value type	[0…] integer value	**Unit**	1

A.2.84 Road marking type

Table A.175 — Signal: Road marking type

Name	Road marking type

Description	The signal “Road marking type” (A.2.84) indicates the type of the road markings.		
Value type	enumeration	**Unit**	1

Table A.176— Enumeration: Road marking type – Example enumerators

Name	Description	RL enumerator
RMT_Solid	The road marking is solid. It could also be a stop line.	“exemplary”
RMT_CentreLineDashedMarking	The centre-line road marking is dashed. See ISO 11270:2014, Annex B.	“exemplary”
RMT_EdgeLineDashedMarking	The edge-line road marking is dashed. See ISO 11270:2014, Annex B.	“exemplary”
RMT_Triangular	The road marking is a line of triangles.	“exemplary”
RMT_DoubleLineSolid	The road marking has two lines and the most inner line (with respect to the ego-vehicle) is solid.	“exemplary”
RMT_CentreLineDoubleLineDashed	The centre-line road marking has two lines and the most inner line (with respect to the ego-vehicle) is dashed. See ISO 11270:2014, Annex B.	“exemplary”
RMT_EdgeLineDoubleLineDashed	The edge-line road marking has two lines and the most inner line (with respect to the ego-vehicle) is dashed. See ISO 11270:2014, Annex B.	“exemplary”
RMT_MultipleLineSolid	The road marking has more than two lines and the most inner line (with respect to the ego-vehicle) is solid.	“exemplary”
RMT_CentreLineMultipleLineDashed	The centre-line road marking has more than two lines and the most inner line (with respect to the ego-vehicle) is dashed. See ISO 11270:2014, Annex B.	“exemplary”
RMT_EdgeLineMultipleLineDashed	The edge-line road marking has more than two lines and the most inner line (with respect to the ego-vehicle) is dashed. See ISO 11270:2014, Annex B.	“exemplary”
RMT_BottsDotsCatsEyes	The road marking consists of Botts' dots or cats' eyes.	“exemplary”
RMT_AttentionMarker	The road marking is an attention marker, for example, US, China and Japan.	“exemplary”
RMT_Hatched	The road marking is hatched/chevron.	“exemplary”
RMT_Box	The road marking of a junction.	“exemplary”
RMT_ColouredArea	The road marking is a coloured area.	“exemplary”
RMT_Arrow	The road marking is an arrow.	“exemplary”
RMT_ZebraCrossing	The road marking is a zebra crossing/continental/ladder.	“exemplary”
RMT_GenericSymbol	The road marking is a generic symbol or icon.	“exemplary”
RMT_TrafficSignOnLane	The road marking is a traffic sign.	“exemplary”

RMT_GenericLine	The road marking is a generic line.	“exemplary”
RMT_ParkingArea	The road marking is a parking area.	“exemplary”
RMT_TShapeMarkingBegin	The road marking is a parking T-shape beginning parking line.	“exemplary”
RMT_TShapeMarkingEnd	The road marking is a parking T-shape ending parking line.	“exemplary”
RMT_IShapeMarkingBegin	The road marking is a parking I-shape beginning parking line.	“exemplary”
RMT_IShapeMarkingEnd	The road marking is a parking I-shape ending parking line.	“exemplary”
RMT_LShapeMarkingBegin	The road marking is a parking L-shape beginning parking line.	“exemplary”
RMT_LShapeMarkingEnd	The road marking is a parking L-shape ending parking line.	“exemplary”
RMT_Nets	The road marking is a net, specifically a non-stopping area.	“exemplary”

A.2.85 Road marking type – confidence

Table A.177 — Signal: Road marking type – confidence

Name	Road marking type – confidence		
Description	The signal “Road marking type – confidence” (A.2.85) provides the confidence of the classified signal “Road marking type” (A.2.84) information.		
Value type	[0…100] real value	**Unit**	%

A.2.86 Road object lane association

Table A.178 — Signal: Road object lane association

Name	Road object lane association		
Description	The signal “Road object lane association” (A.2.86) provides the association of a road marking or a road boundary to a lane with respect to the ego-vehicle lane, that means the ego lane.		
Value type	enumeration	**Unit**	1

Table A.179— Enumeration: Road object lane association – Example enumerators

Name	**Description**	**RL enumerator**
ROLA_EgoLane	The road marking is on the ego lane.	“exemplary”
ROLA_EgoLeft1Lane	The road boundary separates the ego lane from 1st left neighbouring lane. The road marking is associated to the ego lane and the 1st left neighbouring lane.	“exemplary”
ROLA_EgoRight1Lane	The road boundary separates the ego lane from 1st right neighbouring lane. The road marking is associated to the ego lane and the 1st right neighbouring lane.	“exemplary”
ROLA_Left1Lane	The road marking is on the 1st left neighbouring lane.	“exemplary”

ROLA_Right1Lane	The road marking is on the 1st right neighbouring lane.	"exemplary"
ROLA_Left1Left2Lane	The road boundary separates the 1st left lane from the 2nd left neighbouring lane. The road marking is associated to the 1st left and the 2nd left neighbouring lanes.	"exemplary"
ROLA_Right1Right2Lane	The road boundary separates the 1st right lane from the 2nd right neighbouring lane. The road marking is associated to the 1st right and the 2nd right neighbouring lanes.	"exemplary"
ROLA_Left2Lane	The road marking is on the 2nd left neighbouring lane.	"exemplary"
ROLA_Right2Lane	The road marking is on the 2nd right neighbouring lane.	"exemplary"
ROLA_LeftRoadEdge	The road boundary limits at the outer edge of the leftmost lane.	"exemplary"
ROLA_RightRoadEdge	The road boundary limits at the outer edge of the rightmost lane.	"exemplary"

A.2.87 Road object lane association – confidence

Table A.180 — Signal: Road object lane association – confidence

Name	Road object lane association – confidence		
Description	The signal "Road object lane association – confidence" (A.2.87) provides the confidence of the signal's "Road object lane association" (A.2.86) information.		
Value type	[0…100] real value	**Unit**	%

A.2.88 Arrow orientation {yaw}

Table A.181 — Signal: Arrow orientation {yaw}

Name	Arrow orientation {yaw}		
Description	The signal "Arrow orientation {yaw}" (A.2.88) provides the orientation of the arrow symbol on the ground plane with respect to the driving direction of the ego-vehicle. Additional information: The signal "Arrow orientation {yaw}" (A.2.88) ≔ 0 rad, if the signal "Road marking type" (A.2.84) does not have the enumerator "RMT_Arrow".		
Value type	1D vector real value	**Unit**	rad

A.2.89 Arrow direction

Table A.182 — Signal: Arrow direction

Name	Arrow direction
Description	The signal "Arrow direction" (A.2.89) provides the estimated direction of the displayed arrow on the lane. Additional information: The enumerator "AD_Foreward", which essentially means 0 rad, points in the direction of driving straight ahead on the associated lane. The signal "Arrow direction" (A.2.89) ≔ "AD_Foreward", if the signal "Road marking type" (A.2.84) does not have the enumerator "RMT_Arrow".

Value type	enumeration	**Unit**	1

Table A.183 — Enumeration: Arrow direction – Example enumerators

Name	**Description**	**RL enumerator**
AD_Foreward	The arrow has an estimated direction of 0 rad (0 °).	“exemplary”
AD_Left	The arrow has an estimated direction of $+\frac{\pi}{2}$ rad (+90 °).	“exemplary”
AD_Right	The arrow has an estimated direction of $-\frac{\pi}{2}$ rad (−90 °).	“exemplary”
AD_StraightLeft	The arrow is straight left and has an estimated direction of $+\frac{\pi}{2}$ rad (+90 °).	“exemplary”
AD_StraightRight	The arrow is straight right and has an estimated direction of $-\frac{\pi}{2}$ rad (−90 °).	“exemplary”
AD_TurningPointLeft	The arrow has an estimated direction of $+\pi$ rad (+180 °), that means a U-turn left.	“exemplary”
AD_TurningPointRight	The arrow has an estimated direction of $-\pi$ rad (−180 °), that means a U-turn right.	“exemplary”
AD_45DegLeft	The arrow has an estimated direction of $+\frac{\pi}{4}$ rad (+45 °).	“exemplary”
AD_45DegRight	The arrow has an estimated direction of $-\frac{\pi}{4}$ rad (−45 °).	“exemplary”
AD_NoArrow	No arrow is present.	“exemplary”

A.2.90 Number of valid sign classifications

Table A.184 — Signal: Number of valid sign classifications

Name	Number of valid sign classifications		
Description	The signal “Number of valid sign classifications” (A.2.90) provides the current number of valid tuples for sign classifications. The tuples are defined by the signals “Sign classification type” (A.2.91) and “Sign classification type – confidence” (A.2.92).		
Value type	[0…] integer value	**Unit**	1

A.2.91 Sign classification type

Table A.185 — Signal: Sign classification type

Name	Sign classification type		
Description	The signal “Sign classification type” (A.2.91) provides the type of the sign for a main sign or a sign as a road marking.		
Value type	enumeration	**Unit**	1

Table A.186 — Enumeration: Sign classification type – Example enumerators

Name	**Description**	**RL enumerator**
SCT_StopSign	The sign is a stop sign.	“exemplary”
SCT_YieldSign	The sign is a yield sign.	“exemplary”
SCT_SpeedLimitSign	The sign is a speed limit sign.	“exemplary”

Name	Description	RL enumerator
SCT_NoMainSign	The sign is no main sign: it is only one or multiple supplementary signs.	"exemplary"
SCT_GreenArrowSign	The sign is a green arrow sign at traffic lights.	"exemplary"
SCT_HeightLimitSign	The sign is a height limit sign.	"exemplary"
SCT_WidthLimitSign	The sign is a width limit sign.	"exemplary"
SCT_MessageSign	The sign is a message sign.	"exemplary"
SCT_EmptySign	The sign may be a changeable traffic sign without displaying a traffic sign symbol.	"exemplary"

A.2.92 Sign classification type – confidence

Table A.187 — Signal: Sign classification type – confidence

Name	Sign classification type – confidence		
Description	The signal "Sign classification type – confidence" (A.2.92) provides the confidence for the signal's "Sign classification type" (A.2.91) classification information, for example, the degree of certainty that the sign is of the reported type, for example, stop sign.		
Value type	[0...100] real value	**Unit**	%

A.2.93 Sign value

Table A.188 — Signal: Sign value

Name	Sign value		
Description	The signal "Sign value" (A.2.93) provides the depicted numerical value on the sign.		
Value type	real value	**Unit**	The unit is defined by the enumerator of the signal "Sign value unit" (A.2.94).

A.2.94 Sign value unit

Table A.189 — Signal: Sign value unit

Name	Sign value unit		
Description	The signal "Sign value unit" (A.2.94) provides the unit which the numerical value of the signal "Sign value" (A.2.93) is referring to.		
Value type	enumeration	**Unit**	1

Table A.190 — Enumeration: Sign value unit – Example enumerators

Name	Description	RL enumerator
SVU_KilometrePerHour	The unit for the sign value is kilometre per hour.	"exemplary"
SVU_MilePerHour	The unit for the sign value is mile per hour.	"exemplary"
SVU_Metre	The unit for the sign value is metre.	"exemplary"
SVU_Kilometre	The unit for the sign value is kilometre.	"exemplary"
SVU_Feet	The unit for the sign value is feet.	"exemplary"
SVU_Mile	The unit for the sign value is mile.	"exemplary"

Name	Description	RL enumerator
SVU_MetricTon	The unit for the sign value is metric ton.	“exemplary”
SVU_LongTon	The unit for the sign value is long ton.	“exemplary”
SVU_ShortTon	The unit for the sign value is short ton.	“exemplary”
SVU_Minute	The unit for the sign value is minute.	“exemplary”
SVU_Hour	The unit for the sign value is hour.	“exemplary”
SVU_Day	The unit for the sign value is the day of the month.	“exemplary”
SVU_Weekday	The unit for the sign value is the weekday. The numeric value of the weekday is defined as: - Sunday [Sign value (A.2.93) ≔ 0] - ... - Saturday [Sign value (A.2.93) ≔ 6]	“exemplary”
SVU_Percentage	The unit for the sign value is percentage.	“exemplary”

A.2.95 Sign text

Table A.191 — Signal: Sign text

Name	Sign text		
Description	The signal “Sign text” (A.2.95) provides the text message on the sign. The message may be multiline.		
Value type	string	**Unit**	1

A.2.96 Sign text font

Table A.192 — Signal: Sign text font

Name	Sign text font		
Description	The signal “Sign text font” (A.2.96) describes the font style of the text on the sign.		
Value type	enumeration	**Unit**	1

Table A.193 — Enumeration: Sign text font – Example enumerators

Name	Description	RL enumerator
STF_Regular	The font style of the text on the sign is regular.	“exemplary”
STF_Bold	The font style of the text on the sign is bold.	“exemplary”
STF_Italic	The font style of the text on the sign is italic.	“exemplary”
STF_BoldItalic	The font style of the text on the sign is bold and italic.	“exemplary”

A.2.97 Sign text – confidence

Table A.194 — Signal: Sign text – confidence

Name	Sign text – confidence
Description	The signal “Sign text – confidence” (A.2.97) provides the confidence for the text signal “Sign text” (A.2.95) and the text font signal “Sign text font” (A.2.96).

Value type	[0…100] real value	**Unit**	%

A.2.98 Number of valid entity states

Table A.195 — Signal: Number of valid entity states

Name	Number of valid entity states		
Description	The signal “Number of valid entity states” (A.2.98) provides the current number of valid states [see signal “Entity state” (A.2.99)] of an entity, for example, a sign, a traffic sign board region.		
Value type	[0…] integer value	**Unit**	1

A.2.99 Entity state

Table A.196 — Signal: Entity state

Name	Entity state		
Description	The signal “Entity state” (A.2.99) describes the state of an entity of signs or traffic sign boards. It describes, for example, whether or not the message of the entity is variable/changeable, static or if that information is not available. It describes also, if, for example, the traffic sign is out of service, because the symbol is crossed out.		
Value type	enumeration	**Unit**	1

Table A.197 — Enumeration: Entity state – Example enumerators

Name	**Description**	**RL enumerator**
ES_Static	The message sign is a static (non-variable) message sign.	“exemplary”
ES_Variable	The message sign is a variable message sign.	“exemplary”
ES_VariableNonAnimated	The message sign is a variable message sign without animation.	“exemplary”
ES_VariableAnimated	The message sign is a variable message sign with animation.	“exemplary”
ES_SwitchedOff	The message sign is a variable message sign which is switched off.	“exemplary”
ES_FullOutOfService	The message sign is full out of service.	“exemplary”
ES_PartlyOutOfService	Part of the message sign is out of service.	“exemplary”
ES_OutOfView	The message sign has rotated.	“exemplary”
ES_PartlyOccluded	The message sign is partly occluded.	“exemplary”

A.2.100 Colour value – object level

Table A.198 — Signal: Colour value – object level

Name	Colour value – object level		
Description	The signal “Colour value – object level” (A.2.100) provides the colour value(s). The number of values depends on the signal “Colour model type” (A.1.14). Additional information: For example, enumerator “CMT_RGB” indicates 3 colour values, specifically first value red, second value green, third value blue.		
Value type	[0…100] real value	**Unit**	%

A.2.101 Colour tone – confidence – object level

Table A.199 — Signal: Colour tone – confidence – object level

Name	Colour tone – confidence – object level		
Description	The signal “Colour tone – confidence – object level” (A.2.101) provides the confidence of the colour tone. The colour tone is defined by the signal “Colour model type” (A.1.14) and the list of signals “Colour value – object level” (A.2.100).		
Value type	[0…100] real value	**Unit**	%

A.2.102 Number of valid connections

Table A.200 — Signal: Number of valid connections

Name	Number of valid connections		
Description	The signal “Number of valid connections” (A.2.102) provides the current number of valid tuples for connections. The tuples are defined by the signal “Connection type” (A.2.103) and unique signal’s “Connection grouping ID” (A.2.104) value for each connection.		
Value type	[0…] integer value	**Unit**	1

A.2.103 Connection type

Table A.201 — Signal: Connection type

Name	Connection type		
Description	The signal “Connection type” (A.2.103) provides the type of connection of at least two road marking’s polylines or polynomials.		
Value type	enumeration	**Unit**	1

Table A.202 — Enumeration: Connection type – Example enumerators

Name	Description	RL enumerator
CT_Merge	The connection of road markings is a merge (from the point of view of the ego-vehicle) of road markings.	“exemplary”
CT_Split	The connection of road markings is a split (from the point of view of the ego-vehicle) of road markings.	“exemplary”
CT_Interconnection	The connection of road markings is an interconnection of road markings.	“exemplary”
CT_Extension	The connection of road markings is an extension of two road markings.	“exemplary”

A.2.104 Connection grouping ID

Table A.203 — Signal: Connection grouping ID

Name	Connection grouping ID

Description	The signal "Connection grouping ID" (A.2.104) provides a unique grouping ID linking all connected road boundaries together. Additional information: The signal "Connection grouping ID" (A.2.104) shall be unique in each cycle of the sensor cluster.		
Value type	[…] integer value	**Unit**	1

A.2.105 Vertex point {x, y, z}

Table A.204 — Signal: Vertex point {x, y, z}

Name	Vertex point {x, y, z}		
Description	The signal "Vertex point {x, y, z}" (A.2.105) provides the measured longitudinal, lateral and vertical distance of the vertex point.		
Value type	3D vector real value	**Unit**	(m, m, m)

A.2.106 Vertex point {x, y, z} – error

Table A.205 — Signal: Vertex point {x, y, z} – error

Name	Vertex point {x, y, z} – error		
Description	The signal "Vertex point {x, y, z} – error" (A.2.106) provides the measured error of the signal "Vertex point {x, y, z}" (A.2.105).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Vertex point {x, y, z}" (A.2.105).

A.2.107 Vertex point – confidence {x, y, z}

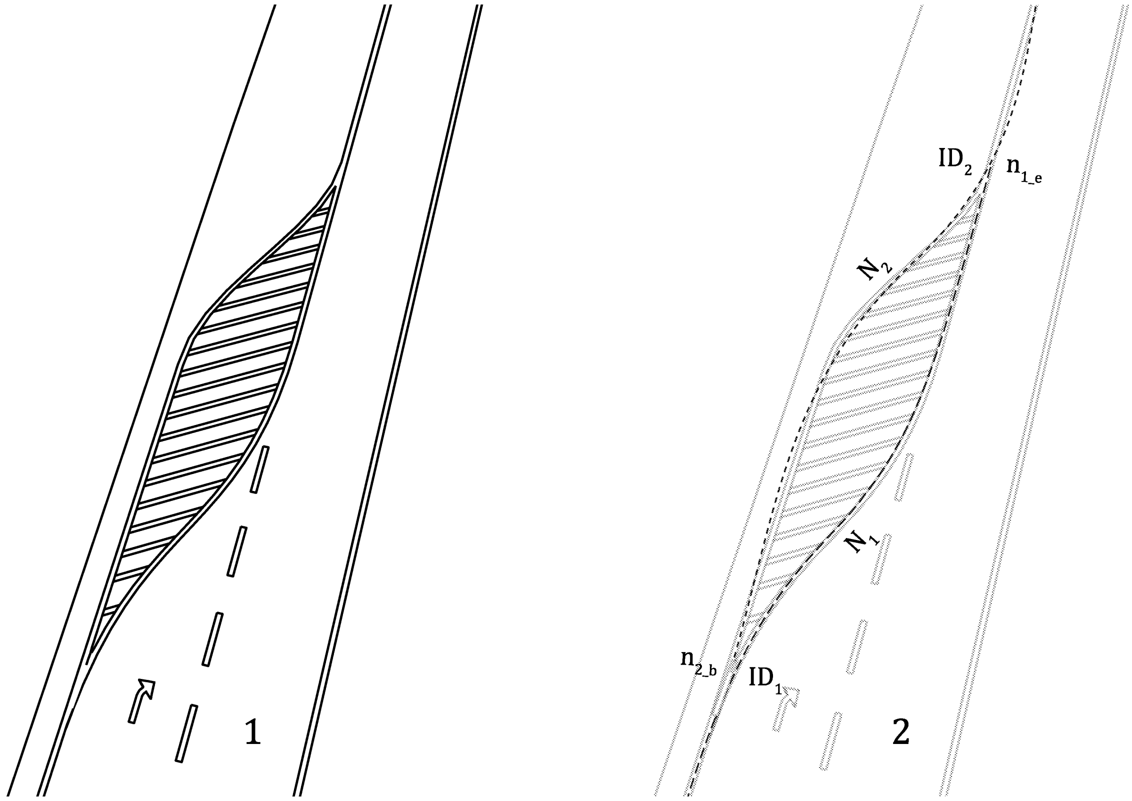
Table A.206 — Signal: Vertex point – confidence {x, y, z}

Name	Vertex point – confidence {x, y, z}		
Description	The signal "Vertex point – confidence {x, y, z}" (A.2.107) provides the confidence of the measured longitudinal, lateral and vertical distance of the vertex point.		
Value type	[0…100] real value	**Unit**	%

A.2.108 Number of valid polynomials

Table A.207 — Signal: Number of valid polynomials

Name	Number of valid polynomials		
Description	The signal "Number of valid polynomials" (A.2.108) provides the current number of valid polynomials to describe the shape (see Figure A.11).		
Value type	[0…] integer value	**Unit**	1



Key

1 real-world scene

2 polynomial contour representation with 2 polynomials and 2 road marking connections

N_x x^{th} polynomial

n_{x_b} range begin of the x^{th} polynomial [see “Polynomial range x {begin, end}” (A.2.113)]

n_{x_e} range end of the x^{th} polynomial [see “Polynomial range x {begin, end}” (A.2.113)]

ID_x road marking connection - signal “Connection grouping ID” (A.2.104) := x

Figure A.11 — Example for a polynomial contour representation

A.2.109 Polynomial coefficient y {c_0, c_1, c_2, c_3}

Table A.208 — Signal: Polynomial coefficient y {c_0, c_1, c_2, c_3}

Name	Polynomial coefficient y {c_0, c_1, c_2, c_3}		
Description	The signal “Polynomial coefficient y {c_0, c_1, c_2, c_3}” (A.2.109) provides the calculated coefficients for the *Y*-axis value of the polynomial line. Calculation method: $y = c_0 + c_1 \cdot x + c_2 \cdot x^2 + c_3 \cdot x^3$ where: c_0: is the coefficient for degree 0, c_1: is the coefficient for degree 1, c_2: is the coefficient for degree 2, c_3: is the coefficient for degree 3 and x: is the value of the *X*-axis in m [see signal “Polynomial range x {begin, end}” (A.2.113)].		
Value type	4D vector real value	**Unit**	(m, 1, 1/m, 1/m²)

A.2.110 Polynomial coefficient z {c_0, c_1, c_2, c_3}

Table A.209 — Signal: Polynomial coefficient z {c_0, c_1, c_2, c_3}

Name	Polynomial coefficient z {c_0, c_1, c_2, c_3}		
Description	The signal "Polynomial coefficient z {c_0, c_1, c_2, c_3}" (A.2.110) provides the calculated coefficients for the *Z*-axis value of the polynomial line. Calculation method: $z = c_0 + c_1 \cdot x + c_2 \cdot x^2 + c_3 \cdot x^3$ where: c_0: is the coefficient for degree 0, c_1: is the coefficient for degree 1, c_2: is the coefficient for degree 2, c_3: is the coefficient for degree 3 and x: is the value of the *X*-axis in m [see signal "Polynomial range x {begin, end}" (A.2.113)].		
Value type	4D vector real value	**Unit**	(m, 1, 1/m, 1/m²)

A.2.111 Polynomial y – error

Table A.210 — Signal: Polynomial y – error

Name	Polynomial y – error		
Description	The signal "Polynomial y – error" (A.2.111) provides the error of the *Y*-axis value of the polynomial line. The unit and the error definition for the signal "Polynomial y – error" (A.2.111) are defined during the system design phase.		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Polynomial coefficient y {c_0, c_1, c_2, c_3}" (A.2.109).

A.2.112 Polynomial z – error

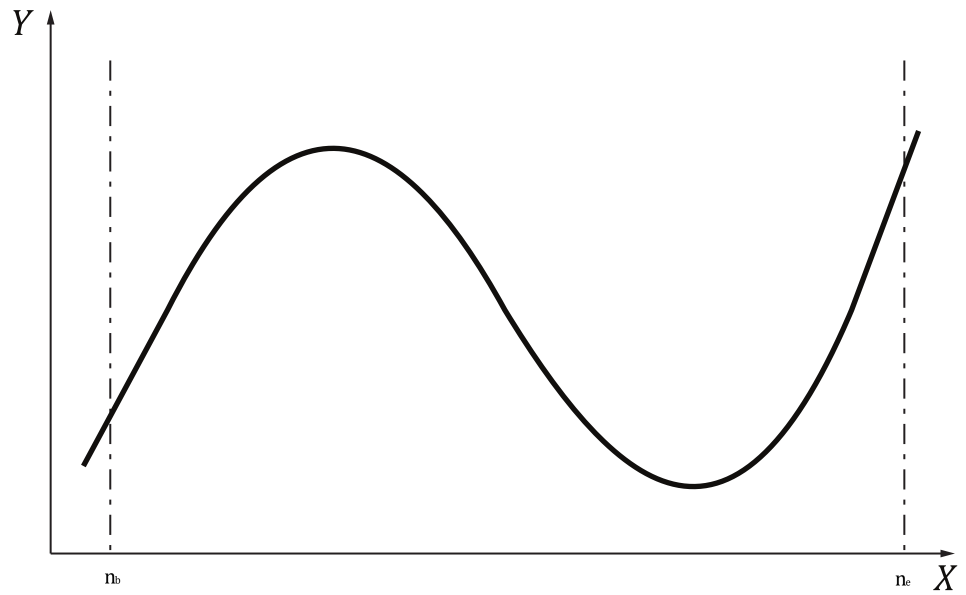
Table A.211 — Signal: Polynomial z – error

Name	Polynomial z – error		
Description	The signal "Polynomial z – error" (A.2.112) provides the error of the *Z*-axis value of the polynomial line. The unit and the error definition for the signal "Polynomial z – error" (A.2.112) are defined during the system design phase.		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Polynomial coefficient z {c_0, c_1, c_2, c_3}" (A.2.110).

A.2.113 Polynomial range x {begin, end}

Table A.212 — Signal: Polynomial range x {begin, end}

Name	Polynomial range x {begin, end}		
Description	The signal "Polynomial range x {begin, end}" (A.2.113) provides the valid range of the polynomials [x_{Begin}, x_{End}] (see Figure A.12).		
Value type	2D vector real value	**Unit**	(m, m)



Key

X-axis and Y-axis: vehicle axis system

n_b, n_e {begin} and {end} of signal “Polynomial range x {begin, end}” (A.2.113)

Figure A.12 — Example for the signal “Polynomial range x {begin, end}” (A.2.113) for signal “Polynomial coefficient y {c_0, c_1, c_2, c_3}” (A.2.109)

A.2.114 Extent {width, height} – polynomial

Table A.213 — Signal: Extent {width, height} – polynomial

Name	Extent {width, height} – polynomial		
Description	The signal “Extent {width, height} – polynomial” (A.2.114) provides the measured width and height at the X-axis value $(x_{\text{Begin}} + x_{\text{End}})/2$ [see “Polynomial range x {begin, end}” (A.2.113)]. The width information is relative to the polynomial line which defines the centre of the width range. The height of the road object is added to the polynomial z value.		
Value type	2D vector real value	**Unit**	(m, m)

A.2.115 Extent {width, height} – polynomial – error

Table A.214 — Signal: Extent {width, height} – polynomial – error

Name	Extent {width, height} – polynomial – error		
Description	The signal “Extent {width, height} – polynomial – error” (A.2.115) provides the error of the signal “Extent {width, height} – polynomial” (A.2.114).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Extent {width, height} – polynomial” (A.2.114).

A.2.116 Extent {width, height} – polynomial – confidence

Table A.215 — Signal: Extent {width, height} – polynomial – confidence

Name	Extent {width, height} – polynomial – confidence

Description	The signal "Extent {width, height} – polynomial – confidence" (A.2.116) provides the confidence of the width and height for the polynomial segment.		
Value type	2D vector [0…100] real value	**Unit**	(%, %)

A.2.117 Number of valid data ranges

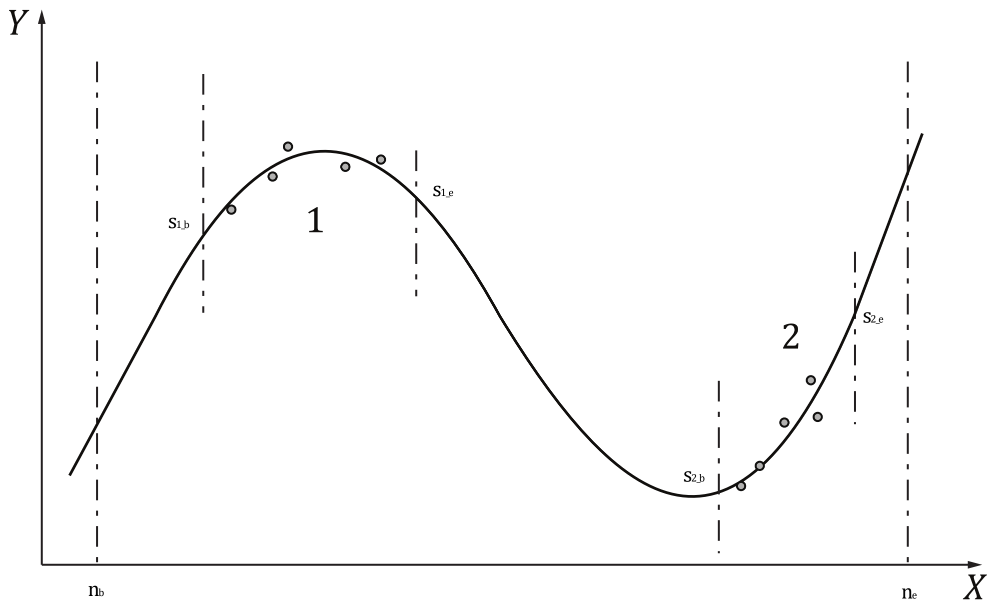
Table A.216 — Signal: Number of valid data ranges

Name	Number of valid data ranges		
Description	The signal "Number of valid data ranges" (A.2.117) provides the current number of valid *X*-axis data ranges for the polynomial lines.		
Value type	[0…] integer value	**Unit**	1

A.2.118 Supported data range x {begin, end}

Table A.217 — Signal: Supported data range x {begin, end}

Name	Supported data range x {begin, end}		
Description	The signal "Supported data range x {begin, end}" (A.2.118) provides the supported range of the polynomial [x_{Begin}, x_{End}] which is covered with measured points (see Figure A.13).		
Value type	2D vector real value	**Unit**	(m, m)



Key

X-axis and *Y*-axis: vehicle axis system

1 supported data range 1 with measured points

2 supported data range 2 with measured points

n_b, n_e {begin} and {end} of signal "Polynomial range x {begin, end}" (A.2.113)

s_{x_b}, s_{x_e} {begin} and {end} of the x^th^ signal "Supported data range x {begin, end}" (A.2.118)

Figure A.13 — Example for the signal "Supported data range x {begin, end}" (A.2.118) for signal "Polynomial coefficient y {c_0, c_1, c_2, c_3}" (A.2.109)

A.2.119 Supported axis

Table A.218 — Signal: Supported axis

Name	Supported axis		
Description	The signal “Supported axis” (A.2.119) provides the information of the polynomial's supported axis for the signal “Supported data range x {begin, end}” (A.2.118).		
Value type	enumeration	**Unit**	1

Table A.219 — Enumeration: Supported axis

Name	Description	RL enumerator
SA_Y	The signal “Supported data range x {begin, end}” (A.2.118) corresponds to *Y*-axis polynomial line of signal “Polynomial coefficient y {*c0, c1, c2, c3*}” (A.2.109).	Mandatory
SA_Z	The signal “Supported data range x {begin, end}” (A.2.118) corresponds to *Z*-axis polynomial line of signal “Polynomial coefficient z {c_0, c_1, c_2, c_3}” (A.2.110).	Optional
SA_YAndZ	The signal “Supported data range x {begin, end}” (A.2.118) corresponds to both polynomial lines of signal “Polynomial coefficient y {c_0, c_1, c_2, c_3}” (A.2.109) and signal “Polynomial coefficient z {c_0, c_1, c_2, c_3}” (A.2.110).	Conditional (B.2.2) * The enumeration has the enumerator “SA_Z”

A.2.120 Polyline interpolation method

Table A.220 — Signal: Polyline interpolation method

Name	Polyline interpolation method		
Description	The signal “Polyline interpolation method” (A.2.120) provides the method for interpolating between the points of a polyline. Additional information: Interpolation method may be different for *Y*-axis and *Z*-axis values.		
Value type	enumeration	**Unit**	1

Table A.221 — Enumeration: Polyline interpolation method – Example enumerators

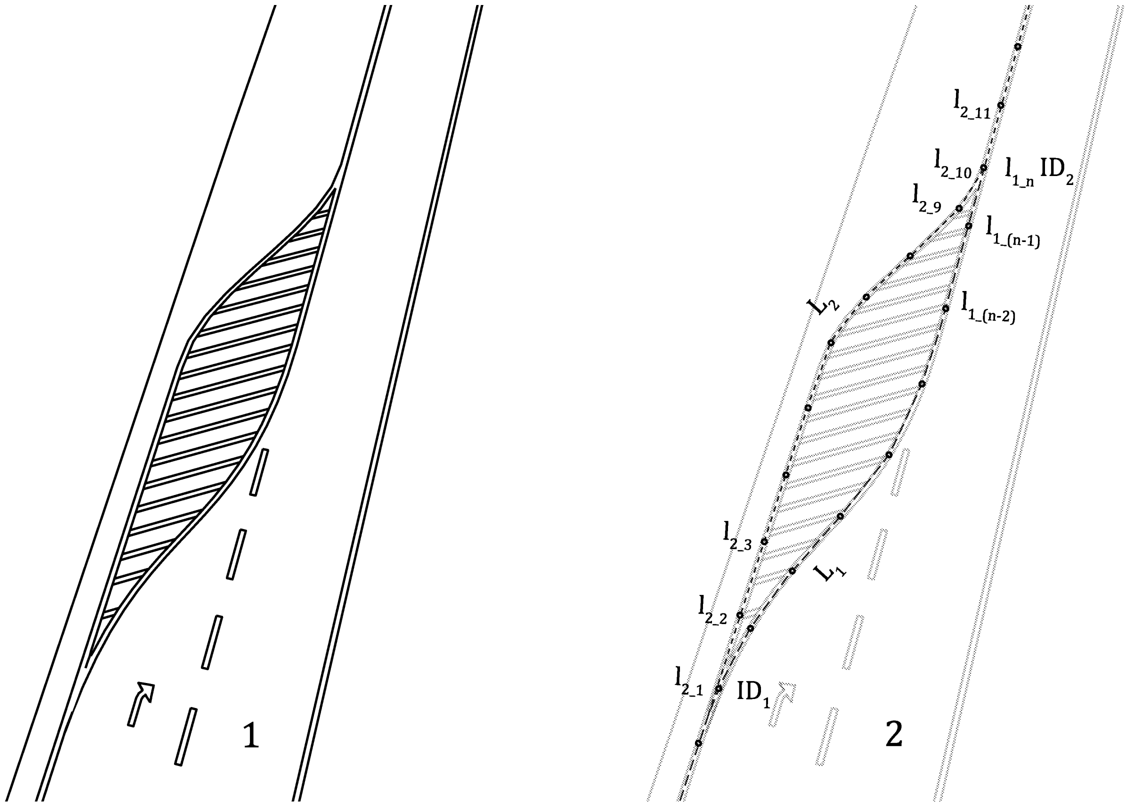
Name	Description	RL enumerator
PIM_Linear	The polyline is interpolated with a linear interpolation between two sequential points.	“exemplary”
PIM_Spline	The polyline is interpolated with a spline interpolation between two sequential points.	“exemplary”
PIM_Cubic	The polyline is interpolated with a cubic interpolation between two sequential points.	“exemplary”

A.2.121 Number of valid polylines

Table A.222 — Signal: Number of valid polylines

Name	Number of valid polylines

Description	The signal "Number of valid polylines" (A.2.121) provides the current number of valid polylines to describe a shape with multiple polylines (see Figure A.14).		
Value type	[0…] integer value	**Unit**	1



Key

1 real-world scene

2 polyline contour representation with 2 polylines (multiple vertices) and 2 road marking connections

L_x x^{th} polyline

l_{x_y} y^{th} vertex point [signal "Vertex point {x, y, z}" (A.2.105)] of the x^{th} polyline

ID_x road marking connection - signal "Connection grouping ID" (A.2.104) := x

Figure A.14 — Example for a polyline contour representation

A.2.122 Number of valid vertices

Table A.223 — Signal: Number of valid vertices

Name	Number of valid vertices		
Description	The signal "Number of valid vertices" (A.2.122) provides the current number of valid vertices of a polyline. A polyline describes a part of the shape border with one continuous segmented line (see Figure A.14) with at least 2 vertex points. Additional information: The signal "Extent {width, height} – vertex" (A.2.123) has attributes of the vertex at the point of the signal "Vertex point {x, y, z}" (A.2.105). The error and confidence signals apply to this point.		
Value type	[2…] integer value	**Unit**	1

A.2.123 Extent {width, height} – vertex

Table A.224 — Signal: Extent {width, height} – vertex

Name	Extent {width, height} – vertex		
Description	The signal “Extent {width, height} – vertex” (A.2.123) provides the measured width and height of the vertex at the vertex point of the signal “Vertex point {x, y, z}” (A.2.105). The width information is relative to the vertex which defines the centre of the width range. The height of the road object is added to the vertex point z value. Additional information: The signal applies to the point of the signal “Vertex point {x, y, z}” (A.2.105).		
Value type	2D vector real value	**Unit**	(m, m)

A.2.124 Extent {width, height} – vertex – error

Table A.225 — Signal: Extent {width, height} – vertex – error

Name	Extent {width, height} – vertex – error		
Description	The signal “Extent {width, height} – vertex – error” (A.2.124) provides the error of the measured width and height [see signal “Extent {width, height} – vertex” (A.2.123)] at the vertex point [see signal “Vertex point {x, y, z}” (A.2.105)]. Additional information: The signal applies to the point of the signal “Vertex point {x, y, z}” (A.2.105).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Extent {width, height} – vertex” (A.2.123).

A.2.125 Extent {width, height} – vertex – confidence

Table A.226 — Signal: Extent {width, height} – vertex – confidence

Name	Extent {width, height} – vertex – confidence		
Description	The signal “Extent {width, height} – vertex – confidence” (A.2.125) provides the confidence of the measured width and height of the vertex [see signal “Extent {width, height} – vertex” (A.2.123)]. Additional information: The signal applies to the point of the signal “Vertex point {x, y, z}” (A.2.105).		
Value type	2D vector [0…100] real value	**Unit**	(%, %)

A.2.126 Number of valid road boundary classifications

Table A.227 — Signal: Number of valid road boundary classifications

Name	Number of valid road boundary classifications		
Description	The signal “Number of valid road boundary classifications” (A.2.126) provides the current number of valid tuples for road boundary types. The tuples are defined by the signals “Road boundary type” (A.2.127), “Road boundary type – confidence” (A.2.128) and additional signals.		
Value type	[0…] integer value	**Unit**	1

A.2.127 Road boundary type

Table A.228 — Signal: Road boundary type

Name	Road boundary type		
Description	The signal “Road boundary type” (A.2.127) indicates the type of the road boundary.		
Value type	enumeration	**Unit**	1

Table A.229 — Enumeration: Road boundary type – Example enumerators

Name	Description	RL enumerator
RBT_GuardRail	The road boundary is a guard rail.	“exemplary”
RBT_Fence	The road boundary is a fence.	“exemplary”
RBT_Wall	The road boundary is a wall, for example, brick wall, building.	“exemplary”
RBT_Barrier	The road boundary is a barrier.	“exemplary”
RBT_TensionCableSystem	The road boundary is a tension cable system.	“exemplary”
RBT_RoadEdge	The road boundary is a road edge, for example, grass, vegetation, sand, gravel, soil.	“exemplary”
RBT_Curb	The road boundary is a curb stone.	“exemplary”

A.2.128 Road boundary type – confidence

Table A.230 — Signal: Road boundary type – confidence

Name	Road boundary type – confidence		
Description	The signal “Road boundary type – confidence” (A.2.128) provides the confidence of the classified signal “Road boundary type” (A.2.127).		
Value type	[0…100] real value	**Unit**	%

A.2.129 Number of valid general landmark classifications

Table A.231 — Signal: Number of valid general landmark classifications

Name	Number of valid general landmark classifications		
Description	The signal “Number of valid general landmark classifications” (A.2.129) provides the current number of valid tuples for general landmark classifications. The tuples are defined by the signals “General landmark classification type” (A.2.130) and “General landmark classification type – confidence” (A.2.131).		
Value type	[0…] integer value	**Unit**	1

A.2.130 General landmark classification type

Table A.232 — Signal: General landmark classification type

Name	General landmark classification type		
Description	The signal “General landmark classification type” (A.2.130) provides the classification of the general landmark.		
Value type	enumeration	**Unit**	1

Table A.233 — Enumeration: General landmark classification type – Example enumerators

Name	Description	RL enumerator
GLCT_Bridge	The general landmark is a bridge.	“exemplary”
GLCT_Beacon	The general landmark is a beacon.	“exemplary”
GLCT_Cone	The general landmark is a cone.	“exemplary”
GLCT_Barrel	The general landmark is a barrel.	“exemplary”
GLCT_GuidePost	The general landmark is a guide post.	“exemplary”
GLCT_LampPost	The general landmark is a lamp post.	“exemplary”
GLCT_VerticalStructure	The general landmark is a vertical structure.	“exemplary”
GLCT_OverheadObject	The general landmark is an overhead object.	“exemplary”
GLCT_RectangularStructure	The general landmark is a rectangular structure.	“exemplary”
GLCT_Tunnel	The general landmark is a tunnel.	“exemplary”
GLCT_Reflector	The general landmark is a reflector.	“exemplary”
GLCT_OverridableObject	The general landmark is an overridable object.	“exemplary”

A.2.131 General landmark classification type – confidence

Table A.234 — Signal: General landmark classification type – confidence

Name	General landmark classification type – confidence		
Description	The signal “General landmark classification type – confidence” (A.2.131) provides the confidence for the corresponding signal “General landmark classification type” (A.2.130).		
Value type	[0…100] real value	**Unit**	%

A.2.132 Sign geometry

Table A.235 — Signal: Sign geometry

Name	Sign geometry		
Description	The signal “Sign geometry” (A.2.132) provides the shape geometry of the sign.		
Value type	enumeration	**Unit**	1

Table A.236 — Enumeration: Sign geometry – Example enumerators

Name	Description	RL enumerator
SG_Circle	The sign has a circle shape as sign geometry.	“exemplary”
SG_TriangleTop	The sign has a triangle shape with tip pointing downwards as sign geometry.	“exemplary”
SG_TriangleDown	The sign has a triangle shape with tip pointing upwards as sign geometry.	“exemplary”
SG_Square	The sign has a square shape as sign geometry.	“exemplary”
SG_Pole	The sign has a pole shape as sign geometry.	“exemplary”
SG_Rectangle	The sign has a rectangle shape as sign geometry.	“exemplary”
SG_Diamond	The sign has a diamond shape as sign geometry.	“exemplary”

Name	Description	RL enumerator
SG_ArrowLeft	The sign has an arrow left, five edge shape as sign geometry.	“exemplary”
SG_ArrowRight	The sign has an arrow right, five edge shape as sign geometry.	“exemplary”
SG_Octagon	The sign has an octagon shape as sign geometry.	“exemplary”
SG_SaintAndrewsCross	The sign has a cross shape as sign geometry.	“exemplary”
SG_GateShape	The sign has a gate shape as sign geometry.	“exemplary”

A.2.133 Number of valid lane relevance classifications

Table A.237 — Signal: Number of valid lane relevance classifications

Name	Number of valid lane relevance classifications		
Description	The signal “Number of valid lane relevance classifications” (A.2.133) provides the current number of valid tuples for lane relevance classifications. The tuples are defined by the signals “Lane relevance classification type” (A.2.134) and “Lane relevance classification type – confidence” (A.2.135).		
Value type	[0…] integer value	**Unit**	1

A.2.134 Lane relevance classification type

Table A.238 — Signal: Lane relevance classification type

Name	Lane relevance classification type		
Description	The signal “Lane relevance classification type” (A.2.134) provides the information regarding if the sign is relevant for the ego-vehicle’s lane, the nearest lane to the ego-vehicle or other relevant lanes.		
Value type	enumeration	**Unit**	1

Table A.239 — Enumeration: Lane relevance classification type – Example enumerators

Name	Description	RL enumerator
LRCT_EgoLane	The entity is relevant on track of ego-vehicle.	“exemplary”
LRCT_Left1Lane	The entity is relevant for the next lane to the ego-vehicle on the left side.	“exemplary”
LRCT_Right1Lane	The entity is relevant for the next lane to the ego-vehicle on the right side.	“exemplary”
LRCT_Left2Lane	The entity is relevant for the second next lane to the ego-vehicle on the left side.	“exemplary”
LRCT_Right2Lane	The entity is relevant for the second next lane to the ego-vehicle on the right side.	“exemplary”
LRCT_EgoAndLeft1Lane	The entity is relevant on track of ego-vehicle and the next left lane.	“exemplary”
LRCT_EgoAndRight1Lane	The entity is relevant on track of ego-vehicle and the next right lane.	“exemplary”
LRCT_LeftmostLane	The entity is relevant for the leftmost lane.	“exemplary”
LRCT_RightmostLane	The entity is relevant for the rightmost lane.	“exemplary”

Name	Description	RL enumerator
LRCT_AllLanes	The entity is relevant for all lanes, which essentially means the lane(s) to the right- and left side and on track.	“exemplary”
LRCT_OtherLane	The entity is relevant for another far lane.	“exemplary”

A.2.135 Lane relevance classification type – confidence

Table A.240 — Signal: Lane relevance classification type – confidence

Name	Lane relevance classification type – confidence		
Description	The signal “Lane relevance classification type – confidence” (A.2.135) provides the confidence for the signal’s “Lane relevance classification type” (A.2.134) classification information, for example, the degree of certainty that the lane relevance is of the reported type, for example, relevant for all lanes.		
Value type	[0…100] real value	**Unit**	%

A.2.136 Number of valid traffic supplementary signs

Table A.241 — Signal: Number of valid traffic supplementary signs

Name	Number of valid traffic supplementary signs		
Description	The signal “Number of valid traffic supplementary signs” (A.2.136) provides the current number of valid supplementary sign entities. Additional information: The entries in the array may or may not be sorted.		
Value type	[0…] integer value	**Unit**	1

A.2.137 Number of valid supplementary sign classifications

Table A.242 — Signal: Number of valid supplementary sign classifications

Name	Number of valid supplementary sign classifications		
Description	The signal “Number of valid supplementary sign classifications” (A.2.137) provides the current number of valid tuples for supplementary sign classifications. The tuples are defined by the signals “Supplementary sign classification type” (A.2.138) and “Supplementary sign classification type – confidence” (A.2.139).		
Value type	[0…] integer value	**Unit**	1

A.2.138 Supplementary sign classification type

Table A.243 — Signal: Supplementary sign classification type

Name	Supplementary sign classification type		
Description	The signal “Supplementary sign classification type” (A.2.138) provides the type of the sign.		
Value type	enumeration	**Unit**	1

Table A.244 — Enumeration: Supplementary sign classification type – Example enumerators

Name	Description	RL enumerator
SSCT_ValidInformationBegin	The sign displays a begin of valid zone.	“exemplary”
SSCT_ValidInformationEnd	The sign displays an end of valid zone.	“exemplary”
SSCT_Frost	The sign displays a frost sign.	“exemplary”
SSCT_WetRoad	The sign displays a wet road sign.	“exemplary”
SSCT_ValidInDistance	The sign displays a distance information and the main sign becomes valid in the defined distance.	“exemplary”
SSCT_ValidForDistance	The sign displays a distance information and the main sign is valid for the defined distance.	“exemplary”
SSCT_Limitation	The sign displays a limitation information.	“exemplary”

A.2.139 Supplementary sign classification type – confidence

Table A.245 — Signal: Supplementary sign classification type – confidence

Name	Supplementary sign classification type – confidence		
Description	The signal “Supplementary sign classification type – confidence” (A.2.139) provides the confidence for the signal’s “Supplementary sign classification type” (A.2.138) classification information, for example, the degree of certainty that the supplementary traffic sign is of the reported type, for example, limitation information.		
Value type	[0…100] real value	**Unit**	%

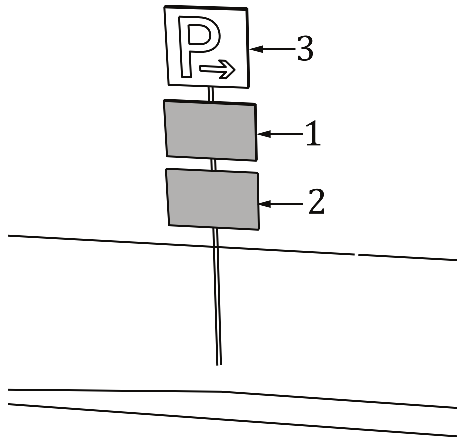
A.2.140 Relative position

Table A.246 — Signal: Relative position

Name	Relative position		
Description	The signal “Relative position” (A.2.140) provides the relative position of the supplemental sign with respect to its main sign (see Figure A.15).		
Value type	enumeration	**Unit**	1

Table A.247 — Enumeration: Relative position – Example enumerators

Name	Description	RL enumerator
RP_Above	The supplementary sign is above the main sign.	“exemplary”
RP_Below	The supplementary sign is below the main sign.	“exemplary”
RP_Left	The supplementary sign is left of the main sign.	“exemplary”
RP_Right	The supplementary sign is right of the main sign.	“exemplary”



Key

1 supplementary sign entity with signal “Relative position” (A.2.140) ≔ enumerator “RP_Below” and signal “Relative position order” (A.2.141) ≔ 1

2 supplementary sign entity with signal “Relative position” (A.2.140) ≔ enumerator “RP_Below” and signal “Relative position order” (A.2.141) ≔ 2

3 main sign entity of the supplementary signs

Figure A.15 — Example for a traffic sign – a main sign with two supplementary signs

A.2.141 Relative position order

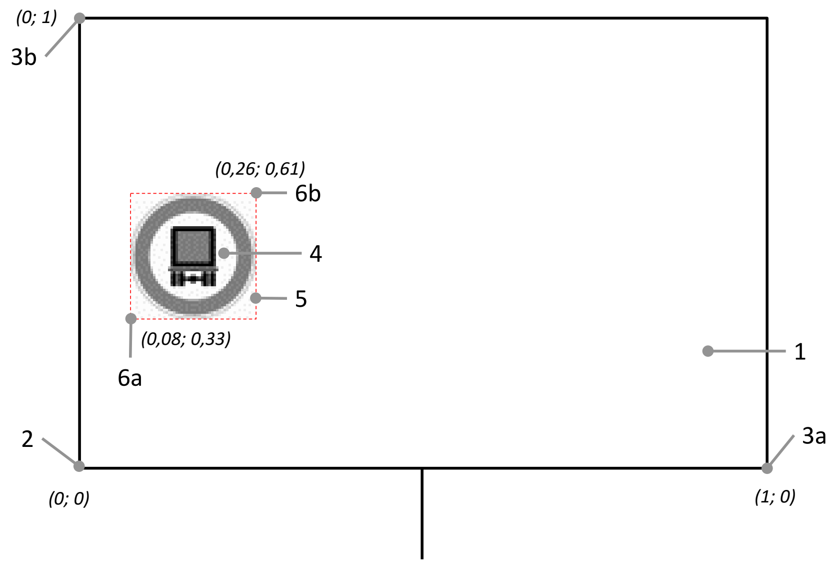
Table A.248 — Signal: Relative position order

Name	Relative position order		
Description	The signal “Relative position order” (A.2.141) provides the relative order of a supplementary sign with respect to the main sign position. The value 1 defines the nearest position of the supplementary sign to the main sign (see Figure A.15).		
Value type	integer value	**Unit**	1

A.2.142 Position uv_origin {x, y, z}

Table A.249 — Signal: Position uv_origin {x, y, z}

Name	Position uv_origin {x, y, z}		
Description	The signal “Position uv_origin {x, y, z}” (A.2.142) provides the position of the reference corner of a sign board which defines the origin of the single sign board affine object coordinate system. It is defined in the ego-vehicle coordinate system [see signal “Vehicle coordinate system type – header” (A.1.20)] (see Figure A.16). Additional information: Even though not always all corners are visible, the origin “Position uv_origin {x, y, z}” (A.2.142) shall be always the left lower corner. The direction of the affine coordinate system is defined by the end positions “Position u_end {x, y, z}” (A.2.144) in negative *Y* direction of the ego-vehicle coordinate system and “Position v_end {x, y, z}” (A.2.146) in the positive *Z* direction of the ego-vehicle coordinate system [see signal “Vehicle coordinate system type – header” (A.1.20)].		
Value type	3D vector real value	**Unit**	(m, m, m)



Key

1 traffic sign board

2 origin of the affine coordinate system of the traffic sign board – signal “Position uv_origin {x, y, z}” (A.2.142) → affine coordinates (0; 0)

3a abscissa of the affine coordinate system of the traffic sign board – signal “Position u_end {x, y, z}” (A.2.144) → affine coordinates (1; 0)

3b ordinate of the affine coordinate system of the traffic sign board – signal “Position v_end {x, y, z}” (A.2.146) → affine coordinates (0; 1)

4 referenced traffic sign as traffic main sign – signal “Object ID reference – object level” (A.2.179)

5 bounding box of the referenced traffic sign as traffic main sign (key 4)

6a $\{u_{\text{Begin}}, v_{\text{Begin}}\}$ of the bounding box (key 5)

6b $\{u_{\text{End}}, v_{\text{End}}\}$ of the bounding box (key 5)

– signal with affine coordinates “Bounding box $\{u_{\text{Begin}}, u_{\text{End}}, v_{\text{Begin}}, v_{\text{End}}\}$” (A.2.173) ≔ (0,08; 0,26; 0,33; 0,61)

Figure A.16 — Affine object coordinate system of a traffic sign board

A.2.143 Position uv_origin {x, y, z} – error

Table A.250 — Signal: Position uv_origin {x, y, z} – error

Name	Position uv_origin {x, y, z} – error		
Description	The signal “Position uv_origin {x, y, z} – error” (A.2.143) provides the error which represents the uncertainty of the measured signal “Position uv_origin {x, y, z}” (A.2.142).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Position uv_origin {x, y, z}” (A.2.142).

A.2.144 Position u_end {x, y, z}

Table A.251 — Signal: Position u_end {x, y, z}

Name	Position u_end {x, y, z}

Description	The signal "Position u_end {x, y, z}" (A.2.144) provides the position of the reference corner of a sign board which defines the one end of a single sign board affine object coordinate system in horizontal direction. The point is defined in the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)] (see Figure A.16). Additional information: Even though not always all corners are visible, the origin "Position uv_origin {x, y, z}" (A.2.142) shall be always the left lower corner. The direction of the affine coordinate system is defined by the end positions "Position u_end {x, y, z}" (A.2.144) in negative *Y* direction of the ego-vehicle coordinate system and "Position v_end {x, y, z}" (A.2.146) in the positive *Z* direction of the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	3D vector real value	**Unit**	(m, m, m)

A.2.145 Position u_end {x, y, z} – error

Table A.252 — Signal: Position u_end {x, y, z} – error

Name	Position u_end {x, y, z} – error		
Description	The signal "Position u_end {x, y, z} – error" (A.2.145) provides the error which represents the uncertainty of the measured signal "Position u_end {x, y, z}" (A.2.144).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Position u_end {x, y, z}" (A.2.144).

A.2.146 Position v_end {x, y, z}

Table A.253 — Signal: Position v_end {x, y, z}

Name	Position v_end {x, y, z}		
Description	The signal "Position v_end {x, y, z}" (A.2.146) provides the position of the reference corner of a sign board which defines the one end of a single sign board affine object coordinate system in vertical direction. The point is defined in the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)] (see Figure A.16). Additional information: Even though not always all corners are visible, the origin "Position uv_origin {x, y, z}" (A.2.142) shall be always the left lower corner. The direction of the affine coordinate system is defined by the end positions "Position u_end {x, y, z}" (A.2.144) in negative *Y* direction of the ego-vehicle coordinate system and "Position v_end {x, y, z}" (A.2.146) in the positive *Z* direction of the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	3D vector real value	**Unit**	(m, m, m)

A.2.147 Position v_end {x, y, z} – error

Table A.254 — Signal: Position v_end {x, y, z} – error

Name	Position v_end {x, y, z} – error
Description	The signal "Position v_end {x, y, z} – error" (A.2.147) provides the error which represents the uncertainty of the measured signal "Position v_end {x, y, z}" (A.2.146).

Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Position v_end {x, y, z}" (A.2.146).

A.2.148 Ratio U- to V-axis

Table A.255 — Signal: Ratio U- to V-axis

Name	Ratio U- to V-axis		
Description	The signal "Ratio U- to V-axis" (A.2.148) provides the ratio of the scaling of the *U*-axis and the *V*-axis unit vectors length in the cartesian coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)]. Additional information: The signal "Ratio U- to V-axis" (A.2.148) ≔ (length of the unit vector of *U*-axis in m)/(length of the unit vector of *V*-axis in m).		
Value type	real value	**Unit**	1

A.2.149 Ratio U- to V-axis – error

Table A.256 — Signal: Ratio U- to V-axis – error

Name	Ratio U- to V-axis – error		
Description	The signal "Ratio U- to V-axis – error" (A.2.149) provides the error which represents the uncertainty of the measured signal "Ratio U- to V-axis" (A.2.148).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Ratio U- to V-axis" (A.2.148).

A.2.150 Number of valid traffic sign board regions

Table A.257 — Signal: Number of valid traffic sign board regions

Name	Number of valid traffic sign board regions		
Description	The signal "Number of valid traffic sign board regions" (A.2.150) provides the current number of valid traffic sign board regions. Additional information: The entries in the array may or may not be sorted.		
Value type	[0…] integer value	**Unit**	1

A.2.151 Sign board entity ID

Table A.258 — Signal: Sign board entity ID

Name	Sign board entity ID

Description	The signal "Sign board entity ID" (A.2.151) provides the unique ID of a sign board type entity within the sign board object (see Figure A.17 and Figure A.18). Additional information: The signal's "Sign board entity ID" (A.2.151) value is unique for the same entity in multiple cycles. The signal "Sign board entity ID" (A.2.151) ≔ 0 refers to the traffic sign board entity.		
Value type	integer value	**Unit**	1

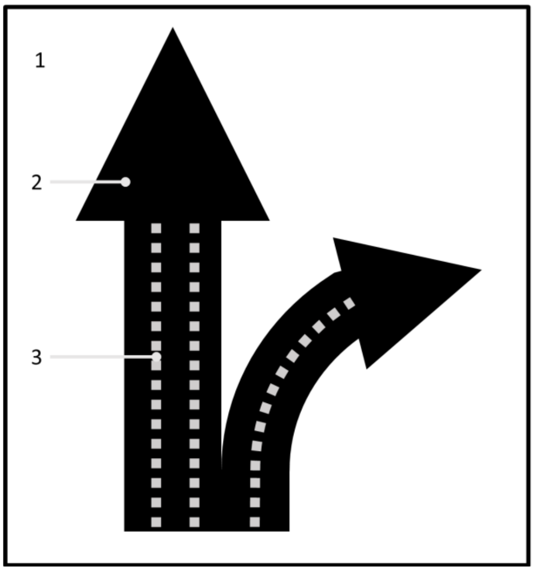
Key

1 traffic sign board – motorway
[Default: "Sign board entity ID" (A.2.151) ≔ 0]

2 traffic sign board region – rural
signal "Sign board entity ID" (A.2.151) ≔ 1 and signal "Sign board entity ID reference – object level" (A.2.153) ≔ {0}

3 traffic sign board region - city
signal "Sign board entity ID" (A.2.151) ≔ 2 and signal "Sign board entity ID reference – object level" (A.2.153) ≔ {1}

Figure A.17 — Example for a logical hierarchy of traffic sign board region entities



Key

1 traffic sign board with an orientation arrow of two directions and five lanes
[default: “Sign board entity ID” (A.2.151) ≔ 0]

2 traffic sign board guiding graph – orientation arrow
signal “Sign board entity ID” (A.2.151) ≔ 1 and signal “Sign board entity ID reference – object level” (A.2.153) ≔ {0}

3 traffic sign board guiding graph – lanes
signal “Sign board entity ID” (A.2.151) ≔ 2 and signal “Sign board entity ID reference – object level” (A.2.153) ≔ {1}

Figure A.18 — Example for a logical hierarchy of traffic sign board guiding graph entities

A.2.152 Number of valid entity ID references – object level

Table A.259 — Signal: Number of valid entity ID references – object level

Name	Number of valid entity ID references – object level		
Description	The signal “Number of valid entity ID references – object level” (A.2.152) provides the current number of valid traffic sign board type entities (for example, region, referenced object, symbol or icon) on the traffic sign board. All referenced object entities are associated with the traffic sign board. Additional information: The entries in the array may or may not be sorted.		
Value type	[0…] integer value	**Unit**	1

A.2.153 Sign board entity ID reference – object level

Table A.260 — Signal: Sign board entity ID reference – object level

Name	Sign board entity ID reference – object level
Description	The signal’s “Sign board entity ID” (A.2.151) value defines a sign board type entity to which this entity is logical associated to (see Figure A.17 and Figure A.18). Additional information: The signal “Sign board entity ID” (A.2.151) ≔ 0 refers to the traffic sign board entity itself.

Value type	[0…] integer value	**Unit**	1

A.2.154 Border width {u, v}

Table A.261 — Signal: Border width {u, v}

Name	Border width {u, v}		
Description	The signal “Border width {u, v}” (A.2.154) provides a borderline width of the edge scaled to the *U*- and *V*-axis (see Figure A.19). Additional information: The scaled width {u} is relative to the *U*-axis of the current measurement cycle and the scaled height {v} is relative to the *V*-axis of the current measurement cycle. As a horizontal line cannot have a width in *U*-direction and a vertical line cannot have a width in *V*-direction, the border width {u} shall be used for the vertical parts of the border and the border width {v} shall be used for the horizontal parts of the border.		
Value type	2D vector [0…1] real value	**Unit**	(1, 1)

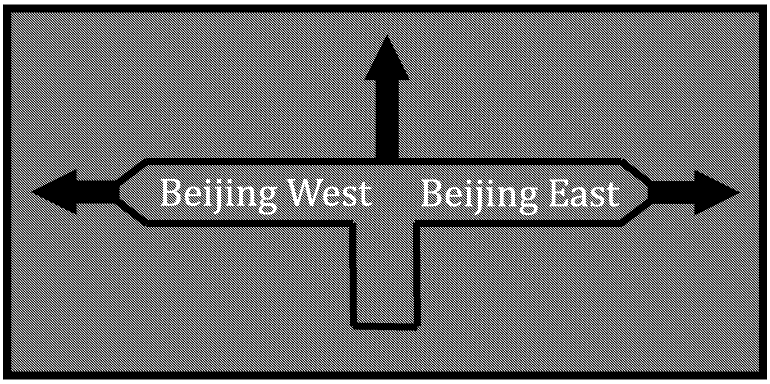


Figure A.19 — Example of a traffic sign board with text on guiding graph which has a borderline

A.2.155 Border width {u, v} – error

Table A.262 — Signal: Border width {u, v} – error

Name	Border width {u, v} – error		
Description	The signal “Border width {u, v} – error” (A.2.155) provides the error which represents the uncertainty of the measured signal “Border width {u, v}” (A.2.154).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Border width {u, v}” (A.2.154).

A.2.156 Traffic sign board region – confidence

Table A.263 — Signal: Traffic sign board region – confidence

Name	Traffic sign board region – confidence		
Description	The signal “Traffic sign board region – confidence” (A.2.156) provides the confidence for the region.		
Value type	[0…100] real value	**Unit**	%

A.2.157 Number of valid colour tones

Table A.264 — Signal: Number of valid colour tones

Name	Number of valid colour tones		
Description	The signal “Number of valid colour tones” (A.2.157) provides the current number of valid colour tones for one colour tone type. Additional information: The entries in the array may or may not be sorted.		
Value type	[0…] integer value	**Unit**	1

A.2.158 Colour tone type

Table A.265 — Signal: Colour tone type

Name	Colour tone type		
Description	The signal “Colour tone type" (A.2.158) provides the type of the colour tone.		
Value type	enumeration	**Unit**	1

Table A.266 — Enumeration: Colour tone type

Name	**Description**	**RL enumerator**
CTT_Shape	The colour tone defines the colour of the shape.	Mandatory
CTT_Border	The colour tone defines the colour of the borderline.	Optional

A.2.159 Number of valid vertex points

Table A.267 — Signal: Number of valid vertex points

Name	Number of valid vertex points		
Description	The signal “Number of valid vertex points” (A.2.159) provides the current number of valid vertex points of the traffic sign board entity. Additional information: The entries in the array may or may not be sorted.		
Value type	[0…] integer value	**Unit**	1

A.2.160 Local position {u, v}

Table A.268 — Signal: Local position {u, v}

Name	Local position {u, v}
Description	The signal “Local position {u, v}” (A.2.160) provides a point on the traffic sign board in the traffic sign board affine coordinate system. Additional information: The origin point of the traffic sign board affine coordinate system is in the lower left corner of the traffic sign board (from point of view of the ego-vehicle coordinate system). The *U*-axis is horizontal, and the *V*-axis is vertical.

Value type	2D vector [0…1] real value	**Unit**	(1, 1)

A.2.161 Local position {u, v} – error

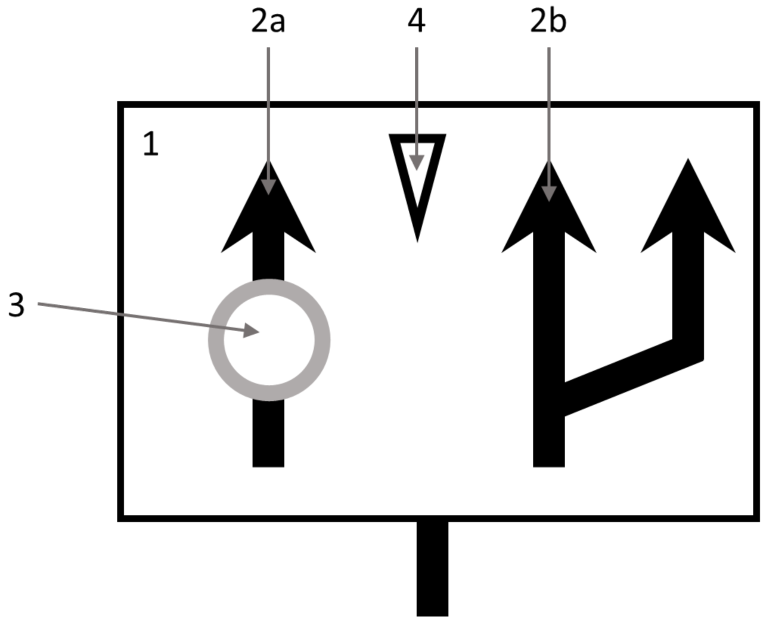
Table A.269 — Signal: Local position {u, v} – error

Name	Local position {u, v} – error		
Description	The signal "Local position {u, v} – error" (A.2.161) provides the error which represents the uncertainty of the measured signal "Local position {u, v}" (A.2.160).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Local position {u, v}" (A.2.160).

A.2.162 Number of valid traffic sign board guiding graphs

Table A.270 — Signal: Number of valid traffic sign board guiding graphs

Name	Number of valid traffic sign board guiding graphs		
Description	The signal "Number of valid traffic sign board guiding graphs" (A.2.162) provides the current number of valid guiding graphs (for example, orientation arrow, marking of a shoulder) on the traffic sign board (see Figure A.20). Additional information: The entries in the array may or may not be sorted. A guiding graph may describe separated direction arrows in one entity. A sensor cluster may describe all guiding graphs in one or multiple entities of the traffic sign board.		
Value type	[0…] integer value	**Unit**	1



Key

1 traffic sign board

2a,b orientation arrow symbol – guiding graph(s)
(the orientation arrows may be described by one entity or separated in different entities)

3 object reference – traffic sign as traffic main sign

(signal "Object ID reference – object level" (A.2.179) references to a traffic sign as traffic main sign which describes the sign)

4 icons and symbols – a road separation symbol

(the signal "Icon and symbol type" (A.2.176) has an enumerator "IAST_RoadSeparation")

Figure A.20 — Example for a traffic sign board with guiding graph(s)

A.2.163 Traffic sign board guiding graph – confidence

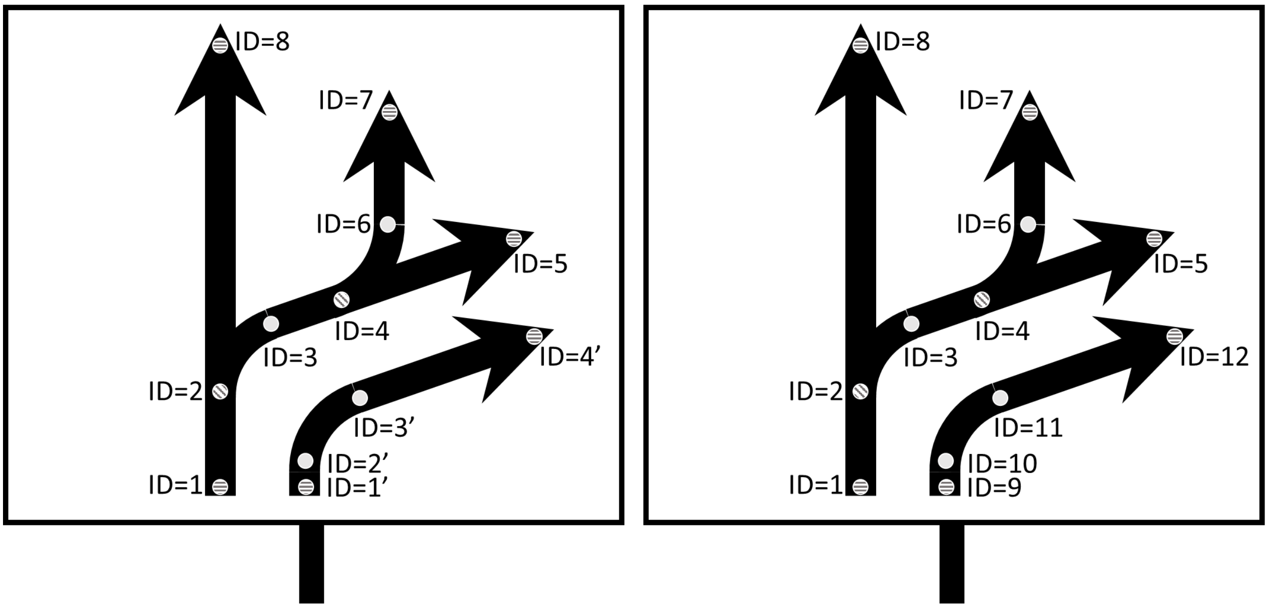
Table A.271 — Signal: Traffic sign board guiding graph – confidence

Name	Traffic sign board guiding graph – confidence		
Description	The signal "Traffic sign board guiding graph – confidence" (A.2.163) provides the confidence for the guiding graph.		
Value type	[0...100] real value	**Unit**	%

A.2.164 Local position ID

Table A.272 — Signal: Local position ID

Name	Local position ID		
Description	The signal "Local position ID" (A.2.164) provides a unique ID for a signal "Local position {u, v}" (A.2.160) within the list of local positions (see Figure A.21).		
Value type	integer value	**Unit**	1



Key

begin or end vertex point

split or merge vertex point

intermediate vertex point

ID= ID of the vertex point – signal "Local position ID" (A.2.164)

Figure A.21 — Two examples for traffic sign board guiding graphs and their vertex point IDs "Local position ID" (A.2.164)

A.2.165 Number of valid edges

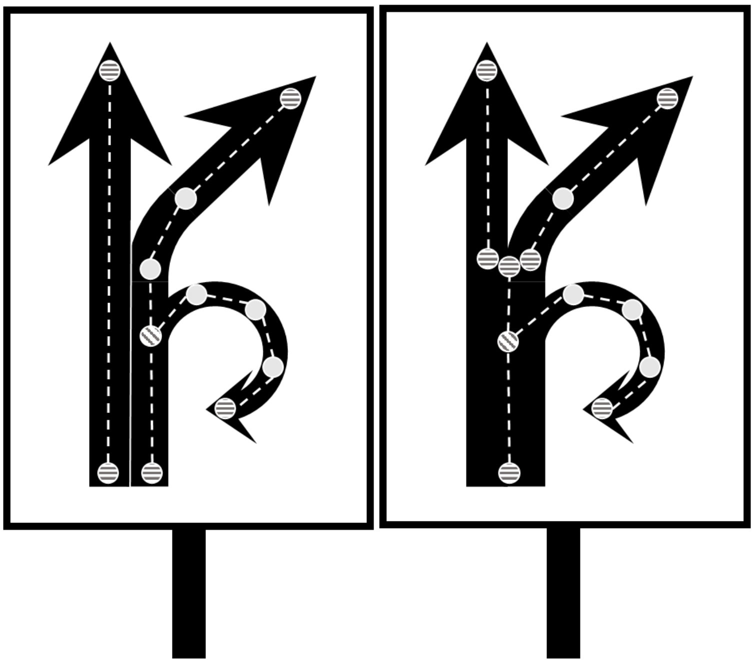
Table A.273 — Signal: Number of valid edges

Name	Number of valid edges		
Description	The signal “Number of valid edges” (A.2.165) provides the current number of valid edges. Additional information: The entries in the array may or may not be sorted.		
Value type	[0…] integer value	**Unit**	1

A.2.166 Local position ID reference {begin, end}

Table A.274 — Signal: Local position ID reference {begin, end}

Name	Local position ID reference {begin, end}		
Description	The signal “Local position ID reference {begin, end}” (A.2.166) provides an edge by connecting a {begin} vertex and an {end} vertex. Each vertex points can be every kind of type (begin-, end-, split-, merge vertex) (see Figure A.22). Additional information: The order of {begin} vertex and {end} vertex represents a direction.		
Value type	2D vector integer value	**Unit**	(1, 1)



Key

begin or end vertex point

split or merge vertex point

intermediate vertex point

---- edge of a guiding graph

Figure A.22 — Two examples for a traffic sign board guiding graphs with their vertex points and edges

A.2.167 Edge type

Table A.275 — Signal: Edge type

Name	Edge type		
Description	The signal "Edge type" (A.2.167) indicates the type of the guiding graph's edge type.		
Value type	enumeration	**Unit**	1

Table A.276 — Enumeration: Edge type – Example enumerators

Name	**Description**	**RL enumerator**
ET_Solid	The edge of the guiding graph is a solid line.	"exemplary"
ET_Dashed	The edge of the guiding graph is a dashed line.	"exemplary"
ET_Triangular	The edge of the guiding graph is a triangular line.	"exemplary"
ET_Dotted	The edge of the guiding graph is a dotted line.	"exemplary"

A.2.168 Edge width {u, v}

Table A.277 — Signal: Edge width {u, v}

Name	Edge width {u, v}		
Description	The signal "Edge width {u, v}" (A.2.168) provides a line width of the guiding graph's edge scaled to the *U*- and *V*-axis. Additional information: The scaled width {u} is relative to the unit vector of the *U*-axis and the scaled height {v} is relative to the unit vector of the *V*-axis. To enable a correct representation of tapering lines, the border width shall be represented per edge. As a horizontal line cannot have a width in *U*-direction, border width {u} is per definition equal to 0. Same applies for width {v} in vertical *V*-direction. Only lines not parallel to both axis *U* and *V* have values unequal to zero for both dimensions {u, v}. If not specified differently, the width shall be measured at the {begin} vertex [see signal "Local position ID reference {begin, end}" (A.2.166)].		
Value type	2D vector [0…1] real value	**Unit**	(1, 1)

A.2.169 Edge width {u, v} – error

Table A.278 — Signal: Edge width {u, v} – error

Name	Edge width {u, v} – error		
Description	The signal "Edge width {u, v} – error" (A.2.169) provides the error which represents the uncertainty of the measured signal "Edge width {u, v}" (A.2.168).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Edge width {u, v}" (A.2.168).

A.2.170 Edge curve type

Table A.279 — Signal: Edge curve type

Name	Edge curve type		
Description	The signal "Edge curve type" (A.2.170) describes the shape of the edge between two vertices. The direction of the edge is implicit defined by the begin and the end vertex [see signal "Local position ID reference {begin, end}" (A.2.166)] and defines, for example, left and right. Additional information: It is up to the sensors capability to use as many vertices as needed to describe a guiding graph on a traffic sign board. To ease the sampling of vertices, this signal offers a simplification by defining a set of standard paths (for example, S-curve) between to vertices.		
Value type	enumeration	**Unit**	1

Table A.280 — Enumeration: Edge curve type – Example enumerators

Name	**Description**	**RL enumerator**
ECT_Straight	The edge is straight.	"exemplary"
ECT_SCurve	The edge is an S-curve.	"exemplary"
ECT_ZCurve	The edge is a Z-curve.	"exemplary"
ECT_RightCurve	The edge is a curve to the right.	"exemplary"
ECT_LeftCurve	The edge is a curve to the left.	"exemplary"
ECT_RightBend	The edge is a bend to the right.	"exemplary"
ECT_LeftBend	The edge is a bend to the left.	"exemplary"

A.2.171 Arrow type

Table A.281 — Signal: Arrow type

Name	Arrow type		
Description	The signal "Arrow type" (A.2.171) indicates an arrow at {begin} or {end} vertex point of the edge [see signal "Local position ID reference {begin, end}" (A.2.166)].		
Value type	enumeration	**Unit**	1

Table A.282 — Enumeration: Arrow type – Example enumerators

Name	**Description**	**RL enumerator**
AT_NoArrow	The symbol has no arrow or termination at {begin} or {end} vertex point of the edge.	"exemplary"
AT_ArrowAtBeginPoint	The symbol has an arrow at {begin} vertex point of the edge.	"exemplary"
AT_ArrowAtEndPoint	The symbol has an arrow at {end} vertex point of the edge.	"exemplary"
AT_ArrowsAtBothPoints	The symbol has an arrow at {begin} and {end} vertex point of the edge.	"exemplary"
AT_TerminationAtBeginPoint	The symbol has a termination at {begin} vertex point of the edge.	"exemplary"
AT_TerminationAtEndPoint	The symbol has a termination at {end} vertex point of the edge.	"exemplary"
AT_TerminationsAtBothPoints	The symbol has a termination at {begin} and {end} vertex point of the edge.	"exemplary"

A.2.172 Number of valid traffic sign board texts

Table A.283 — Signal: Number of valid traffic sign board texts

Name	Number of valid traffic sign board texts		
Description	The signal "Number of valid traffic sign board texts" (A.2.172) provides the current number of valid text fragments on the traffic sign board. Additional information: The entries in the array may or may not be sorted.		
Value type	[0…] integer value	**Unit**	1

A.2.173 Bounding box {u_{Begin}, u_{End}, v_{Begin}, v_{End}}

Table A.284 — Signal: Bounding box {u_{Begin}, u_{End}, v_{Begin}, v_{End}}

Name	Bounding box {u_{Begin}, u_{End}, v_{Begin}, v_{End}}		
Description	The signal "Bounding box {u_{Begin}, u_{End}, v_{Begin}, v_{End}}" (A.2.173) provides a bounding box on the traffic sign board (and defines the affine traffic sign board coordinate system) for a traffic sign board entity (for example, a referenced traffic sign or traffic light object entity) (see Figure A.16).		
Value type	4D vector [0…1] real value	**Unit**	(1, 1, 1, 1)

A.2.174 Bounding box {u_{Begin}, u_{End}, v_{Begin}, v_{End}} – error

Table A.285 — Signal: Bounding box {u_{Begin}, u_{End}, v_{Begin}, v_{End}} – error

Name	Bounding box {u_{Begin}, u_{End}, v_{Begin}, v_{End}} – error		
Description	The signal "Bounding box {u_{Begin}, u_{End}, v_{Begin}, v_{End}} – error" (A.2.174) provides the error which represents the uncertainty of the measured signal "Bounding box {u_{Begin}, u_{End}, v_{Begin}, v_{End}}" (A.2.173).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Bounding box {u_{Begin}, u_{End}, v_{Begin}, v_{End}}" (A.2.173).

A.2.175 Number of valid traffic sign board icons and symbols

Table A.286 — Signal: Number of valid traffic sign board icons and symbols

Name	Number of valid traffic sign board icons and symbols		
Description	The signal "Number of valid traffic sign board icons and symbols" (A.2.175) provides the current number of valid icons and symbols on the traffic sign board. Additional information: The entries in the array may or may not be sorted.		
Value type	[0…] integer value	**Unit**	1

A.2.176 Icon and symbol type

Table A.287 — Signal: Icon and symbol type

Name	Icon and symbol type

Description	The signal “Icon and symbol type” (A.2.176) indicates the type of the icon or the symbol of a commonly used symbol for characteristic road elements (for example, road separation) or destinations (for example, city centre, central station) but no traffic sign main or supplementary signs.		
Value type	enumeration	**Unit**	1

Table A.288 — Enumeration: Icon and symbol type – Example enumerators

Name	**Description**	**RL enumerator**
IAST_CentralStation	The icon symbolises the central station.	“exemplary”
IAST_Airport	The icon symbolises the airport.	“exemplary”
IAST_AirportDeparture	The icon symbolises the departure at the airport.	“exemplary”
IAST_AirportArrival	The icon symbolises the arrival at the airport.	“exemplary”
IAST_Church	The icon symbolises a church.	“exemplary”
IAST_CityCentre	The icon symbolises the city centre.	“exemplary”
IAST_IndustrialPark	The icon symbolises an industrial park.	“exemplary”
IAST_Plant	The icon symbolises a plant.	“exemplary”
IAST_Sightseeing	The icon symbolises sight-seeing.	“exemplary”
IAST_RoadSeparation	The symbol symbolises a separation of the road to guide single or multiple lanes.	“exemplary”
IAST_Harbour	The icon symbolises a harbour.	“exemplary”
IAST_Hospital	The icon symbolises a hospital or a medical service.	“exemplary”
IAST_Stadium	The icon symbolises a stadium.	“exemplary”
IAST_Police	The icon symbolises a police station.	“exemplary”
IAST_Cemetery	The icon symbolises a cemetery.	“exemplary”
IAST_Mining	The icon symbolises a mining.	“exemplary”
IAST_InformationPoint	The icon symbolises an information point.	“exemplary”
IAST_Toll	The icon symbolises a toll station.	“exemplary”
IAST_GasStation	The icon symbolises a gas station.	“exemplary”
IAST_ElectricChargingPoint	The icon symbolises an electric charging point.	“exemplary”
IAST_Tunnel	The icon symbolises a tunnel portal.	“exemplary”
IAST_Bridge	The icon symbolises a bridge.	“exemplary”
IAST_UnrecognisedSymbol	The symbol is not a recognised symbol or icon, for example, a locally used symbol.	“exemplary”

A.2.177 Icon and symbol type – confidence

Table A.289 — Signal: Icon and symbol type – confidence

Name	Icon and symbol type – confidence		
Description	The signal “Icon and symbol type – confidence” (A.2.177) provides the confidence for the icon and symbol type signal “Icon and symbol type” (A.2.176).		
Value type	[0…100] real value	**Unit**	%

A.2.178 Number of valid traffic sign board object references

Table A.290 — Signal: Number of valid traffic sign board object references

Name	Number of valid traffic sign board object references		
Description	The signal "Number of valid traffic sign board object references" (A.2.178) provides the current number of valid references to object entities on the traffic sign board which could be described in a separate object entity (for example, traffic sign, traffic light). Additional information: The entries in the array may or may not be sorted.		
Value type	[0…] integer value	**Unit**	1

A.2.179 Object ID reference – object level

Table A.291 — Signal: Object ID reference – object level

Name	Object ID reference – object level		
Description	The signal's "Object ID" (A.2.2) value defines the object to which this object is associated to; invalid = "no associated object". Additional information: Refers to an object entity with the highest probability for the association, for example, a free-space area references a static-object entity which limits the area, a traffic sign board references a traffic sign which is associated to the traffic sign board. The signal's "Object ID reference – object level" (A.2.179) value could reference entities of the sensor cluster's OLI or entities which are used internally by the sensor cluster. Alternative A2I (B.3.2): the mapping of objects signal "Object ID" (A.2.2) and other object level interfaces (for example, free space area object and the object's limitations) signal "Object ID reference – feature level" (A.3.3) could be provided in a separate interface.		
Value type	[0…] integer value	**Unit**	1

A.2.180 Object ID reference – confidence

Table A.292 — Signal: Object ID reference – confidence

Name	Object ID reference – confidence		
Description	The signal "Object ID reference – confidence" (A.2.180) provides the confidence for the object reference signal "Object ID reference – object level" (A.2.179).		
Value type	[0…100] real value	**Unit**	%

A.2.181 Number of valid traffic sign board occlusions

Table A.293 — Signal: Number of valid traffic sign board occlusions

Name	Number of valid traffic sign board occlusions
Description	The signal "Number of valid traffic sign board occlusions" (A.2.181) provides the current number of valid occlusion parts on or in front of the traffic sign board. Additional information: The entries in the array may or may not be sorted.

Value type	[0…] integer value	**Unit**	1

A.2.182 Occlusion type

Table A.294 — Signal: Occlusion type

Name	Occlusion type		
Description	The signal “Occlusion type” (A.2.182) indicates the type of occlusion of traffic sign board parts.		
Value type	enumeration	**Unit**	1

Table A.295 — Enumeration: Occlusion type – Example enumerators

Name	**Description**	**RL enumerator**
OT_Graffiti	Parts of the traffic sign boards are occluded by graffiti or stickers.	“exemplary”
OT_Vegetation	Parts of the traffic sign boards are occluded by vegetation, for example, tree branches, leaves or the trunk.	“exemplary”
OT_MovingObjects	Parts of the traffic sign boards are occluded by moving objects, for example, a heavy truck.	“exemplary”
OT_Snow	Parts of the traffic sign boards are occluded by snow.	“exemplary”
OT_Dirt	Parts of the traffic sign boards are occluded by dirt.	“exemplary”

A.2.183 Occlusion type – confidence

Table A.296 — Signal: Occlusion type – confidence

Name	Occlusion type – confidence		
Description	The signal “Occlusion type – confidence” (A.2.183) provides the confidence for the occlusion type signal “Occlusion type” (A.2.182).		
Value type	[0…100] real value	**Unit**	%

A.2.184 Number of valid structure light classifications

Table A.297 — Signal: Number of valid structure light classifications

Name	Number of valid structure light classifications		
Description	The signal “Number of valid structure light classifications” (A.2.184) provides the current number of valid tuples for structure classifications of the traffic light. The tuples are defined by the signals “Structure light classification type” (A.2.185) and “Structure light classification type – confidence” (A.2.186).		
Value type	[0…] integer value	**Unit**	1

A.2.185 Structure light classification type

Table A.298 — Signal: Structure light classification type

Name	Structure light classification type		
Description	The signal “Structure light classification type” (A.2.185) provides the classification of the traffic light’s shape.		
Value type	enumeration	**Unit**	1

Table A.299 — Enumeration: Structure light classification type – Example enumerators

Name	Description	RL enumerator
SLCT_Vertical3	The traffic light is composed of three vertical light spots.	“exemplary”
SLCT_Horizontal3	The traffic light is composed of three horizontal light spots.	“exemplary”
SLCT_DogHouse	The traffic light is composed of multiple light spots.	“exemplary”

A.2.186 Structure light classification type – confidence

Table A.300 — Signal: Structure light classification type – confidence

Name	Structure light classification type – confidence		
Description	The signal “Structure light classification type – confidence” (A.2.186) provides the confidence for the signal’s “Structure light classification type” (A.2.185) classification information, for example, the degree of certainty that the structure light type is of the reported type, for example, a traffic light with 3 vertical stacked traffic light spots.		
Value type	[0…100] real value	**Unit**	%

A.2.187 Minimum visibility distance

Table A.301 — Signal: Minimum visibility distance

Name	Minimum visibility distance		
Description	The signal “Minimum visibility distance” (A.2.187) provides the minimum distance to the traffic light until the traffic light is still in the FOV of the sensor cluster, for example, in close distance.		
Value type	[0…] real value	**Unit**	m

A.2.188 Total number of traffic light spots

Table A.302 — Signal: Total number of traffic light spots

Name	Total number of traffic light spots		
Description	The signal “Total number of traffic light spots” (A.2.188) provides the estimation of the number of traffic light spots which are part of the traffic light. Additional information: This signal is considered to be an estimation since turned-off spots are barely visible (especially at night) and therefore, hard to detect. Signal “Total number of traffic light spots” (A.2.188) ≥ signal “Number of valid traffic light spots” (A.2.190).		
Value type	[0…] integer value	**Unit**	1

A.2.189 Total number of traffic light spots – confidence

Table A.303 — Signal: Total number of traffic light spots – confidence

Name	Total number of traffic light spots – confidence

Description	The signal "Total number of traffic light spots – confidence" (A.2.189) provides the confidence for the signal's "Total number of traffic light spots" (A.2.188) classification information, for example, the degree of certainty that the number of traffic light spots is of the reported type, for example, 3.		
Value type	[0…100] real value	**Unit**	%

A.2.190 Number of valid traffic light spots

Table A.304 — Signal: Number of valid traffic light spots

Name	Number of valid traffic light spots		
Description	The signal "Number of valid traffic light spots" (A.2.190) provides the current number of valid traffic light entities. Additional information: The entries in the array may or may not be sorted.		
Value type	[0…] integer value	**Unit**	1

A.2.191 Number of valid light shape classifications

Table A.305 — Signal: Number of valid light shape classifications

Name	Number of valid light shape classifications		
Description	The signal "Number of valid light shape classifications" (A.2.191) provides the current number of valid tuples for light shape classifications. The tuples are defined by the signals "Light shape classification type" (A.2.192) and "Light shape classification type – confidence" (A.2.193).		
Value type	[0…] integer value	**Unit**	1

A.2.192 Light shape classification type

Table A.306 — Signal: Light shape classification type

Name	Light shape classification type		
Description	The signal "Light shape classification type" (A.2.192) provides the light's shape which is displayed by the light spot.		
Value type	enumeration	**Unit**	1

Table A.307 — Enumeration: Light shape classification type – Example enumerators

Name	Description	RL enumerator
LSCT_NoShape	The traffic light spot displays no additional shape.	"exemplary"
LSCT_ArrowStraightAhead	The traffic light spot displays an arrow straight ahead shape.	"exemplary"
LSCT_ArrowLeft	The traffic light spot displays an arrow left shape.	"exemplary"
LSCT_ArrowDiagonalLeft	The traffic light spot displays an arrow diagonal left shape.	"exemplary"
LSCT_ArrowStraightAheadLeft	The traffic light spot displays an arrow straight ahead and arrow left shape.	"exemplary"
LSCT_ArrowRight	The traffic light spot displays an arrow right shape.	"exemplary"

Name	Description	RL enumerator
LSCT_ArrowDiagonalRight	The traffic light spot displays an arrow diagonal right shape.	“exemplary”
LSCT_ArrowStraightAheadRight	The traffic light spot displays an arrow straight ahead and arrow right shape.	“exemplary”
LSCT_ArrowLeftRight	The traffic light spot displays an arrow left and arrow right shape.	“exemplary”
LSCT_ArrowDown	The traffic light spot displays an arrow down shape.	“exemplary”
LSCT_ArrowDownLeft	The traffic light spot displays an arrow U-turn left shape.	“exemplary”
LSCT_ArrowDownRight	The traffic light spot displays an arrow U-turn right shape.	“exemplary”
LSCT_Cross	The traffic light spot displays a cross figure.	“exemplary”
LSCT_Pedestrian	The traffic light spot displays a pedestrian figure.	“exemplary”
LSCT_Walk	The traffic light spot displays a text “walk” figure.	“exemplary”
LSCT_DontWalk	The traffic light spot displays a text “don’t walk” figure.	“exemplary”
LSCT_Bicycle	The traffic light spot displays a bicycle figure.	“exemplary”
LSCT_PedestrianAndBicycle	The traffic light spot displays a pedestrian and bicycle figure.	“exemplary”
LSCT_CountdownSecond	The traffic light spot displays a countdown in seconds figure, the signal “Light shape value” (A.2.194) contains the value in seconds.	“exemplary”
LSCT_CountdownPercent	The traffic light spot displays a countdown in percent figure, the signal “Light shape value” (A.2.194) contains the value in percentage.	“exemplary”
LSCT_Train	The traffic light spot displays a train or tram figure.	“exemplary”
LSCT_Bus	The traffic light spot displays a bus figure.	“exemplary”
LSCT_BusAndTrain	The traffic light spot displays a bus and train or tram figure.	“exemplary”

A.2.193 Light shape classification type – confidence

Table A.308 — Signal: Light shape classification type – confidence

Name	Light shape classification type – confidence		
Description	The signal “Light shape classification type – confidence” (A.2.193) provides the confidence for the signal’s “Light shape classification type” (A.2.192) classification information, for example, the degree of certainty that the light shape is of the reported type, for example, the shape of a bus.		
Value type	[0…100] real value	**Unit**	%

A.2.194 Light shape value

Table A.309 — Signal: Light shape value

Name	Light shape value

<table>
<tr><td>Description</td><td colspan="3">The signal “Light shape value” (A.2.194) provides an additional countdown value of the light shape which is defined by the signal “Light shape classification type” (A.2.192).

Additional information:
The value meaning and the value unit depends on the enumerator of the signal “Light shape classification type” (A.2.192).</td></tr>
<tr><td>Value type</td><td>[0…] integer value</td><td>Unit</td><td>The unit is defined by the enumerator of the signal “Light shape classification type” (A.2.192).
NOTE The signal “Light shape classification type” (A.2.192) has an enumerator “LSCT_CountdownSecond”, an enumerator “LSCT_CountdownPercent” or a similar enumerator defined during the system design phase.</td></tr>
</table>

A.2.195 Number of valid colour classifications

Table A.310 — Signal: Number of valid colour classifications

Name	Number of valid colour classifications		
Description	The signal “Number of valid colour classifications” (A.2.195) provides the current number of valid tuples for colour classifications. The tuples are defined by the signals “Colour classification type” (A.2.196) and “Colour classification type – confidence” (A.2.197).		
Value type	[0…] integer value	**Unit**	1

A.2.196 Colour classification type

Table A.311 — Signal: Colour classification type

Name	Colour classification type		
Description	The signal “Colour classification type” (A.2.196) provides the colour of the light spot.		
Value type	enumeration	**Unit**	1

Table A.312 — Enumeration: Colour classification type – Example enumerators

Name	**Description**	**RL enumerator**
CCT_Red	The light spot colour is red.	“exemplary”
CCT_Yellow	The light spot colour is yellow.	“exemplary”
CCT_Green	The light spot colour is green.	“exemplary”
CCT_White	The light spot colour is white.	“exemplary”

A.2.197 Colour classification type – confidence

Table A.313 — Signal: Colour classification type – confidence

Name	Colour classification type – confidence		
Description	The signal “Colour classification type – confidence” (A.2.197) provides a confidence for the corresponding signal “Colour classification type” (A.2.196).		
Value type	[0…100] real value	**Unit**	%

A.2.198 Number of valid light mode classifications

Table A.314 — Signal: Number of valid light mode classifications

Name	Number of valid light mode classifications		
Description	The signal "Number of valid light mode classifications" (A.2.198) provides the current number of valid tuples for light mode classifications. The tuples are defined by the signals "Light mode classification type" (A.2.199) and "Light mode classification type – confidence" (A.2.200).		
Value type	[0...] integer value	**Unit**	1

A.2.199 Light mode classification type

Table A.315 — Signal: Light mode classification type

Name	Light mode classification type		
Description	The signal "Light mode classification type" (A.2.199) provides the light's mode.		
Value type	enumeration	**Unit**	1

Table A.316 — Enumeration: Light mode classification type – Example enumerators

Name	**Description**	**RL enumerator**
LMCT_Continuous	The light source is currently on, and it is not blinking.	"exemplary"
LMCT_Blinking	One light source is visibly blinking.	"exemplary"
LMCT_TurnedOff	The light source is turned off.	"exemplary"
LMCT_Counting	It is a light source with counting.	"exemplary"

A.2.200 Light mode classification type – confidence

Table A.317 — Signal: Light mode classification type – confidence

Name	Light mode classification type – confidence		
Description	The signal "Light mode classification type – confidence" (A.2.200) provides a confidence for the corresponding signal "Light mode classification type" (A.2.199).		
Value type	[0...100] real value	**Unit**	%

A.2.201 Free space type

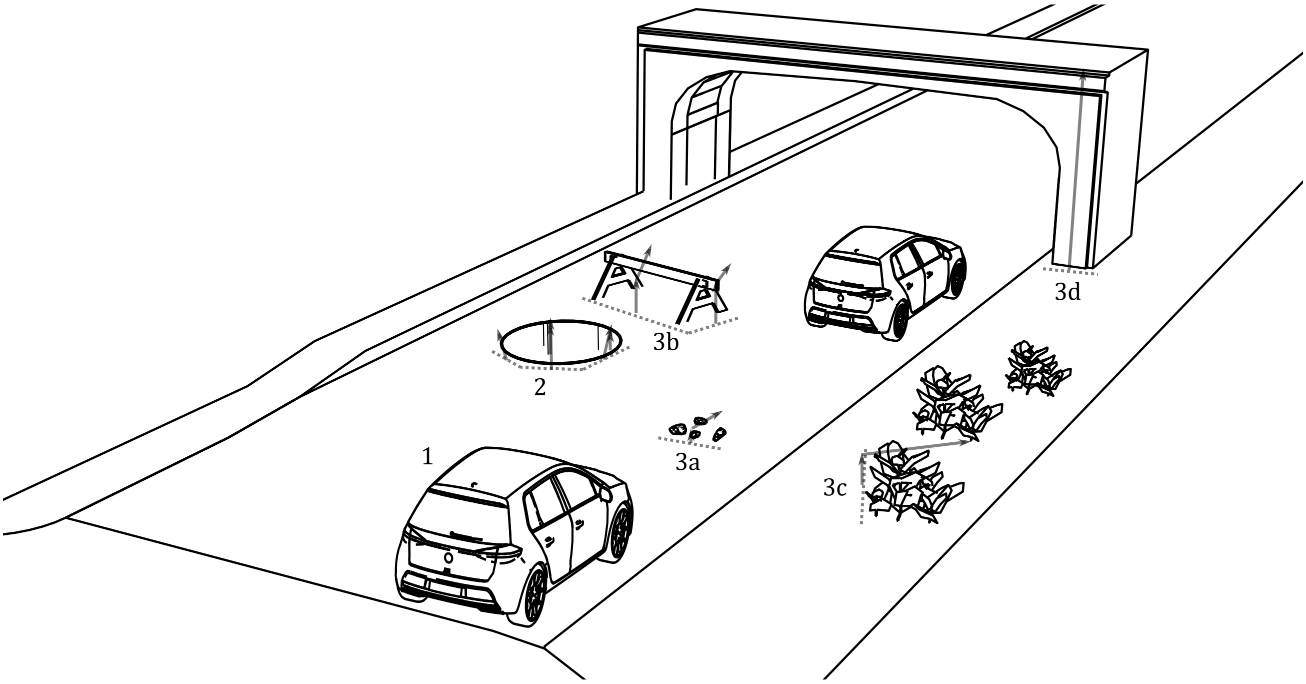
Table A.318 — Signal: Free space type

Name	Free space type		
Description	The signal "Free space type" (A.2.201) describes the type of information that the free space description contains. This type of information depends on the recognition capabilities of the sensor (measurable states) and the combination of object properties that are required for object level fusion. The fusion might request for a free space description with or without static or dynamic objects or even holes ("negative limiting objects").		
Value type	enumeration	**Unit**	1

Table A.319— Enumeration: Free space type

Name	**Description**	**RL enumerator**
FST_LimitedByStatic	The space is limited by static objects, no confirmed free space area by measurement. Dynamic objects may not be recognized (see Figure A.23).	Mandatory

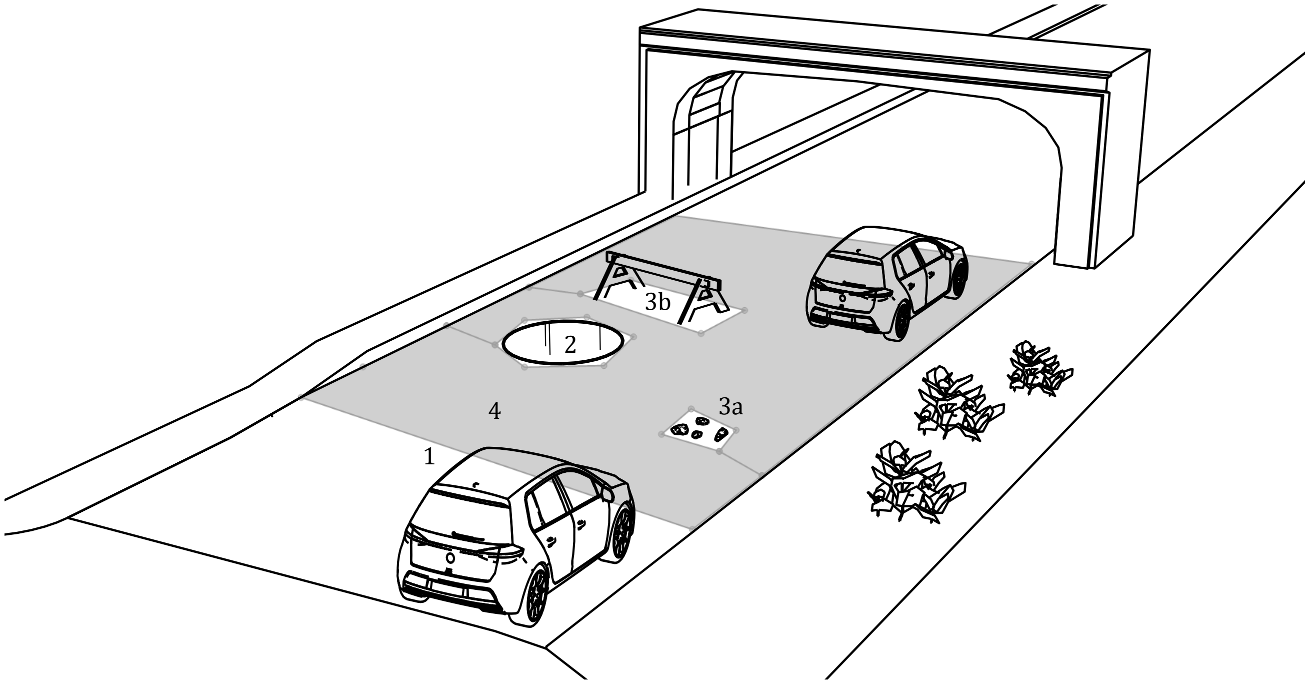
FST_PerceivedLimitedByStatic	The perceived measured free space area which is reduced by static objects. The free space area is not reduced by dynamic objects. The free space area is confirmed by active measurement of the sensor or the sensor cluster (see Figure A.24).	Mandatory
FST_PerceivedLimitedByStaticAndDynamic	The perceived free space area which is reduced by static and dynamic objects. The free space area is confirmed by active measurement of the sensor or the sensor cluster (see Figure A.25).	Mandatory



Key

1 ego-vehicle
2 static object “LR_Hole”
3a static object “LR_Static” – small stones
3b static object “LR_Static” – barrier
3c static object “LR_Static” – vegetation
3d static object “LR_Static” – wall
height and extent of the limitation (static object)
edge of the limitation (static object) – signal “Free space type” (A.2.201) ≔ enumerator “FST_LimitedByStatic”

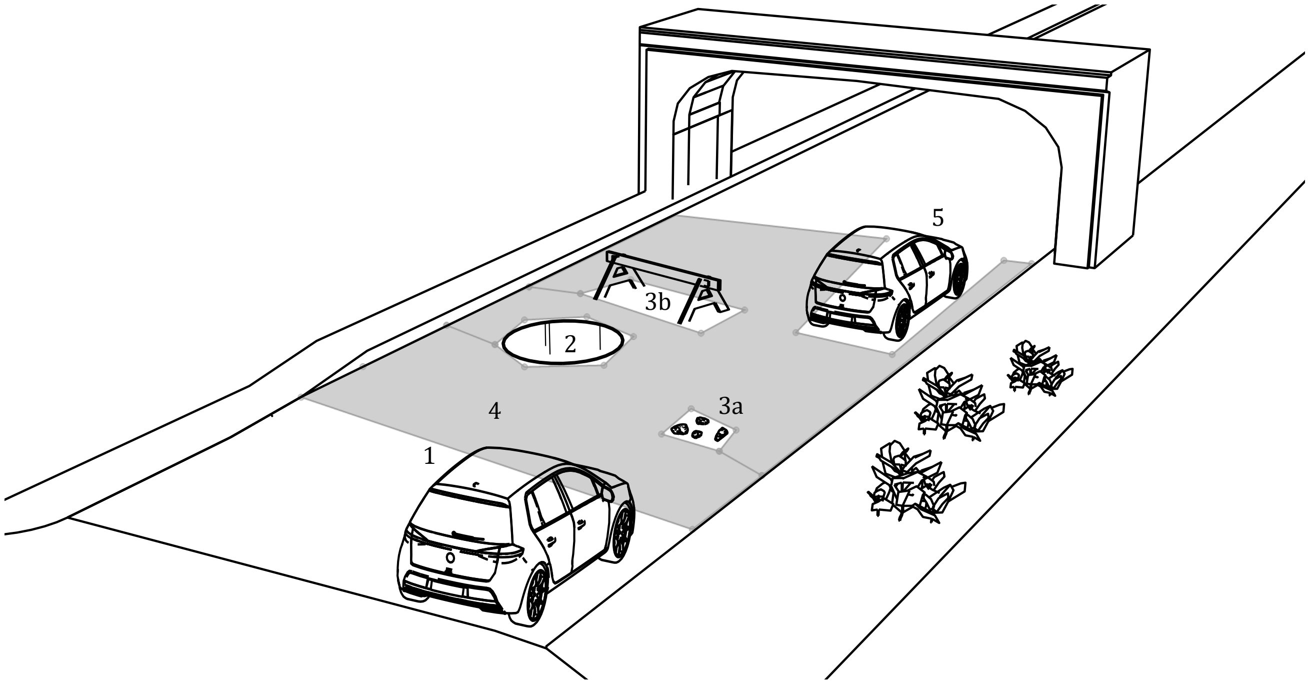
Figure A.23 — Example for signal “Free space type” (A.2.201) as enumerator “FST_LimitedByStatic” and signal “Shape type – object level” (A.2.204) as enumerator “ST_PolylineOpen”



Key

1 ego-vehicle
2 static object "LR_Hole"
3a static object "LR_Static" – small stones
3b static object "LR_Static" – barrier
4 free space area shape – signal "Free space type" (A.2.201) ≔ enumerator "FST_PerceivedLimitedByStatic"

Figure A.24 — Example for signal "Free space type" (A.2.201) as enumerator "FST_PerceivedLimitedByStatic" and signal "Shape type – object level" (A.2.204) as enumerator "ST_PolylineClosed"



Key

1 ego-vehicle
2 static object “LR_Hole”
3a static object “LR_Static” – small stones
3b static object “LR_Static” – barrier
4 free space area shape – signal “Free space type” (A.2.201) ≔ enumerator “FST_PerceivedLimitedByStaticAndDynamic”
5 dynamic object “LR_PotentiallyMovingObject” - vehicle

Figure A.25 — Example for signal “Free space type” (A.2.201) as enumerator “FST_PerceivedLimitedByStaticAndDynamic” and signal “Shape type – object level” (A.2.204) as enumerator “ST_PolylineClosed”

A.2.202 Number of valid free space area shapes

Table A.320 — Signal: Number of valid free space area shapes

Name	Number of valid free space area shapes		
Description	The signal “Number of valid free space area shapes” (A.2.202) provides the current number of valid free space area shapes.		
Value type	[0…] integer value	**Unit**	1

A.2.203 Limitation geometry type

Table A.321 — Signal: Limitation geometry type

Name	Limitation geometry type		
Description	The signal “Limitation geometry type” (A.2.203) provides the information about the reference point where the geometric information (limitation and clearance) is located.		
Value type	enumeration	**Unit**	1

Table A.322— Enumeration: Limitation geometry type

Name	**Description**	**RL enumerator**
LGT_Vertex	The limitation and clearance geometry information are assigned at the vertex point.	Mandatory
LGT_Edge	The limitation and clearance geometry information are assigned to the property of the edge (for example, average, minimum or maximum value) between this and the next vertex point. Geometry information of the last vertex point may be invalid because it is not assigned to an edge.	Mandatory

A.2.204 Shape type – object level

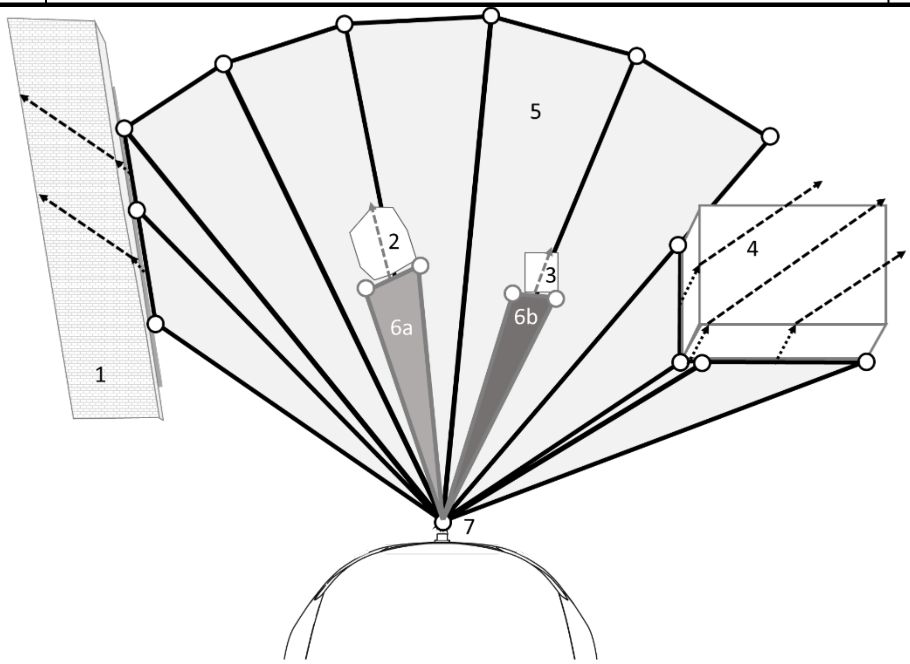
Table A.323 — Signal: Shape type – object level

Name	Shape type – object level
Description	The signal “Shape type – object level” (A.2.204) provides the shape type which is used for the shape segment's borderline. Additional information: The shape defines how the vertex points are connected.

Value type	enumeration	**Unit**	1

Table A.324— Enumeration: Shape type – object level – Example enumerators

Name	**Description**	**RL enumerator**
ST_Sector	The shape is a triangular sector (2 or more explicit points and 1 implicit point). The area is defined by the two vertex points and a common vertex point of the ego-vehicle for all segments on road level [see signal “Sector common vertex point {x, y, z}” (A.2.205)]. The sectors may overlap. The limitation information of all free space sectors may overlap and may be combined to limit the free space area of a sector (see Figure A.26 – key 6).	“exemplary”
ST_PolylineOpen	The shape is an open polyline (2 or more points). The polyline is not closed with an edge between the last and first vertex point. A free space area is not perceived.	“exemplary”
ST_PolylineClosed	The shape is a closed polyline (3 or more points). The polyline is closed with an edge between the last and first vertex point (see Figure A.27 – key 5). The closed polylines may not overlap.	“exemplary”



Key

1 road edge

2 hole

3 static small object, for example, a box or a tire (that means the sensor can perceive beyond the object)

4 static large object (that means the sensor cannot perceive beyond the object)

5 free space area with multiple vertex points, which means with multiple segments (for example, the sensors maximum range)

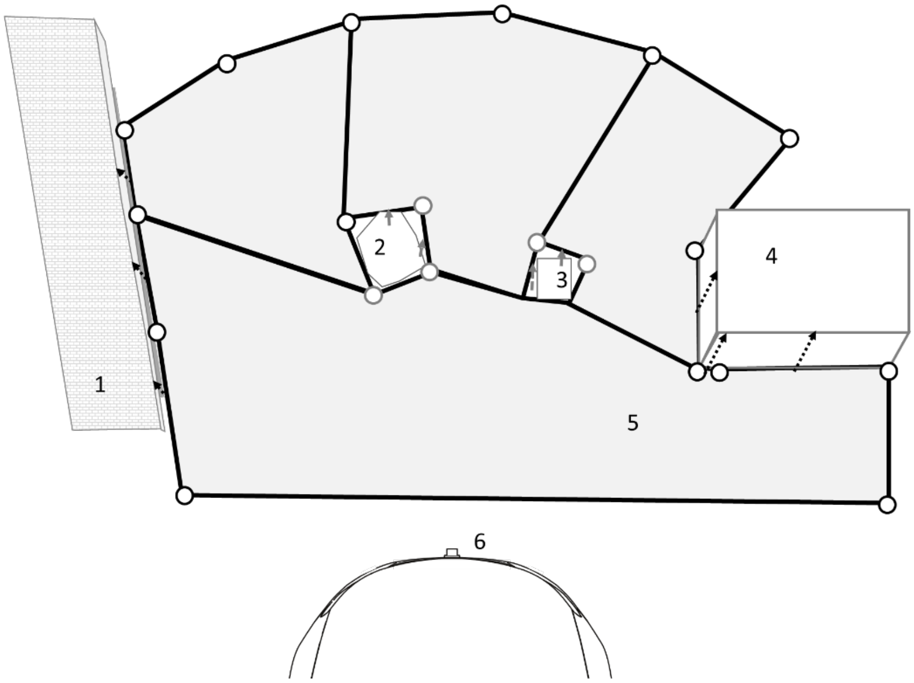
6 free space area with 2 vertex points (for example, 6a a hole and 6b a box) – ego-vehicle reference vertex point

7 common vertex point - ego-vehicle with sensor [see signal “Sector common vertex point {x, y, z}” (A.2.205)]

limitation {height}

limitation {radial extent}

Figure A.26 — Example for signal “Shape type – object level” (A.2.204) as enumerator “ST_Sector” and signal “Limitation geometry type” (A.2.203) as enumerator “LGT_Edge”



Key

1 road edge
2 hole
3 static small object, for example, a box or a tire (that means the sensor can perceive beyond the object)
4 static large object (that means the sensor cannot perceive beyond the object)
5 free space area shape with multiple vertex points
6 ego-vehicle with sensor
.........→ limitation {height}

Figure A.27 — Example for signal "Shape type – object level" (A.2.204) as enumerator "ST_PolylineClosed" and signal "Limitation geometry type" (A.2.203) as enumerator "LGT_Edge"

A.2.205 Sector common vertex point {x, y, z}

Table A.325 — Signal: Sector common vertex point {x, y, z}

Name	Sector common vertex point {x, y, z}		
Description	The signal "Sector common vertex point {x, y, z}" (A.2.205) provides the measured longitudinal, lateral and vertical distance of the common vertex point for all sectors [see signal "Shape type – object level" (A.2.204) enumerator "ST_Sector"].		
Value type	3D vector real value	**Unit**	(m, m, m)

A.2.206 Sector common vertex point {x, y, z} – error

Table A.326 — Signal: Sector common vertex point {x, y, z} – error

Name	Sector common vertex point {x, y, z} – error		
Description	The signal "Sector common vertex point {x, y, z} – error" (A.2.206) provides the measured error of the signal "Sector common vertex point {x, y, z}" (A.2.205).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Sector common vertex point {x, y, z}" (A.2.205).

A.2.207 Sector common vertex point – confidence {x, y, z}

Table A.327 — Signal: Vertex point – confidence {x, y, z}

Name	Vertex point – confidence {x, y, z}		
Description	The signal "Sector common vertex point – confidence {x, y, z}" (A.2.207) provides the confidence for the signals of the sectors common vertex point [see signal "Sector common vertex point {x, y, z}" (A.2.205) and signal "Sector common vertex point {x, y, z} – error" (A.2.206)].		
Value type	[0…100] real value	**Unit**	%

A.2.208 Limitation reason

Table A.328 — Signal: Limitation reason

Name	Limitation reason		
Description	The signal "Limitation reason" (A.2.208) describes the reason for the limit of the free space area at the given vertex point or edge [see signal "Limitation geometry type" (A.2.203)]. Additional information: There is no definition for "overhang" of a vehicle load.		
Value type	enumeration	**Unit**	1

Table A.329— Enumeration: Limitation reason – Example enumerators

Name	**Description**	**RL enumerator**
LR_None	The free space area is not limited at the current vertex point or edge. The vertex point or edge is at the connection of two shapes which describe a geometric complex free space area.	"exemplary"
LR_Performance	The free space area is limited at the current vertex point or edge by the maximum range or by performance reduction reasons.	"exemplary"
LR_Unclassified	The free space area is limited at the current vertex point or edge by an unclassified object.	"exemplary"
LR_Static	The free space area is limited at the current vertex point or edge by a static object (SOI) or a road object (RDOI).	"exemplary"
LR_PotentiallyMovingObject	The free space area is limited at the current vertex point or edge by a potentially moving object (PMOI).	"exemplary"
LR_Hole	The free space area is limited at the current vertex point by a hole (that means a "negative limiting object").	"exemplary"
LR_SurfaceCondition	The free space area is limited at the current vertex point or edge by almost flat media, for example, water, water puddle, oil spills, sand or ice.	"exemplary"
LR_OverheadStructure	The free space area is limited by elevated objects (for example, lower bridges, tunnel or carpark entrance) (SOI).	"exemplary"
LR_ShadowEffect	The free space area is limited by crosstalk or blooming effects.	"exemplary"
LR_Horizon	The free space area is limited by road topology.	"exemplary"

A.2.209 Limitation moving probability

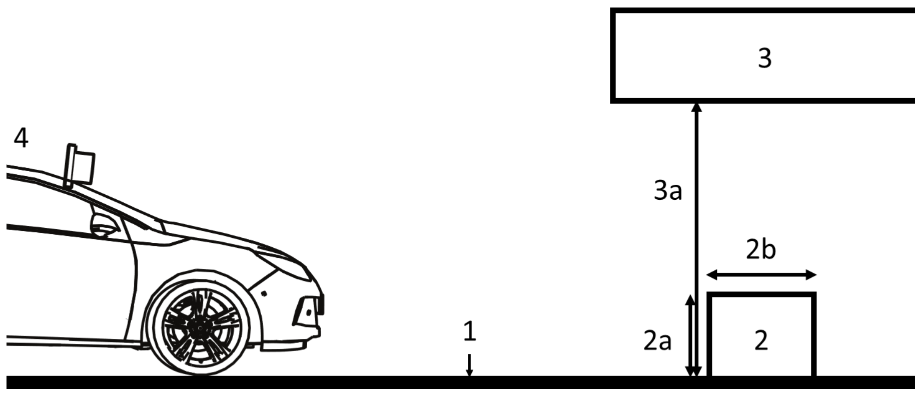
Table A.330 — Signal: Limitation moving probability

Name	Limitation moving probability		
Description	The signal "Limitation moving probability" (A.2.209) is only applicable to "FST_PerceivedLimitedByStaticAndDynamic" [see signal "Free space type" (A.2.201)] and may indicate a probability, whether the limitation is expected to be static or dynamic.		
Value type	[0…100] real value	**Unit**	%

A.2.210 Limitation {radial extent, height}

Table A.331 — Signal: Limitation {radial extent, height}

Name	Limitation {radial extent, height}		
Description	The signal "Limitation {radial extent, height}" (A.2.210) provides the measured height and radial extend of the limitation for the edge or at the vertex point [see signal "Vertex point {x, y, z}" (A.2.105) and Figure A.28]. The {height} of the limitation is added to the {z} value of the vertex point or the edge [see signal "Limitation geometry type" (A.2.203)]. {radial extent} is applicable if the signal "Shape type – object level" (A.2.204) is "ST_Sector". The axis of the extent corresponds to the direction from the common vertex point or edge to the related vertex point or edge of the extent. {height} provides the height of, for example, the step between two adjacent closed polylines or the height of a limiting obstacle at position of the vertex point or edge. A positive height is used to describe a step upward or an elevated structure. A negative height describes a step downward or holes.		
Value type	real value	**Unit**	(m, m)



Key

1 road surface (free space area)
2 limitation – obstacle
2a {height} of the limitation "Limitation {radial extent, height}" (A.2.210)
2b {radial extent} of the limitation "Limitation {radial extent, height}" (A.2.210)
3 limitation – clearance and overhead object, for example, a bridge
3a {height} of the clearance "Clearance {height}" (A.2.213) for the limitation bridge
4 ego-vehicle with sensor

Figure A.28 — Example for signal "Limitation {radial extent, height}" (A.2.210) and signal "Clearance {height}" (A.2.213) of a free space area

A.2.211 Limitation {radial extent, height} – error

Table A.332 — Signal: Limitation {radial extent, height} – error

Name	Limitation {radial extent, height} – error		
Description	The signal “Limitation {radial extent, height} – error” (A.2.211) provides the error of the measured signal “Limitation {radial extent, height}” (A.2.210).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Limitation {radial extent, height}” (A.2.210).

A.2.212 Limitation– confidence {radial extent, height}

Table A.333 — Signal: Limitation– confidence {radial extent, height}

Name	Limitation– confidence {radial extent, height}		
Description	The signal “Limitation– confidence {radial extent, height}” (A.2.212) provides the confidence of the signal “Limitation {radial extent, height}” (A.2.210) and the signal “Limitation {radial extent, height} – error” (A.2.211).		
Value type	[0…100] real value	**Unit**	%

A.2.213 Clearance {height}

Table A.334 — Signal: Clearance {height}

Name	Clearance {height}		
Description	The signal “Clearance {height}” (A.2.213) provides the measured height of the limiting undriveable structure for the edge or at the vertex point [see signal “Vertex point {x, y, z}” (A.2.105)]. The {clearance} of the underdriveable structure is added to the {z} value of the vertex point or the edge [see signal “Limitation geometry type” (A.2.203) and Figure A.28]. Additional information: The signal applies to the point of the vertex point or the edge depending on the signal “Limitation geometry type” (A.2.203).		
Value type	real value	**Unit**	(m, m)

A.2.214 Clearance {height} – error

Table A.335 — Signal: Clearance {height} – error

Name	Clearance {height} – error		
Description	The signal “Clearance {height} – error” (A.2.214) provides the error of the measured clearance’s height.		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Clearance {height}” (A.2.213).

A.2.215 Clearance – confidence {height}

Table A.336 — Signal: Clearance – confidence {height}

Name	Clearance – confidence {height}

Description	The signal “Clearance – confidence {height}” (A.2.215) provides the confidence of the clearance’s height [see signal “Clearance {height}” (A.2.213) and signal “Clearance {height} – error” (A.2.214)].		
Value type	[0…100] real value	**Unit**	%

A.3 Feature level entity signals

Signals are defined for the entities of subclauses 8.3 and 8.4 in this subclause (see Table A.337-Table A.381). These interfaces are located at FLI. No FLI for radar or lidar sensors is defined.

The FLI originates from several sensors of a sensor cluster. Therefore, at feature level, the term sensor cluster is always used, even if a single sensor is serving the interface.

A.3.1 Existence probability – feature level

Table A.337 — Signal: Existence probability – feature level

Name	Existence probability – feature level		
Description	The signal “Existence probability – feature level” (A.3.1) provides the existence probability of the feature, based on history. Additional information: Use as a confidence measure where a low value means less confidence and a high value indicates strong confidence.		
Value type	[0…100] real value	**Unit**	%

A.3.2 Feature ID

Table A.338 — Signal: Feature ID

Name	Feature ID		
Description	The signal “Feature ID” (A.3.2) provides the unique identification number of the feature within the feature list. Additional information: The signal’s “Feature ID” (A.3.2) value is only unique for each sensor cluster's feature entities of FLI within one measurement cycle. If interfaces use the signal “Feature ID” (A.3.2) to link, for example, detection entities with feature entities, the interfaces shall ensure the unambiguity of the referenced entities at each or multiple measurement, tracking or prediction cycle(s) [see, for example, cross interface optimisation “Source entities of a derived signal” (B.3.4)].		
Value type	[0…] integer value	**Unit**	1

A.3.3 Object ID reference – feature level

Table A.339 — Signal: Object ID reference – feature level

Name	Object ID reference – feature level

Description	The signal's "Object ID" (A.2.2) value defines the object to which this feature is associated to; invalid = "no associated object", for example, for the first feature cycle of the entity. Additional information: Refers to an object (for example, potentially moving object) with the highest probability for the association. The signal's "Object ID reference – feature level" (A.3.3) value could reference entities of the sensor cluster's OLI or entities which are used internally by the sensor cluster. Alternative A2I (B.3.2): the mapping of objects signal "Object ID" (A.2.2) and features signal "Object ID reference – feature level" (A.3.3) could be provided in a separate interface.		
Value type	[0…] integer value	**Unit**	1

A.3.4 Time stamp difference – feature level

Table A.340 — Signal: Time stamp difference – feature level

Name	Time stamp difference – feature level		
Description	Each feature entity could provide an individual time stamp, specifically a time stamp difference to the signal's "Time stamp – prediction" (A.1.5.1) value of the interface. Additional information: The time stamp of the feature can be calculated as the signal "Time stamp – prediction" (A.1.5.1) of the FLI header for the cycle plus the signal "Time stamp difference – feature level" (A.3.4) of the feature.		
Value type	real value	**Unit**	s

A.3.5 Number of valid observations – feature level

Table A.341 — Signal: Number of valid observations – feature level

Name	Number of valid observations – feature level		
Description	The signal "Number of valid observations – feature level" (A.3.5) provides the current number of valid tuples [specifically the signal "Time stamp reference – feature level" (A.3.6) and the signal "Observation status – feature level" (A.3.7)].		
Value type	[0…] integer value	**Unit**	1

A.3.6 Time stamp reference – feature level

Table A.342 — Signal: Time stamp reference – feature level

Name	Time stamp reference – feature level		
Description	The signal "Time stamp reference – feature level" (A.3.6) provides a reference to a previous sent interface message with the referenced time stamp for signal "Time stamp – <…>" (A.1.5).		
Value type	real value	**Unit**	s

A.3.7 Observation status – feature level

Table A.343 — Signal: Observation status – feature level

Name	Observation status – feature level

Description	The signal "Observation status – feature level" (A.3.7) provides the observation status of the feature, which was recognised in a previous cycle [see signal "Time stamp reference – feature level" (A.3.6)].		
Value type	enumeration	**Unit**	1

Table A.344 — Enumeration: Observation status – feature level – Example enumerators

Name	Description	RL enumerator
OS_True	The feature was observed in the referenced cycle.	"exemplary"
OS_False	The feature was not observed in the referenced cycle. It may be predicted in the referenced cycle.	"exemplary"

A.3.8 Feature grouping ID

Table A.345 — Signal: Feature grouping ID

Name	Feature grouping ID		
Description	A sensor can group features from the FLI which are linked together. All features from the same entity have the same signal's "Feature grouping ID" (A.3.8) value. The ID is unique considering all FLIs of a sensor cluster. EXAMPLE A pedestrian can be described with multiple camera shapes. All shapes of one pedestrian use the same "Feature grouping ID" (A.3.8) value. Additional information: The signal "Feature grouping ID" (A.3.8) ≔ 0 if the feature is not associated with another feature.		
Value type	integer value	**Unit**	1

A.3.9 Number of valid shape classifications – feature level

Table A.346 — Signal: Number of valid shape classifications – feature level

Name	Number of valid shape classifications – feature level		
Description	The signal "Number of valid shape classifications – feature level" (A.3.9) provides the current number of valid tuples for shape classifications. The tuples are defined by the signals "Shape classification type – feature level" (A.3.10) and "Shape classification type – confidence – feature level" (A.3.11).		
Value type	[0…] integer value	**Unit**	1

A.3.10 Shape classification type – feature level

Table A.347 — Signal: Shape classification type – feature level

Name	Shape classification type – feature level		
Description	The signal "Shape classification type – feature level" (A.3.10) provides the classification type for the shape.		
Value type	enumeration	**Unit**	1

Table A.348 — Enumeration: Shape classification type – feature level – Example enumerators

Name	Description	RL enumerator
SCT_Background	The shape is classified as a background entity.	“exemplary”
SCT_Foreground	The shape is classified as a foreground entity.	“exemplary”
SCT_Flat	The shape is classified as a flat entity.	“exemplary”
SCT_Upright	The shape is classified as an upright entity.	“exemplary”
SCT_Ground	The shape is classified as a ground entity.	“exemplary”
SCT_Building	The shape is classified as a building entity.	“exemplary”
SCT_Vegetation	The shape is classified as a vegetation entity.	“exemplary”
SCT_Road	The shape is classified as a road entity.	“exemplary”
SCT_NonRoad	The shape is classified as a non-road entity.	“exemplary”
SCT_Pavement	The shape is classified as a pavement entity.	“exemplary”
SCT_Pedestrian	The shape is classified as a pedestrian entity.	“exemplary”
SCT_Vehicle	The shape is classified as a vehicle entity.	“exemplary”
SCT_TrafficSign	The shape is classified as a traffic sign entity.	“exemplary”
SCT_PedestrianFront	The shape is classified as a pedestrian front-view entity.	“exemplary”
SCT_PedestrianSide	The shape is classified as a pedestrian side-view entity.	“exemplary”
SCT_PedestrianRear	The shape is classified as a pedestrian rear-view entity.	“exemplary”

A.3.11 Shape classification type – confidence – feature level

Table A.349 — Signal: Shape classification type – confidence – feature level

Name	Shape classification type – confidence – feature level		
Description	The signal “Shape classification type – confidence – feature level” (A.3.11) provides the classification confidence of the shape segment's possible content.		
Value type	[0...100] real value	**Unit**	%

A.3.12 Colour value – feature level

Table A.350 — Signal: Colour value – feature level

Name	Colour value – feature level		
Description	The signal “Colour value – feature level” (A.3.12) provides the definition of the colour value(s). The number of values depends on the signal “Colour model type” (A.1.14). Additional information: For example, enumerator “CMT_RGB” has 3 colour values, specifically first value is red, second value is green, third value is blue.		
Value type	[0...100] real value	**Unit**	%

A.3.13 Colour tone – confidence – feature level

Table A.351 — Signal: Colour tone – confidence – feature level

Name	Colour tone – confidence – feature level		
Description	The signal "Colour tone – confidence – feature level" (A.3.13) provides the confidence of the shape area with the specified colour tone. The tone is defined by the signal "Colour model type" (A.1.14) and the list of signals "Colour value – feature level" (A.3.12).		
Value type	[0…100] real value	**Unit**	%

A.3.14 Shape type – feature level

Table A.352 — Signal: Shape type – feature level

Name	Shape type – feature level		
Description	The signal "Shape type – feature level" (A.3.14) provides the shape type which is used for the shape segment's borderline. Additional information: The shape defines how the referenced points are connected. The interpretation of the enumerators will be defined during the system design phase.		
Value type	enumeration	**Unit**	1

Table A.353 — Enumeration: Shape type – feature level – Example enumerators

Name	Description	RL enumerator
ST_Point	The shape is a point.	"exemplary"
ST_Box	The shape is a box (2 or 3 points).	"exemplary"
ST_Ellipse	The shape is an ellipse (2 or 3 points).	"exemplary"
ST_Polygon	The shape is a polygon (3 or more points).	"exemplary"
ST_Polyline	The shape is a polyline (2 or more points).	"exemplary"
ST_PointCloud	The shape is a point cloud (2 or more points).	"exemplary"

A.3.15 Number of valid shape points – feature level

Table A.354 — Signal: Number of valid shape points – feature level

Name	Number of valid shape points – feature level		
Description	The signal "Number of valid shape points – feature level" (A.3.15) provides the current number of valid shape points. The shape points are part of, for example, the polyline, which defines the border of the shape [see signal "Shape type – feature level" (A.3.14)]. Additional information: The signal "Number of valid shape points – feature level" (A.3.15) ≥ 1.		
Value type	[0…] integer value	**Unit**	1

A.3.16 Point existence probability – feature level

Table A.355 — Signal: Point existence probability – feature level

Name	Point existence probability – feature level		
Description	The signal "Point existence probability – feature level" (A.3.16) provides the existence probability of the point [see signal "Position – feature level {x, y, z}" (A.3.17)]. Each point is only used by one shape [maybe one shape is sent in several entities with different shape classification confidences – see signal "Shape classification type – confidence – feature level" (A.3.11)]. Additional information: Use as confidence measure where a low value means less confidence and a high value indicates strong confidence.		
Value type	[0…100] real value	**Unit**	%

A.3.17 Position – feature level {x, y, z}

Table A.356 — Signal: Position – feature level {x, y, z}

Name	Position – feature level {x, y, z}		
Description	The signal "Position – feature level {x, y, z}" (A.3.17) provides the 3D point in ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	3D vector real value	**Unit**	(m, m, m)

A.3.18 Position – feature level {x, y, z} – error

Table A.357 — Signal: Position – feature level {x, y, z} – error

Name	Position – feature level {x, y, z} – error		
Description	The signal "Position – feature level {x, y, z} – error" (A.3.18) provides the error representing the uncertainty of the state estimation of the signal "Position – feature level {x, y, z}" (A.3.17).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Position – feature level {x, y, z}" (A.3.17).

A.3.19 Number of valid shape reference points – feature level

Table A.358 — Signal: Number of valid shape reference points – feature level

Name	Number of valid shape reference points – feature level		
Description	The signal "Number of valid shape reference points – feature level" (A.3.19) provides the current number of valid shape reference points. Each signal's "Position – feature level {x, y, z}" (A.3.17) position of a shape reference point is part of the shape surface.		
Value type	[0…] integer value	**Unit**	1

A.3.20 Shape surface normal {x, y, z}

Table A.359 — Signal: Shape surface normal {x, y, z}

Name	Shape surface normal {x, y, z}

Description	The signal "Shape surface normal {x, y, z}" (A.3.20) provides the normal vector of the shape's approximated tangential plane at the shape reference point [see signal "Position – feature level {x, y, z}" (A.3.17)]. Additional information: The vector is normalised.		
Value type	3D vector real value	**Unit**	(1, 1, 1)

A.3.21 Shape surface normal {x, y, z} – error

Table A.360 — Signal: Shape surface normal {x, y, z} – error

Name	Shape surface normal {x, y, z} – error		
Description	The signal "Shape surface normal {x, y, z} – error" (A.3.21) provides the error of the signal "Shape surface normal {x, y, z}" (A.3.20) which is the normal of the shape's approximated tangential plane at the shape reference point [see corresponding signal "Position – feature level {x, y, z}" (A.3.17)].		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Shape surface normal {x, y, z}" (A.3.20).

A.3.22 Translation rate {x, y, z} – feature level

Table A.361 — Signal: Translation rate {x, y, z} – feature level

Name	Translation rate {x, y, z} – feature level		
Description	The signal "Translation rate {x, y, z} – feature level" (A.3.22) provides the scaled translation of the shape's approximated tangential plane at the shape reference point [see corresponding signal "Position – feature level {x, y, z}" (A.3.17)]. Longitudinally (along the view axis) that is the inverse time to collision. No motion → (0, 0, 0) m/s		
Value type	3D vector real value	**Unit**	(m/s, m/s, m/s)

A.3.23 Translation rate {x, y, z} – feature level – error

Table A.362 — Signal: Translation rate {x, y, z} – feature level – error

Name	Translation rate {x, y, z} – feature level – error		
Description	The signal "Translation rate {x, y, z} – feature level – error" (A.3.23) provides the error of the signal "Translation rate {x, y, z} – feature level" (A.3.22) of the shape's approximated tangential plane at the shape reference point [see corresponding signal "Position – feature level {x, y, z}" (A.3.17)].		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Translation rate {x, y, z} – feature level" (A.3.22).

A.3.24 Rotation rate {yaw, pitch, roll} – feature level

Table A.363 — Signal: Rotation rate {yaw, pitch, roll} – feature level

Name	Rotation rate {yaw, pitch, roll} – feature level

Description	The signal “Rotation rate {yaw, pitch, roll} – feature level” (A.3.24) provides the rotation change of the shape’s approximated tangential plane at the shape reference point [see corresponding signal “Position – feature level {x, y, z}” (A.3.17)]. No rotation change → (0, 0, 0) rad/s		
Value type	3D vector real value	**Unit**	(rad/s, rad/s, rad/s)

A.3.25 Rotation rate {yaw, pitch, roll} – error – feature level

Table A.364 — Signal: Rotation rate {yaw, pitch, roll} – error – feature level

Name	Rotation rate {yaw, pitch, roll} – error – feature level		
Description	The signal “Rotation rate {yaw, pitch, roll} – error – feature level” (A.3.25) provides the error of the signal’s “Rotation rate {yaw, pitch, roll} – feature level” (A.3.24) change of the shape’s approximated tangential plane at the shape reference point [see corresponding signal “Position – feature level {x, y, z}” (A.3.17)].		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Rotation rate {yaw, pitch, roll} – feature level” (A.3.24).

A.3.26 Scale change – feature level

Table A.365 — Signal: Scale change – feature level

Name	Scale change – feature level		
Description	The signal “Scale change – feature level” (A.3.26) provides the mean scale ratio of the shape’s approximated tangential plane at the shape reference point [see corresponding signal “Position – feature level {x, y, z}” (A.3.17)]. No change in size ≔ ratio of 100 %. Additional information: Describes the lateral shift and size change of the shape segment over time. The signal “Scale change – feature level” (A.3.26) is normalised.		
Value type	real value	**Unit**	%/s

A.3.27 Scale change – feature level – error

Table A.366 — Signal: Scale change – feature level – error

Name	Scale change – feature level – error		
Description	The signal “Scale change – feature level – error” (A.3.27) provides the error of the signal “Scale change – feature level” (A.3.26) of the shape’s approximated tangential plane at the shape reference point [see corresponding signal “Position – feature level {x, y, z}” (A.3.17)].		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Scale change – feature level” (A.3.26).

A.3.28 Number of valid ultrasonic feature classifications

Table A.367 — Signal: Number of valid ultrasonic feature classifications

Name	Number of valid ultrasonic feature classifications

Description	The signal “Number of valid ultrasonic feature classifications” (A.3.28) provides the current number of valid tuples for ultrasonic feature classifications. The tuples are defined by the signals “Ultrasonic feature classification type” (A.3.29) and “Ultrasonic feature classification type – confidence” (A.3.30).		
Value type	[0…] integer value	**Unit**	1

A.3.29 Ultrasonic feature classification type

Table A.368 — Signal: Ultrasonic feature classification type

Name	Ultrasonic feature classification type		
Description	The signal “Ultrasonic feature classification type” (A.3.29) contains information about the current measurement of this feature.		
Value type	enumeration	**Unit**	1

Table A.369 — Enumeration: Ultrasonic feature classification type – Example enumerators

Name	**Description**	**RL enumerator**
UFCT_Point	The feature is defined by one point and optional by a height value.	“exemplary”
UFCT_LineSegment	The feature is defined by two or more points and optional by height values.	“exemplary”

A.3.30 Ultrasonic feature classification type – confidence

Table A.370 — Signal: Ultrasonic feature classification type – confidence

Name	Ultrasonic feature classification type – confidence		
Description	The signal “Ultrasonic feature classification type – confidence” (A.3.30) provides the confidence of the ultrasonic feature type.		
Value type	[0…100] real value	**Unit**	%

A.3.31 Number of valid points

Table A.371 — Signal: Number of valid points

Name	Number of valid points		
Description	The signal “Number of valid points” (A.3.31) provides the current number of valid points.		
Value type	[0…] integer value	**Unit**	1

A.3.32 Orientation – feature level {pitch}

Table A.372 — Signal: Orientation – feature level {pitch}

Name	Orientation – feature level {pitch}		
Description	The signal “Orientation – feature level {pitch}” (A.3.32) provides the orientation of the feature.		
Value type	1D vector real value	**Unit**	rad

A.3.33 Orientation – feature level {pitch} – error

Table A.373 — Signal: Orientation – feature level {pitch} – error

Name	Orientation – feature level {pitch} – error		
Description	The signal "Orientation – feature level {pitch} – error" (A.3.33) provides the error value of the signal "Orientation – feature level {pitch}" (A.3.32).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Orientation – feature level {pitch}" (A.3.32).

A.3.34 Extent {height} – feature level

Table A.374 — Signal: Extent {height} – feature level

Name	Extent {height} – feature level		
Description	The signal "Extent {height} – feature level" (A.3.34) provides the height of the point [see signal "Position – feature level {x, y, z}" (A.3.17)]. That means, the upper edge of the feature is specified. Additional information: The signal "Extent {height} – feature level" (A.3.34) is the *Z*-axis offset of the signal "Position – feature level {x, y, z}" (A.3.17). If {z} is not specified, the height is with respect to the origin of the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	real value	**Unit**	m

A.3.35 Extent {height} – feature level – error

Table A.375 — Signal: Extent {height} – feature level – error

Name	Extent {height} – feature level – error		
Description	The signal "Extent {height} – feature level – error" (A.3.35) provides the error value of the signal "Extent {height} – feature level" (A.3.34).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Extent {height} – feature level" (A.3.34).

A.3.36 Velocity {x, y} – feature level

Table A.376 — Signal: Velocity {x, y} – feature level

Name	Velocity {x, y} – feature level		
Description	The signal "Velocity {x, y} – feature level" (A.3.36) provides the velocity over ground of the feature which is specified in the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	2D vector real value	**Unit**	(m/s, m/s)

A.3.37 Velocity {x, y} – feature level – error

Table A.377 — Signal: Velocity {x, y} – feature level – error

Name	Velocity {x, y} – feature level – error

Description	The signal "Velocity {x, y} – feature level – error" (A.3.37) provides the error values for the signal "Velocity {x, y} – feature level" (A.3.36) in the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – header" (A.1.20)].		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Velocity {x, y} – feature level" (A.3.36).

A.3.38 Trilateration status

Table A.378 — Signal: Trilateration status

Name	Trilateration status		
Description	The signal "Trilateration status" (A.3.38) provides the information whether the feature is trilaterated with multiple signal ways or is not trilaterated.		
Value type	enumeration	**Unit**	1

Table A.379 — Enumeration: Trilateration status – Example enumerators

Name	Description	RL enumerator
TS_Trilaterated	The measurement of the signal's "Position – feature level {x, y, z}" (A.3.17) point is based on at least three detections for a 2D information.	"exemplary"
TS_NotTrilaterated	The measurement of the signal's "Position – feature level {x, y, z}" (A.3.17) point is based on less than three detections.	"exemplary"

A.3.39 Measurement status – feature level

Table A.380 — Signal: Measurement status – feature level

Name	Measurement status – feature level		
Description	The signal "Measurement status – feature level" (A.3.39) provides the information about the measurement status of the feature.		
Value type	enumeration	**Unit**	1

Table A.381 — Enumeration: Measurement status – feature level – Example enumerators

Name	Description	RL enumerator
MS_Initialisation	No information is available.	"exemplary"
MS_Tracked	It was not measured in the current cycle.	"exemplary"
MS_Measured	Current position of this feature was measured.	"exemplary"
MS_Delete	Tracking will be deleted in the next cycle.	"exemplary"
MS_New	It is the first cycle of tracking of the feature.	"exemplary"

A.4 Detection level entity signals

Signals are defined for the entities of subclauses 9.3-9.6 in this subclause (see Table A.382-Table A.429). These interfaces are located at the DLI. Normally the DLI originates from one sensing element. Therefore, at detection level, the term sensor is always used, even if a combination of emitting as well as sensing elements are serving the interface.

A.4.1 Existence probability – detection level

Table A.382 — Signal: Existence probability – detection level

Name	Existence probability – detection level		
Description	The signal "Existence probability – detection level" (A.4.1) of the detection uses, for example, signal to noise ratio (SNR) and radar cross section (RCS). It is not based on history. Additional information: Use as confidence measure where a low value means less confidence and a high value indicates strong confidence.		
Value type	[0…100] real value	**Unit**	%

A.4.2 Detection ID

Table A.383 — Signal: Detection ID

Name	Detection ID		
Description	The signal "Detection ID" (A.4.2) provides the unique identification number of the detection within the detection list. Additional information: The signal's "Detection ID" (A.4.2) value is only unique for each sensor cluster's detection entities of DLI within one measurement cycle. If interfaces use the signal "Detection ID" (A.4.2) to link, for example, object entities with detection entities, the interfaces shall ensure the unambiguity of the referenced entities at each or multiple measurement cycle(s) [see, for example, cross interface optimisation "Source entities of a derived signal" (B.3.4)].		
Value type	[0…] integer value	**Unit**	1

A.4.3 Object ID reference – detection level

Table A.384 — Signal: Object ID reference – detection level

Name	Object ID reference – detection level		
Description	The signal's "Object ID" (A.2.2) value defines the object to which this detection is associated to; invalid = "no associated object", for example, for the first detection cycle of the entity. Additional information: Refers to object (for example, potentially moving object) with the highest probability. The signal's "Object ID reference – detection level" (A.4.3) value could reference entities of the sensor cluster's OLI or entities which are used internally by the sensor cluster. Alternative A2I (B.3.2): The mapping of objects signal "Object ID" (A.2.2) and detections signal "Object ID reference – detection level" (A.4.3) could be provided in a separate interface.		
Value type	[0…] integer value	**Unit**	1

A.4.4 Feature ID reference

Table A.385 — Signal: Feature ID reference

Name	Feature ID reference

Description	The signal's "Feature ID" (A.3.2) value defines the feature to which this detection is associated to; invalid = "no associated Feature", for example, for the first detection cycle of the entity. Additional information: Refers to feature (for example, camera feature, ultrasonic feature) with the highest probability for the association. The signal's "Feature ID reference" (A.4.4) value could reference entities of the sensor cluster's FLI or entities which are used internally by the sensor cluster. Alternative A2I (B.3.2): the mapping of features signal "Feature ID" (A.3.2) and detections signal "Feature ID reference" (A.4.4) could be provided in a separate interface.		
Value type	[0…] integer value	**Unit**	1

A.4.5 Time stamp difference – detection level

Table A.386 — Signal: Time stamp difference – detection level

Name	Time stamp difference – detection level		
Description	Each detection entity could provide an individual time stamp, specifically a time stamp difference to the signal "Time stamp – measurement" (A.1.5.2) value of the interface. Additional information: The time stamp of the detection can be calculated as the signal "Time stamp – measurement" (A.1.5.2) of the DLI header for the cycle plus the signal "Time stamp difference – detection level" (A.4.5) of the detection.		
Value type	real value	**Unit**	s

A.4.6 Radar cross section

Table A.387 — Signal: Radar cross section

Name	Radar cross section		
Description	The signal "Radar cross section" (A.4.6) provides the RCS of the detection. Additional information: It is the representative RCS of the detection. The value is compensated. Slow changes (for example, aging of the sensor) are compensated, fast changes (for example, rain) are not compensated. All systematic absorptions are compensated, for example, from the bumper.		
Value type	real value	**Unit**	dB m^2

A.4.7 Radar cross section – error

Table A.388 — Signal: Radar cross section – error

Name	Radar cross section – error		
Description	The signal "Radar cross section – error" (A.4.7) provides the error value of the signal "Radar cross section" (A.4.6).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Radar cross section" (A.4.6).

A.4.8 Signal to noise ratio – detection level

Table A.389 — Signal: Signal to noise ratio – detection level

Name	Signal to noise ratio – detection level		
Description	The signal “Signal to noise ratio – detection level” (A.4.8) provides the SNR of the detection.		
Value type	real value	**Unit**	dB

A.4.9 Signal to noise ratio – detection level – error

Table A.390 — Signal: Signal to noise ratio – detection level – error

Name	Signal to noise ratio – detection level – error		
Description	The signal “Signal to noise ratio – detection level – error” (A.4.9) provides the error value of the signal “Signal to noise ratio – detection level” (A.4.8).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Signal to noise ratio – detection level” (A.4.8).

A.4.10 Multi target probability

Table A.391 — Signal: Multi target probability

Name	Multi target probability		
Description	The signal “Multi target probability” (A.4.10) describes the possibility if more than one real-world object has led to this detection.		
Value type	[0…100] real value	**Unit**	%

A.4.11 Ambiguity grouping ID

Table A.392 — Signal: Ambiguity grouping ID

Name	Ambiguity grouping ID		
Description	Ambiguous measurement uses one ID for signal “Ambiguity grouping ID” (A.4.11) for ambiguous detection candidates. Ambiguous detections (all detection candidates for the same measurement value) are shown by the same signal’s “Ambiguity grouping ID” (A.4.11) value. Detections of unambiguous measurements have signal “Ambiguity grouping ID” (A.4.11) ≔ 0. Additional information: Ambiguity can be specified by, for example, the signal “Radial velocity ambiguity domain {begin, end}” (A.1.15), “Range ambiguity domain {begin, end}” (A.1.16), “Angle azimuth ambiguity domain {begin, end}” (A.1.17) or “Angle elevation ambiguity domain {begin, end}” (A.1.18). Other ambiguities can add an additional signal analogous to these signals. The signal’s “Ambiguity grouping ID” (A.4.11) value in the list is unique only for each cycle. The signal’s “Ambiguity grouping ID” (A.4.11) values could be reused every cycle.		
Value type	[0…] integer value	**Unit**	1

A.4.12 Detection ambiguity probability

Table A.393 — Signal: Detection ambiguity probability

Name	Detection ambiguity probability

Description	The signal "Detection ambiguity probability" (A.4.12) provides the probability for different hypotheses, sum is less or equal 100 % for all detections with the same signal's "Ambiguity grouping ID" (A.4.11) value. Additional information: Use as confidence measure where a low value means less confidence and a high value indicates strong confidence.		
Value type	[0…100] real value	**Unit**	%

A.4.13 Free space probability

Table A.394 — Signal: Free space probability

Name	Free space probability		
Description	The signal "Free space probability" (A.4.13) provides the free space probability in the range [0, 100] % from the origin of the sensor up to this detection, as given by the distance. Additional information: The probability of free space between the origin and this detection as given by the distance in the range [0, 100] %. In this range, for example, the signal "Signal to noise ratio – detection level" (A.4.8) is very low. A second detection (detection behind another detection) has the signal "Free space probability" (A.4.13) = 0 %. In case of an empty measurement, the detection's signal "Existence probability – detection level" (A.4.1) is set to 0 % and the distance is set to a default value. The distance of the detection combined with the signal "Free space probability" (A.4.13) give the free space. Use as confidence measure where a low value means less confidence and a high value indicates strong confidence.		
Value type	[0…100] real value	**Unit**	%

A.4.14 Number of valid detection classifications

Table A.395 — Signal: Number of valid detection classifications

Name	Number of valid detection classifications		
Description	The signal "Number of valid detection classifications" (A.4.14) provides the current number of valid tuples for detection classifications. The tuples are defined by the signals "Detection classification type" (A.4.15) and "Detection classification type – confidence" (A.4.16).		
Value type	[0…] integer value	**Unit**	1

A.4.15 Detection classification type

Table A.396 — Signal: Detection classification type

Name	Detection classification type
Description	Additional classification information if detection is assigned to an object [see signal "Object ID reference – detection level" (A.4.3)]. Additional information: Exception to single shot rule: can be tracked over time. A detection might require multiple time steps.

Value type	enumeration	**Unit**	1

Table A.397 — Enumeration: Detection classification type – Example enumerators

Name	Description	RL enumerator
DCT_NoClassification	The detection entity is not classified.	“exemplary”
DCT_Noise	The detection entity is noise.	“exemplary”
DCT_Obstacle	The detection entity is an obstacle for the ego-vehicle.	“exemplary”
DCT_Underdriveable	The detection entity is under-driveable for the ego-vehicle.	“exemplary”
DCT_Overdriveable	The detection entity is over-driveable for the ego-vehicle.	“exemplary”
DCT_Nearest	The detection entity is the nearest detection of a measurement.	“exemplary”
DCT_Strongest	The detection entity has the strongest signal of a measurement.	“exemplary”

A.4.16 Detection classification type – confidence

Table A.398 — Signal: Detection classification type – confidence

Name	Detection classification type – confidence		
Description	The signal “Detection classification type – confidence” (A.4.16) provides the confidence for the corresponding signal “Detection classification type” (A.4.15).		
Value type	[0…100] real value	**Unit**	%

A.4.17 Position {radial distance, azimuth, elevation}

Table A.399 — Signal: Position {radial distance, azimuth, elevation}

Name	Position {radial distance, azimuth, elevation}		
Description	Due to sensor specific measurement method, the values of the signal “Position {radial distance, azimuth, elevation}” (A.4.17) are given in the sensor coordinate system. Additional information: In case of an ambiguity the detection is sent several times. For example, a measured detection with angle ambiguity will send detection candidates with different angles and different values for signal “Detection ambiguity probability” (A.4.12)] and the same value for signal “Ambiguity grouping ID” (A.4.11).		
Value type	3D vector real value	**Unit**	(m, rad, rad)

A.4.18 Position {radial distance, azimuth, elevation} – error

Table A.400 — Signal: Position {radial distance, azimuth, elevation} – error

Name	Position {radial distance, azimuth, elevation} – error
Description	The signal “Position {radial distance, azimuth, elevation} – error” (A.4.18) provides the error values of the signal “Position {radial distance, azimuth, elevation}” (A.4.17). Additional information: The values are given in the sensor coordinate system.

Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Position {radial distance, azimuth, elevation}” (A.4.17).

A.4.19Relative velocity {radial distance}

Table A.401 — Signal: Relative velocity {radial distance}

Name	Relative velocity {radial distance}		
Description	The signal “Relative velocity {radial distance}” (A.4.19) provides the velocity (in direction to the sensing element) of the detection. The velocity is the relative velocity between the absolute velocity of the sensor and the absolute velocity of the detection in radial direction. Additional information: An entity approaching the sensor shall have a negative radial relative velocity. An entity moving away from the sensor shall have a positive radial relative velocity. The values are given in the sensor coordinate system.		
Value type	1D vector real value	**Unit**	m/s

A.4.20Relative velocity {radial distance} – error

Table A.402 — Signal: Relative velocity {radial distance} – error

Name	Relative velocity {radial distance} – error		
Description	The signal “Relative velocity {radial distance} – error” (A.4.20) provides the error value of the signal “Relative velocity {radial distance}” (A.4.19). Additional information: The values are given in the sensor coordinate system.		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Relative velocity {radial distance}” (A.4.19).

A.4.21Reflectivity

Table A.403 — Signal: Reflectivity

Name	Reflectivity		
Description	The signal “Reflectivity” (A.4.21) provides the reflectivity of the detection with respect to the norm target. Additional information: It is the representative lidar reflectivity of the detection. For lidar sensors (for example, assuming Lambertian reflectivity) for the wavelength used by the laser. The signal is comparable to the signal “Radar cross section” (A.4.6).		
Value type	real value	**Unit**	%

A.4.22 Reflectivity – error

Table A.404 — Signal: Reflectivity – error

Name	Reflectivity – error		
Description	The signal "Reflectivity – error" (A.4.22) provides the error value of the detection's signal "Reflectivity" (A.4.21).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Reflectivity" (A.4.21).

A.4.23 Extent {height} – lidar

Table A.405 — Signal: Extent {height} – lidar

Name	Extent {height} – lidar		
Description	The signal "Extent {height} – lidar" (A.4.23) is required if multiple lidar scan points are vertically clustered. The spherical point of detection [the signal "Position {radial distance, azimuth, elevation}" (A.4.17)] is the lower point of height. The height is vertical (*Z*-axis of the vehicle). Only vertical clustering allowed. Additional information: The values are given in the sensor coordinate system.		
Value type	real value	**Unit**	m

A.4.24 Extent {height} – lidar – error

Table A.406 — Signal: Extent {height} – lidar – error

Name	Extent {height} – lidar – error		
Description	The signal "Extent {height} – lidar – error" (A.4.24) provides the error value of the detection's signal "Extent {height} – lidar" (A.4.23).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Extent {height} – lidar" (A.4.23).

A.4.25 Number of valid shape classifications – detection level

Table A.407 — Signal: Number of valid shape classifications – detection level

Name	Number of valid shape classifications – detection level		
Description	The signal "Number of valid shape classifications – detection level" (A.4.25) provides the current number of valid tuples for shape classifications. The tuples are defined by the signals "Shape classification type – detection level" (A.4.26) and "Shape classification type – confidence – detection level" (A.4.27).		
Value type	[0…] integer value	**Unit**	1

A.4.26 Shape classification type – detection level

Table A.408 — Signal: Shape classification type – detection level

Name	Shape classification type – detection level

Description	The signal "Shape classification type – detection level" (A.4.26) provides the classification type for the shape.		
Value type	enumeration	**Unit**	1

Table A.409 — Enumeration: Shape classification type – detection level – Example enumerators

Name	**Description**	**RL enumerator**
SCT_Background	The shape is classified as a background entity.	"exemplary"
SCT_Foreground	The shape is classified as a foreground entity.	"exemplary"
SCT_Flat	The shape is classified as a flat entity.	"exemplary"
SCT_Upright	The shape is classified as an upright entity.	"exemplary"
SCT_Ground	The shape is classified as a ground entity.	"exemplary"
SCT_Sky	The shape is classified as a sky entity.	"exemplary"
SCT_Building	The shape is classified as a building entity.	"exemplary"
SCT_Vegetation	The shape is classified as a vegetation entity.	"exemplary"
SCT_Road	The shape is classified as a road entity.	"exemplary"
SCT_NonRoad	The shape is classified as a non-road entity.	"exemplary"
SCT_Pavement	The shape is classified as a pavement entity.	"exemplary"
SCT_Pedestrian	The shape is classified as a pedestrian entity.	"exemplary"
SCT_Vehicle	The shape is classified as a vehicle entity.	"exemplary"
SCT_TrafficSign	The shape is classified as a traffic sign entity.	"exemplary"
SCT_PedestrianFront	The shape is classified as a pedestrian front-view entity.	"exemplary"
SCT_PedestrianSide	The shape is classified as a pedestrian side-view entity.	"exemplary"
SCT_PedestrianRear	The shape is classified as a pedestrian rear-view entity.	"exemplary"

A.4.27 Shape classification type – confidence – detection level

Table A.410 — Signal: Shape classification type – confidence – detection level

Name	Shape classification type – confidence – detection level		
Description	The signal "Shape classification type – confidence – detection level" (A.4.27) provides the confidence of the shape [see signal "Shape classification type – detection level" (A.4.26)].		
Value type	enumeration	**Unit**	1

Table A.411 — Enumeration: Shape classification type – confidence – detection level – Example enumerators

Name	**Description**	**RL enumerator**
SCTC_HighConfidence	The classification of the shape has a high confidence.	"exemplary"
SCTC_MediumConfidence	The classification of the shape has a medium confidence.	"exemplary"
SCTC_LowConfidence	The classification of the shape has a low confidence.	"exemplary"

A.4.28 Shape ambiguity grouping ID

Table A.412 — Signal: Shape ambiguity grouping ID

Name	Shape ambiguity grouping ID		
Description	Each ambiguous shape classification with different shape classification probabilities uses one unique ID. Ambiguous detections (all shape detection candidates for the same measurement) are shown by the identical signal's "Shape ambiguity grouping ID" (A.4.28) value. Additional information: Unambiguous shape classifications have the signal's value "Shape ambiguity grouping ID" (A.4.28) ≔ 0. The signal "Shape ambiguity grouping ID" (A.4.28) shall be unique in each cycle of the sensor.		
Value type	[0…] integer value	**Unit**	1

A.4.29 Colour value – detection level

Table A.413 — Signal: Colour value – detection level

Name	Colour value – detection level		
Description	The signal "Colour value – detection level" (A.4.29) provides the definition of the colour value(s). The number of values depends on the signal "Colour model type" (A.1.14). Additional information: For example, enumerator "CMT_RGB" has 3 colour values, specifically first value is red, second value is green, third value is blue.		
Value type	[0…100] real value	**Unit**	%

A.4.30 Colour tone – confidence – detection level

Table A.414 — Signal: Colour tone – confidence – detection level

Name	Colour tone – confidence – detection level		
Description	The signal "Colour tone – confidence – detection level" (A.4.30) gives the proportion of the area with the specified colour tone. The tone is defined by the signal "Colour model type" (A.1.14) and the list of signals "Colour value – detection level" (A.4.29). Additional information: Multicolour may be indicated by the signal's "Colour tone – confidence – detection level" (A.4.30) value.		
Value type	[0…100] real value	**Unit**	%

A.4.31 Shape type – detection level

Table A.415 — Signal: Shape type – detection level

Name	Shape type – detection level

Description	The signal “Shape type – detection level” (A.4.31) provides the shape of the segment's borderline. Additional information: The shape defines how the referenced points are connected. The interpretation of the enumerators will be defined during the system design phase.		
Value type	enumeration	**Unit**	1

Table A.416 — Enumeration: Shape type – detection level – Example enumerators

Name	**Description**	**RL enumerator**
ST_Point	The shape is a point.	“exemplary”
ST_Box	The shape is a box (2 or 3 points).	“exemplary”
ST_Ellipse	The shape is an ellipse (2 or 3 points).	“exemplary”
ST_Polygon	The shape is a polygon (3 or more points).	“exemplary”
ST_Polyline	The shape is a polyline (2 or more points).	“exemplary”
ST_PointCloud	The shape is a point cloud (2 or more points).	“exemplary”

A.4.32 Number of valid shape points – detection level

Table A.417 — Signal: Number of valid shape points – detection level

Name	Number of valid shape points – detection level		
Description	The signal “Number of valid shape points – detection level” (A.4.32) provides the current number of valid shape points. The shape points are part of the polyline, which defines the border of the shape. Additional information: The signal “Number of valid shape points – detection level” (A.4.32) ≥ 1.		
Value type	[0…] integer value	**Unit**	1

A.4.33 Point existence probability – detection level

Table A.418 — Signal: Point existence probability – detection level

Name	Point existence probability – detection level		
Description	The signal “Point existence probability – detection level” (A.4.33) provides the existence probability of the point. Each point is only used by one shape [maybe one shape is sent in several entities with different shape classification probabilities and the same signal “Shape ambiguity grouping ID” (A.4.28)]. Additional information: Use as confidence measure where a low value means less confidence and a high value indicates strong confidence.		
Value type	[0…100] real value	**Unit**	%

A.4.34 Number of valid shape reference points – detection level

Table A.419 — Signal: Number of valid shape reference points – detection level

Name	Number of valid shape reference points – detection level		
Description	The signal "Number of valid shape reference points – detection level" (A.4.34) provides the current number of valid shape reference points. The shape reference points are parts of the detection's shape.		
Value type	[0…] integer value	**Unit**	1

A.4.35 Detection ID reference – detection level

Table A.420 — Signal: Detection ID reference – detection level

Name	Detection ID reference – detection level		
Description	The signal's "Detection ID" (A.4.2) value defines the detection to which this detection is associated to; invalid = "no associated detection". Additional information: This refers to detection (for example, camera detection points) with the highest probability. Alternative A2I (B.3.2): The mapping of objects signal "Detection ID" (A.4.2) and detections signal "Detection ID reference – detection level" (A.4.35) could be provided in a separate interface.		
Value type	[0…] integer value	**Unit**	1

A.4.36 Extent {azimuth, elevation}

Table A.421 — Signal: Extent {azimuth, elevation}

Name	Extent {azimuth, elevation}		
Description	The signal "Extent {azimuth, elevation}" (A.4.36) provides the extent width of the detection point for each angle.		
Value type	2D vector real value	**Unit**	(rad, rad)

A.4.37 Extent {azimuth, elevation} – error

Table A.422 — Signal: Extent {azimuth, elevation} – error

Name	Extent {azimuth, elevation} – error		
Description	The signal "Extent {azimuth, elevation} – error" (A.4.37) provides the error of the signal "Extent {azimuth, elevation}" (A.4.36) of the detection point.		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Extent {azimuth, elevation}" (A.4.36).

A.4.38 Translation rate {radial distance, azimuth, elevation} – detection level

Table A.423 — Signal: Translation rate {radial distance, azimuth, elevation} – detection level

Name	Translation rate {radial distance, azimuth, elevation} – detection level

Description	The signal "Translation rate {radial distance, azimuth, elevation} – detection level" (A.4.38) provides the translation of the shape's approximated tangential plane at the shape reference point [see corresponding signal "Position {radial distance, azimuth, elevation}" (A.4.17)]. No motion → (0, 0, 0)		
Value type	3D vector real value	**Unit**	(m/s, rad/s, rad/s)

A.4.39 Translation rate {radial distance, azimuth, elevation} – detection level – error

Table A.424 — Signal: Translation rate {radial distance, azimuth, elevation} – detection level – error

Name	Translation rate {radial distance, azimuth, elevation} – detection level – error		
Description	The signal "Translation rate {radial distance, azimuth, elevation} – detection level – error" (A.4.39) provides the error of the signal "Translation rate {radial distance, azimuth, elevation} – detection level" (A.4.38) of the shape's approximated tangential plane at the shape reference point [see corresponding signal "Position {radial distance, azimuth, elevation}" (A.4.17)].		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Translation rate {radial distance, azimuth, elevation} – detection level" (A.4.38).

A.4.40 Second sensor ID reference

Table A.425 — Signal: Second sensor ID reference

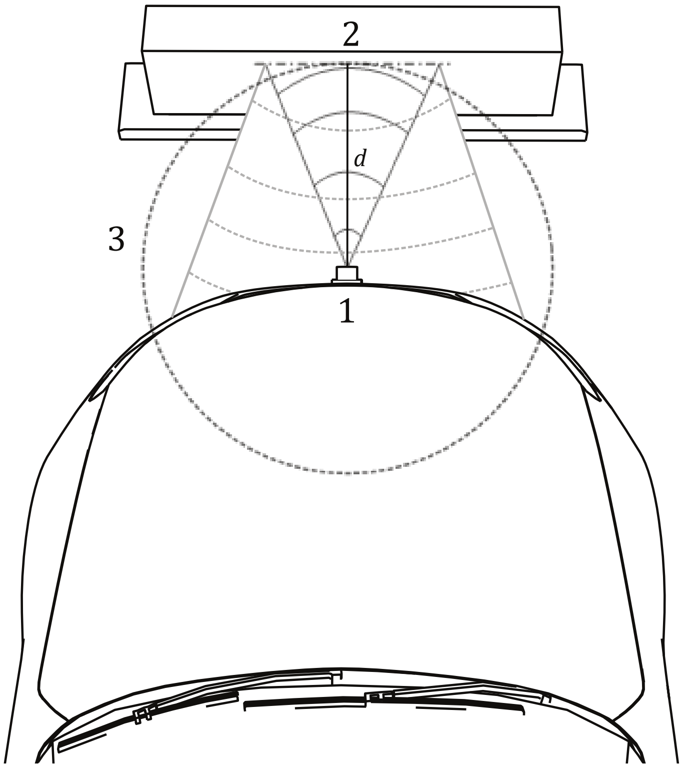
Name	Second sensor ID reference		
Description	The signal "Second sensor ID reference" (A.4.40) provides the ID of the corresponding sensor to the DLI header signal "Sensor ID" (A.1.4) of a virtual sensor. One ID provides the emitting the other the sensing sensor ID. Additional information: A sensor will transmit all received detections of a sensor cluster which were triggered by the ultrasonic wave of the sensor with the signal's "Sensor ID" (A.1.4) value or all received detections by the sensor signal "Sensor ID" (A.1.4). All emitting and/or sensing sensors may provide the SPI, in detail the LSG "Information: sensor pose" (see Table 51). Requirement: The definition of the signals "Sensor ID" (A.1.4)/"Second sensor ID reference" (A.4.40) corresponding to the emitting/sensing sensor is defined in the system design phase [see Profile: Ultrasonic sensor cluster (9.6.3)].		
Value type	integer value	**Unit**	1

A.4.41 Distance

Table A.426 — Signal: Distance

Name	Distance

Description	The signal "Distance" (A.4.41) provides the mean distance of a detection to the emitting and sensing sensor. Additional information: In case of a combined sending and receiving ultrasonic sensor, the obstacle's reflection point is theoretically on a circle (see Figure A.29). In case of a separated emitting ultrasonic sensor and a sensing ultrasonic sensor, the obstacle's reflection point is theoretically on an ellipse (see Figure A.30).		
Value type	real value	**Unit**	m



Key

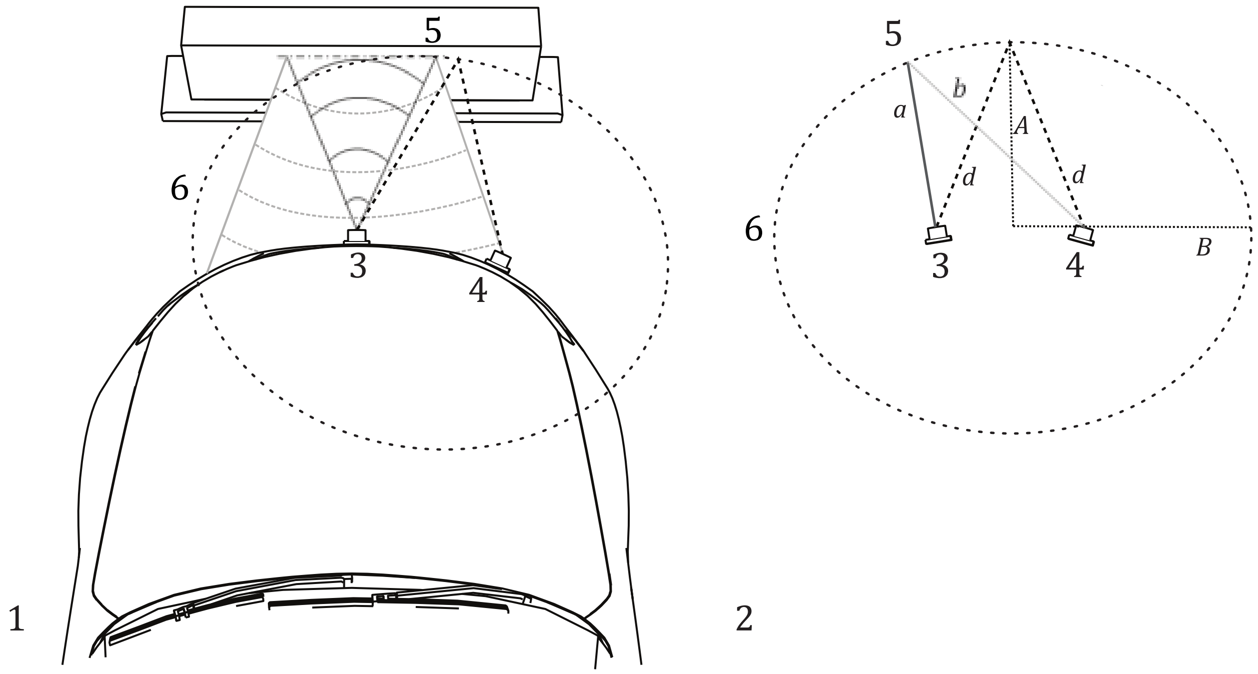
1 ultrasonic sender/receiver $\overrightarrow{(SR)}$ – emitting and sensing ultrasonic element

2 obstacle's reflection point $\overrightarrow{(O)}$

3 ellipse (theoretically possible points of an obstacle's reflection) – a circle

d direct distance to the obstacle $:= \left|\overrightarrow{(O)} - \overrightarrow{(SR)}\right|$

Figure A.29 — Example for a detection where emitting and sensing element is the same (real sensor)



Key

1 scenario

2 elliptical description (aligned to the axes A and B of the ellipse)

3 ultrasonic sender $\overrightarrow{(S)}$ – emitting ultrasonic element

4 ultrasonic receiver $\overrightarrow{(R)}$ – sensing ultrasonic element

5 obstacle's reflection point $\overrightarrow{(O)}$

6 ellipse (theoretically possible points of an obstacle's reflection)

A ellipse semi-minor axis $:= \sqrt{d^2 - \left(\frac{\left|\overrightarrow{(S)}-\overrightarrow{(R)}\right|}{2}\right)^2}$

B ellipse semi-major axis ≔ d

a distance from the emitting ultrasonic element to the obstacle's reflection point $:= \left|\overrightarrow{(O)} - \overrightarrow{(S)}\right|$

b distance from the obstacle's reflection point to the sensing ultrasonic element $:= \left|\overrightarrow{(R)} - \overrightarrow{(O)}\right|$

d mean distance of the echo of a reflection between emitting ultrasonic element, obstacle's reflection point and sensing ultrasonic element $:= (a + b)/2$

Figure A.30 — Example for an ultrasonic detection where emitting- and sensing element are different (virtual sensor)

A.4.42 Distance – error

Table A.427 — Signal: Distance – error

Name	Distance – error		
Description	The signal "Distance – error" (A.4.42) provides the error of the estimated signal's "Distance" (A.4.41) value of the detection.		
Value type	real value	**Unit**	m

A.4.43 Extent {height} – ultrasonic

Table A.428 — Signal: Extent {height} – ultrasonic

Name	Extent {height} – ultrasonic		
Description	The signal "Extent {height} – ultrasonic" (A.4.43) provides the estimated height of the detection. Additional information: The values are given in the sensor coordinate system.		
Value type	real value	**Unit**	m

A.4.44 Extent {height} – ultrasonic – error

Table A.429 — Signal: Extent {height} – ultrasonic – error

Name	Extent {height} – ultrasonic – error		
Description	The signal "Extent {height} – ultrasonic – error" (A.4.44) provides the error of the estimated height of the detection.		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Extent {height} – ultrasonic (A.4.43).

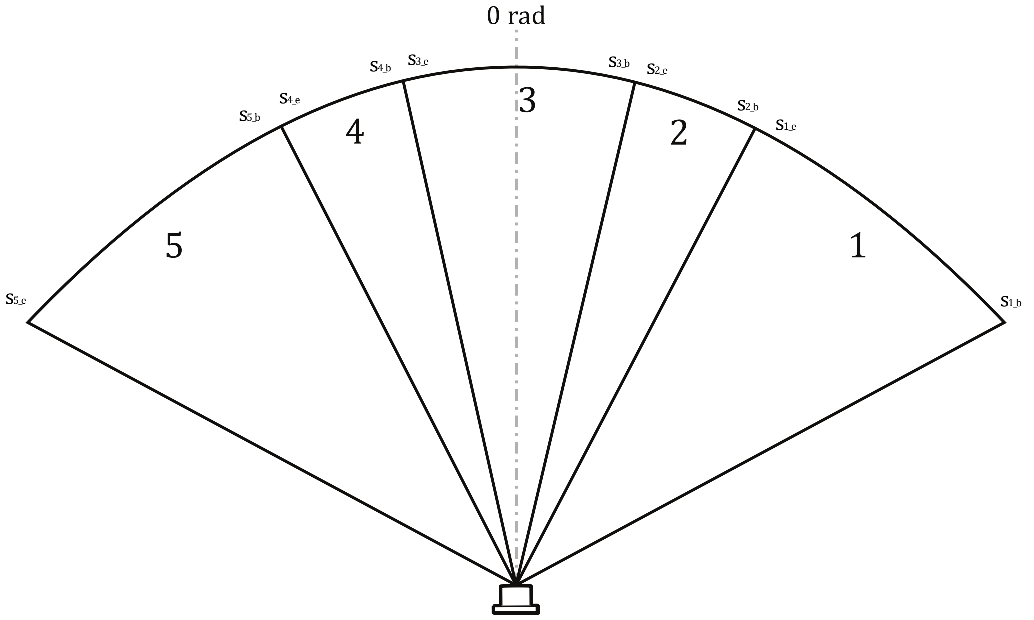
A.5 Supportive sensor interface entity signals

Signals are defined for the entities of subclauses 10.3 and 10.4 in this subclause (see Table A.430-Table A.498). These interfaces are located at SSI. The subclause 10.4 consists of one information entity for the complete sensor. Sensors and sensor clusters serve supportive sensor interfaces (SSI). In this subclause for SSI, the term sensor is always used, even if a sensor cluster is serving the interface.

A.5.1 Segment azimuth – supportive sensor level {begin, end}

Table A.430 — Signal: Segment azimuth – supportive sensor level {begin, end}

Name	Segment azimuth – supportive sensor level {begin, end}		
Description	The FOV segment is defined by the opening angles in the sensor *XY*-plane (see Figure A.31). Additional information: The values are given in the sensor coordinate system.		
Value type	2D vector real value	**Unit**	(rad, rad)



Key

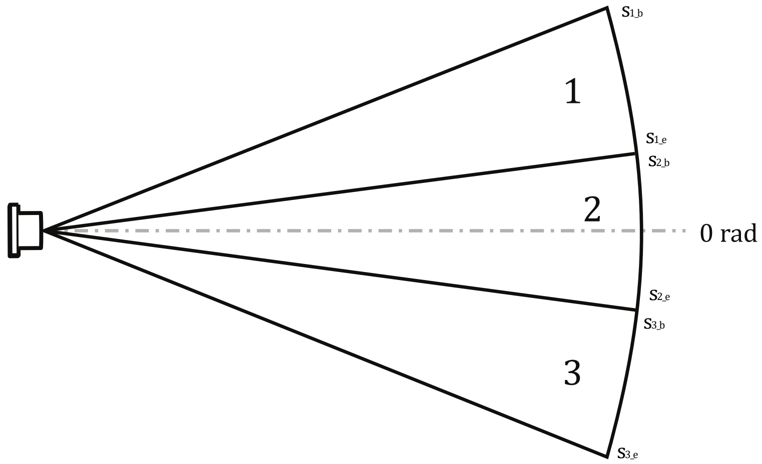
1	segment azimuth 1 $s_{1\_b} = -5\frac{\pi}{12}$ rad, $s_{1\_e} = -2\frac{\pi}{12}$ rad for signal "Segment azimuth – supportive sensor level {begin, end}" (A.5.1)
2	segment azimuth 2 $s_{2\_b} = -2\frac{\pi}{12}$ rad, $s_{2\_e} = -\frac{\pi}{12}$ rad for signal "Segment azimuth – supportive sensor level {begin, end}" (A.5.1)
3	segment azimuth 3: $s_{3\_b} = -\frac{\pi}{12}$ rad, $s_{3\_e} = \frac{\pi}{12}$ rad for signal "Segment azimuth – supportive sensor level {begin, end}" (A.5.1)
4	segment azimuth 4: $s_{4\_b} = \frac{\pi}{12}$ rad, $s_{4\_e} = 2\frac{\pi}{12}$ rad for signal "Segment azimuth – supportive sensor level {begin, end}" (A.5.1)
5	segment azimuth 5: $s_{5\_b} = 2\frac{\pi}{12}$ rad, $s_{5\_e} = 5\frac{\pi}{12}$ rad for signal "Segment azimuth – supportive sensor level {begin, end}" (A.5.1)

Figure A.31 — Example for the signal "Segment azimuth – supportive sensor level {begin, end}" (A.5.1) in XY-plane

A.5.2 Segment elevation – supportive sensor level {begin, end}

Table A.431 — Signal: Segment elevation – supportive sensor level {begin, end}

Name	Segment elevation – supportive sensor level {begin, end}		
Description	The FOV segment is defined by the opening angles in the sensor *XZ*-plane (see Figure A.32). Additional information: The values are given in the sensor coordinate system.		
Value type	2D vector real value	**Unit**	(rad, rad)



Key

1 segment elevation 1: $s_{1\_b} = -3\frac{\pi}{12}$ rad, $s_{1\_e} = -\frac{\pi}{12}$ rad for signal "Segment elevation – supportive sensor level {begin, end}" (A.5.2)

2 segment elevation 2: $s_{2\_b} = -\frac{\pi}{12}$ rad, $s_{2\_e} = \frac{\pi}{12}$ rad for signal "Segment elevation – supportive sensor level {begin, end}" (A.5.2)

3 segment elevation 3: $s_{3\_b} = \frac{\pi}{12}$ rad, $s_{3\_e} = 3\frac{\pi}{12}$ rad for signal "Segment elevation – supportive sensor level {begin, end}" (A.5.2)

Figure A.32 — Example for the signal "Segment elevation – supportive sensor level {begin, end}" (A.5.2) in XZ-plane

A.5.3 Measurement grid resolution {radial distance, azimuth, elevation}

Table A.432 — Signal: Measurement grid resolution {radial distance, azimuth, elevation}

Name	Measurement grid resolution {radial distance, azimuth, elevation}		
Description	The signal "Measurement grid resolution {radial distance, azimuth, elevation}" (A.5.3) provides the sensor resolution of the applied measurement grid. In case this value in not constant within the segment the worst-case resolution of the segment is used. Additional information: The resolution may change during operation, for example: — by binning pixels of a camera sensing element; — by changing the length of a radar azimuth fast Fourier transform (FFT).		
Value type	3D vector real value	**Unit**	(m, rad, rad)

A.5.4 Beam divergence {azimuth, elevation}

Table A.433 — Signal: Beam divergence {azimuth, elevation}

Name	Beam divergence {azimuth, elevation}		
Description	The signal "Beam divergence {azimuth, elevation}" (A.5.4) provides the beam divergence of the sensor within the specified segment. It is the full width at half maximum (FWHM) of the beam (given as the angle in rad).		
Value type	2D vector real value	**Unit**	(rad, rad)

A.5.5 Range gain

Table A.434 — Signal: Range gain

Name	Range gain		
Description	The signal “Range gain” (A.5.5) describes the range difference in this segment compared to a defined normative value. A value of 100 % means the same range as the initially defined segment, values >100 % would be a corresponding range increase and <100 % a range loss.		
Value type	real value	**Unit**	%

A.5.6 Blockage status

Table A.435 — Signal: Blockage status

Name	Blockage status		
Description	The signal “Blockage status” (A.5.6) defines the overall blockage of the FOV segment.		
Value type	enumeration	**Unit**	1

Table A.436 — Enumeration: Blockage status – Example enumerators

Name	**Description**	**RL enumerator**
BS_FullBlockage	The sensor is completely blocked, no more recognitions and functionalities working due to blockage condition.	“exemplary”
BS_PartialBlockageHighImpact	The sensor has recognised a blockage condition which has a significant impact on sensor performance (for example, huge range limitation).	“exemplary”
BS_PartialBlockageMediumImpact	The sensor has recognised a blockage condition which already has impact on sensor performance (for example, medium range limitation).	“exemplary”
BS_PartialBlockageLowImpact	The sensor recognises that a blockage condition is present or is increasing, but the degree of blockage has not yet had a significant impact on the sensor performance and functionality.	“exemplary”
BS_Defect	The full specified range is blocked, due to, for example, a defect. This segment may overlap with other segments.	“exemplary”
BS_None	The sensor is in normal mode for the segment.	“exemplary”

A.5.7 Number of valid field-of-view reduction reasons

Table A.437 — Signal: Number of valid field-of-view reduction reasons

Name	Number of valid field-of-view reduction reasons		
Description	The signal “Number of valid field-of-view reduction reasons” (A.5.7) provides the current number of valid FOV reduction reasons.		
Value type	[0...] integer value	**Unit**	1

A.5.8 Field-of-view reduction reason type

Table A.438 — Signal: Field-of-view reduction reason type

Name	Field-of-view reduction reason type		
Description	The signal “Field-of-view reduction reason type” (A.5.8) defines the reason for an FOV reduction of the segment. A reduction of the FOV can have many reasons.		
Value type	enumeration	**Unit**	1

Table A.439 — Enumeration: Field-of-view reduction reason type – Example enumerators

Name	Description	RL enumerator
FOVRRT_Snow	The reduction in range is due to snow.	“exemplary”
FOVRRT_Rain	The reduction in range is due to rain.	“exemplary”
FOVRRT_Clutter	The reduction in range is due to clutter.	“exemplary”
FOVRRT_FlyingLeaves	The reduction in range is due to flying leaves.	“exemplary”
FOVRRT_NightAndLights	The reduction in range is due to night and lights.	“exemplary”
FOVRRT_Shades	The reduction in range is due to shades.	“exemplary”
FOVRRT_ContrastIssues	The reduction in range is due to contrast issues.	“exemplary”
FOVRRT_Jamming	The reduction in range is due to jamming, for example, electromagnetic compatibility.	“exemplary”
FOVRRT_DeviceInterference	The reduction in range is due to device interference, for example, electromagnetic compatibility.	“exemplary”
FOVRRT_Sand	The reduction in range is due to sand.	“exemplary”
FOVRRT_WetRoads	The reduction in range is due to wet roads.	“exemplary”
FOVRRT_Ghosts	The reduction in range is due to ghosts.	“exemplary”
FOVRRT_SnowOnSensorSurface	The reduction in range is due to snow on the sensor's surface. The range is almost blocked.	“exemplary”
FOVRRT_WaterOnSensorSurface	The reduction in range is due to water on the sensor's surface. The range is almost blocked.	“exemplary”
FOVRRT_SoilOnSensorSurface	The reduction in range is due to soil on the sensor's surface. The range is almost blocked.	“exemplary”
FOVRRT_ScratchesOnSensorSurface	The reduction in range is due to scratches on the sensor's surface. The range is almost blocked.	“exemplary”

A.5.9 Field-of-view reduction reason type – confidence

Table A.440 — Signal: Field-of-view reduction reason type – confidence

Name	Field-of-view reduction reason type – confidence		
Description	The signal “Field-of-view reduction reason type – confidence” (A.5.9) provides the confidence of the FOV reduction of the segment by the signal “Field-of-view reduction reason type” (A.5.8).		
Value type	[0...100] real value	**Unit**	%

A.5.10 Number of valid recognisable object types

Table A.441 — Signal: Number of valid recognisable object types

Name	Number of valid recognisable object types		
Description	The signal "Number of valid recognisable object types" (A.5.10) provides the current number of valid tuples for "real-world" object recognition classifications. The tuples are defined by the signals "Recognised object type" (A.5.11) and additional signals.		
Value type	[0…] integer value	**Unit**	1

A.5.11 Recognised object type

Table A.442 — Signal: Recognised object type

Name	Recognised object type		
Description	The signal "Recognised object type" (A.5.11) provides the classification of the sensor's recognition capabilities for the defined object types.		
Value type	enumeration	**Unit**	1

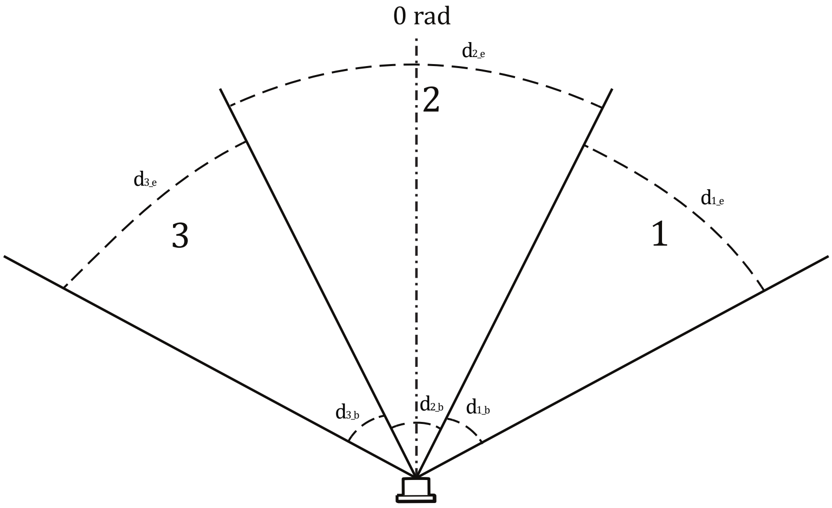
Table A.443 — Enumeration: Recognised object type – Example enumerators

Name	**Description**	**RL enumerator**
ROT_Car	The recognised entity is a car.	"exemplary"
ROT_HeavyTruck	The recognised entity is a heavy truck.	"exemplary"
ROT_Motorbike	The recognised entity is a motorbike.	"exemplary"
ROT_Bicycle	The recognised entity is a bicycle.	"exemplary"
ROT_Pedestrian	The recognised entity is a pedestrian.	"exemplary"
ROT_Pole	The recognised entity is a pole.	"exemplary"
ROT_GuardRail	The recognised entity is a guard rail.	"exemplary"
ROT_Building	The recognised entity is a building.	"exemplary"
ROT_TrafficSign	The recognised entity is a traffic sign.	"exemplary"
ROT_TrafficLight	The recognised entity is a traffic light.	"exemplary"

A.5.12 Detection range radial distance {begin, end}

Table A.444 — Signal: Detection range radial distance {begin, end}

Name	Detection range radial distance {begin, end}		
Description	The signal "Detection range radial distance {begin, end}" (A.5.12) provides the sensor detection range for one object type with the signals "True positive rate" (A.5.13) and "False positive rate" (A.5.14) for this object type. The signal "Detected range distance {begin}" is the closest possible detection and the signal "Detection range distance {end}" is the farthest possible detection with respect to the sensor origin (see Figure A.33). Additional information: The values are given in the sensor coordinate system.		
Value type	2D vector real value	**Unit**	(m, m)



Key

1 segment 1: d_{1_b} = 10 m, d_{1_e} = 100 m for signal “Detection range radial distance {begin, end}” (A.5.12)

2 segment 2: d_{2_b} = 8 m, d_{2_e} = 115 m for signal “Detection range radial distance {begin, end}” (A.5.12)

3 segment 3: d_{3_b} = 11 m, d_{3_e} = 105 m for signal “Detection range radial distance {begin, end}” (A.5.12)

Figure A.33 — Example for the signal “Detection range radial distance {begin, end}” (A.5.12) of FOV segments

A.5.13 True positive rate

Table A.445 — Signal: True positive rate

Name	True positive rate		
Description	The signal “True positive rate” (A.5.13) provides the estimated true positive rate for an FOV segment, specifically valid over the complete range of the signal “Detection range radial distance {begin, end}” (A.5.12).		
Value type	[0…100] real value	**Unit**	%

A.5.14 False positive rate

Table A.446 — Signal: False positive rate

Name	False positive rate		
Description	The signal “False positive rate” (A.5.14) provides the estimated false positive rate for an FOV segment, specifically valid over the complete range of the signal “Detection range radial distance {begin, end}” (A.5.12).		
Value type	[0…100] real value	**Unit**	%

A.5.15 Positive predictive value

Table A.447 — Signal: Positive predictive value

Name	Positive predictive value		
Description	The signal “Positive predictive value” (A.5.15) provides the estimated positive predictive value for an FOV segment, specifically valid over the complete range of the signal “Detection range radial distance {begin, end}” (A.5.12).		
Value type	[0…100] real value	**Unit**	%

A.5.16 Number of valid reference target types

Table A.448 — Signal: Number of valid reference target types

Name	Number of valid reference target types		
Description	The signal “Number of valid reference target types” (A.5.16) provides the current number of valid tuples for reference detection classifications. The tuples are defined by several signals.		
Value type	[0…] integer value	**Unit**	1

A.5.17 Reference target type

Table A.449 — Signal: Reference target type

Name	Reference target type		
Description	The signal “Reference target type” (A.5.17) provides the classification of the sensor’s recognition capabilities for defined reference targets. Requirement: The reference target types are defined during the system design phase.		
Value type	enumeration	**Unit**	1

Table A.450 — Enumeration: Reference target type – Example enumerators

Name	**Description**	**RL enumerator**
RTT_PatternA	The recognised entity is a defined pattern A.	“exemplary”
RTT_PatternB	The recognised entity is a defined pattern B.	“exemplary”
RTT_PatternC	The recognised entity is a defined pattern C.	“exemplary”

A.5.18 Radar cross section reference target

Table A.451 — Signal: Radar cross section reference target

Name	Radar cross section reference target		
Description	The signal “Radar cross section reference target” (A.5.18) provides a defined reference target type with a real-world RCS.		
Value type	real value	**Unit**	dB m^2

A.5.19 Reflectivity reference target

Table A.452 — Signal: Reflectivity reference target

Name	Reflectivity reference target		
Description	The signal “Reflectivity reference target” (A.5.19) provides a defined reference target type with a real-world reflectivity.		
Value type	real value	**Unit**	%

A.5.20 Relative radial velocity range {begin, end}

Table A.453 — Signal: Relative radial velocity range {begin, end}

Name	Relative radial velocity range {begin, end}		
Description	The signal “Relative radial velocity range {begin, end}” (A.5.20) describes the relative radial velocity range in the sensor coordinate system. Negative values, for example, for {begin}, indicate entities approaching the sensor, positive values, for example, for {end}, indicate entities receding from the sensor.		
Value type	2D vector real value	**Unit**	(m/s, m/s)

A.5.21 Signal to noise ratio – supportive level

Table A.454 — Signal: Signal to noise ratio – supportive level

Name	Signal to noise ratio – supportive level		
Description	The signal “Signal to noise ratio – supportive level” (A.5.21) provides the SNR of the reference target detection.		
Value type	real value	**Unit**	dB

A.5.22 Spatial separability {radial distance, azimuth, elevation}

Table A.455 — Signal: Spatial separability {radial distance, azimuth, elevation}

Name	Spatial separability {radial distance, azimuth, elevation}		
Description	The signal “Spatial separability {radial distance, azimuth, elevation}” (A.5.22) provides the required spatial difference in one dimension (radial distance, azimuth angle or elevation angle) for separation of two reference targets assuming all other properties are identical for both targets.		
Value type	3D vector real value	**Unit**	(m, rad, rad)

A.5.23 Velocity separability {radial distance, azimuth, elevation}

Table A.456 — Signal: Velocity separability {radial distance, azimuth, elevation}

Name	Velocity separability {radial distance, azimuth, elevation}		
Description	The signal “Velocity separability {radial distance, azimuth, elevation}” (A.5.23) provides the required velocity difference in one dimension (radial velocity, azimuth angular velocity or elevation angular velocity) for separation of two reference targets assuming all other properties are identical for both targets.		
Value type	3D vector real value	**Unit**	(m/s, rad/s, rad/s)

A.5.24 Number of valid sensor operation modes

Table A.457 — Signal: Number of valid sensor operation modes

Name	Number of valid sensor operation modes		
Description	The signal “Number of valid sensor operation modes” (A.5.24) provides the current number of valid operation modes defined by the signal “Sensor operation mode” (A.5.25).		
Value type	[0…] integer value	**Unit**	1

A.5.25 Sensor operation mode

Table A.458 — Signal: Sensor operation mode

Name	Sensor operation mode		
Description	The signal “Sensor operation mode” (A.5.25) provides the status information of the sensor.		
Value type	enumeration	**Unit**	1

Table A.459 — Enumeration: Sensor operation mode – Example enumerators

Name	Description	RL enumerator
SOM_Normal	All sensor components are up and running, for example, all initialisations are given, and the communication is fully established.	“exemplary”
SOM_SensorMeasuringActive	The sensor is active and performs measurements.	“exemplary”
SOM_Limited	Only limited processing power is available.	“exemplary”
SOM_Off	This status is the status during shut-off.	“exemplary”
SOM_SensorMeasuringDisabled	The sensor is disabled and performs no measurement at the moment.	“exemplary”
SOM_Error	An internal error was detected, for example, memory check.	“exemplary”
SOM_Initialising	The sensor initialisation is carried out.	“exemplary”
SOM_SensorInEndOfLineMode	The end-of-line alignment is in operation.	“exemplary”
SOM_SensorInSelfDiagnosisMode	The sensor is in self-diagnosis mode; normal sensor operation is not provided.	“exemplary”

A.5.26 Sensor defect recognised

Table A.460 — Signal: Sensor defect recognised

Name	Sensor defect recognised		
Description	The signal “Sensor defect recognised” (A.5.26) describes a defect recognised for the sensor.		
Value type	enumeration	**Unit**	1

Table A.461 — Enumeration: Sensor defect recognised – Example enumerators

Name	Description	RL enumerator
SensorDefectRecognised_SensorFullyFunctional	The sensor has no defects recognised.	“exemplary”
SensorDefectRecognised_NotFullyFunctionalDueToDefect	The sensor has recognised defects. The sensor can measure with limited performance.	“exemplary”
SensorDefectRecognised_OutOfOrder	The sensor has recognised defects and cannot perform measurements anymore.	“exemplary”

A.5.27Sensor defect reason

Table A.462 — Signal: Sensor defect reason

Name	Sensor defect reason		
Description	The signal “Sensor defect reason” (A.5.27) provides detailed information why the signal “Sensor defect recognised” (A.5.26) is notifying a sensor problem.		
Value type	enumeration	**Unit**	1

Table A.463 — Enumeration: Sensor defect reason – Example enumerators

Name	Description	RL enumerator
SDR_NoDefectRecognised	No defects recognised by the sensor.	“exemplary”
SDR_InternalMemoryError	The sensor has recognised an internal memory error.	“exemplary”
SDR_ElectronicDefect	The sensor has recognised an electronic defect.	“exemplary”
SDR_ThermalDefect	The sensor has recognised a thermal problem/thermal defect.	“exemplary”
SDR_SurgeDefect	The sensor has recognised a surge defect.	“exemplary”
SDR_CalibrationError	The sensor has recognised a calibration error.	“exemplary”
SDR_ImplausibleSensorParametrisation	The sensor has recognised an implausible parametrisation.	“exemplary”
SDR_MechanicalDefect	The sensor has recognised a mechanical defect.	“exemplary”
SDR_SoftwareDefect	The sensor has recognised a software defect.	“exemplary”
SDR_ComputingPowerNotSufficient	The sensor has recognised a too low power supply.	“exemplary”
SDR_OutOfTimeSynchronisation	The sensor has recognised an out of time synchronisation.	“exemplary”
SDR_SensorExternallyDisturbed	The sensor has recognised an external disturbance.	“exemplary”

A.5.28Supply voltage status

Table A.464 — Signal: Supply voltage status

Name	Supply voltage status		
Description	The signal “Supply voltage status” (A.5.28) provides the current supply voltage status.		
Value type	enumeration	**Unit**	1

Table A.465 — Enumeration: Supply voltage status – Example enumerators

Name	Description	RL enumerator
SVS_Low	The supply voltage is out of valid range. Supply voltage is too low.	“exemplary”
SVS_PreLow	The supply voltage is still in the valid range, but close to the lower limit and expected to leave the valid range soon.	“exemplary”
SVS_WithinLimits	The supply voltage is optimal.	“exemplary”

SVS_PreHigh	The supply voltage is still in the valid range, but close to the upper limit and expected to leave the valid range soon.	“exemplary”
SVS_High	The supply voltage is out of valid range. Supply voltage is too high.	“exemplary”

A.5.29 Sensor temperature status

Table A.466 — Signal: Sensor temperature status

Name	Sensor temperature status		
Description	The signal “Sensor temperature status” (A.5.29) provides the current status of the sensor temperature.		
Value type	enumeration	**Unit**	1

Table A.467 — Enumeration: Sensor temperature status – Example enumerators

Name	Description	RL enumerator
STS_UnderTemperature	The sensor temperature is under temperature and no measurement updates are available.	“exemplary”
STS_PreUnderTemperature	The sensor temperature is close before under temperature.	“exemplary”
STS_TemperatureInLimits	The sensor temperature is normal and therefore the sensor is in normal mode.	“exemplary”
STS_PreOverTemperature	The sensor temperature is close before over temperature.	“exemplary”
STS_OverTemperature	The sensor temperature is over temperature and no measurement updates are available.	“exemplary”

A.5.30 Number of valid sensor input signal statuses

Table A.468 — Signal: Number of valid sensor input signal statuses

Name	Number of valid sensor input signal statuses		
Description	The signal “Number of valid sensor input signal statuses” (A.5.30) provides the current number of valid tuples for sensor input signal statuses. The tuples are defined by the signals “Sensor input signal type” (A.5.31) and “Sensor input signal status” (A.5.32).		
Value type	[0…] integer value	**Unit**	1

A.5.31 Sensor input signal type

Table A.469 — Signal: Sensor input signal type

Name	Sensor input signal type		
Description	The signal “Sensor input signal type” (A.5.31) provides the classification, which defines a group of sensor input signals that were received by the sensor.		
Value type	enumeration	**Unit**	1

Table A.470 — Enumeration: Sensor input signal type – Example enumerators

Name	Description	RL enumerator
SIST_DynamicMotionControl	The signal “Sensor input signal status” (A.5.32) is defined for the dynamic motion control sensor input signals.	“exemplary”

Name	Description	RL enumerator
SIST_VehicleDynamic	The signal "Sensor input signal status" (A.5.32) is defined for the vehicle dynamic sensor input signals.	"exemplary"
SIST_CSIISensorOperation	The signal "Sensor input signal status" (A.5.32) is defined for the LSG "Sensor Operation" of the CSII.	"exemplary"
SIST_CSIIEnvironmentalInformation	The signal "Sensor input signal status" (A.5.32) is defined for the LSG "Environmental information" of the CSII.	"exemplary"
SIST_CSIIVehicleState	The signal "Sensor input signal status" (A.5.32) is defined for the LSG "Vehicle state" of the CSII.	"exemplary"
SIST_CSIIRegionInformation	The signal "Sensor input signal status" (A.5.32) is defined for the LSG "Region information" of the CSII.	"exemplary"
SIST_CSIIVehicleConfiguration	The signal "Sensor input signal status" (A.5.32) is defined for the LSG "Vehicle configuration" of the CSII.	"exemplary"
SIST_CSIISensorPose	The signal "Sensor input signal status" (A.5.32) is defined for the LSG "Sensor pose" of the CSII.	"exemplary"
SIST_CSIIOperations	The signal "Sensor input signal status" (A.5.32) is defined for the LSGs "<Interface> operation" of the CSII.	"exemplary"

A.5.32 Sensor input signal status

Table A.471 — Signal: Sensor input signal status

Name	Sensor input signal status		
Description	The signal "Sensor input signal status" (A.5.32) provides an enumeration if valid input signals [specified by the signal "Sensor input signal type" (A.5.31)] are received by the sensor.		
Value type	enumeration	**Unit**	1

Table A.472 — Enumeration: Sensor input signal status – Example enumerators

Name	Description	RL enumerator
SISS_Valid	The input signals are valid for the current mode.	"exemplary"
SISS_Implausible	The input signals in context of sensor signals are not plausible compared with other signals or internal calculations.	"exemplary"
SISS_Missing	The input signals were never received.	"exemplary"
SISS_OufOfRange	The input signals violated the signal's ranges.	"exemplary"
SISS_Timeout	The input signals were received, however not in the time period as expected.	"exemplary"

A.5.33 Sensor externally disturbed

Table A.473 — Signal: Sensor externally disturbed

Name	Sensor externally disturbed

Description	The signal "Sensor externally disturbed" (A.5.33) provides the disturbance of the sensing elements by an external source. Additional information: For example, radar sensors can be disturbed by other devices that transmit similar emissions (interference). The SHII provides a basic qualifier. Detailed information about the effects is provided in the SPI (for example, reduction of range (see, for example, signal "Field-of-view reduction reason type" (A.5.8)] and so forth).		
Value type	enumeration	**Unit**	1

Table A.474 — Enumeration: Sensor externally disturbed – Example enumerators

Name	Description	RL enumerator
SED_FullDisturbance	The sensor is completely disturbed, recognitions and functionalities are not working due to external disturbance.	"exemplary"
SED_DisturbanceHighImpact	The sensor has recognised an external disturbance which has a significant impact on the sensor performance.	"exemplary"
SED_DisturbanceMediumImpact	The sensor has recognised an external disturbance which already has impact on the sensor performance.	"exemplary"
SED_DisturbanceLowImpact	The sensor recognises that an external disturbance is present or is increasing, but the degree of disturbance has not yet had a significant impact on the sensor performance and functionality.	"exemplary"
SED_None	The sensor is in normal mode.	"exemplary"

A.5.34Sensor transmit power reduced

Table A.475 — Signal: Sensor transmit power reduced

Name	Sensor transmit power reduced		
Description	The signal "Sensor transmit power reduced" (A.5.34) provides an enumeration if the sensor works, for example, with full output power. Additional information: For example, some sensors (lidars or radars) can only use limited/reduced transmit power in standstill/low speed or requested by, for example, an AD function or the fusion unit. The power reduction could be part of the sensor strategy to reduce transmit emissions.		
Value type	Enumeration	**Unit**	1

Table A.476 — Enumeration: Sensor transmit power reduced – Example enumerators

Name	Description	RL enumerator
STPR_NormalOperation	The transmit output power is normal.	"exemplary"
STPR_OutputPowerLimited	The transmit output power is reduced.	"exemplary"

A.5.35Sensor heating status

Table A.477 — Signal: Sensor heating status

Name	Sensor heating status		
Description	The signal “Sensor heating status” (A.5.35) provides the status of the sensor heating.		
Value type	enumeration	**Unit**	1

Table A.478 — Enumeration: Sensor heating status – Example enumerators

Name	Description	RL enumerator
SHS_HeatingOff	The sensor heating is not active.	“exemplary”
SHS_HeatingLevel	The sensor heating is active.	“exemplary”
SHS_HeatingError	The sensor heating is defective.	“exemplary”

A.5.36Sensor cleaning status

Table A.479 — Signal: Sensor cleaning status

Name	Sensor cleaning status		
Description	The signal “Sensor cleaning status” (A.5.36) provides the status of the sensor cleaning.		
Value type	enumeration	**Unit**	1

Table A.480 — Enumeration: Sensor cleaning status – Example enumerators

Name	Description	RL enumerator
SCS_CleaningIdle	The sensor cleaning is not active.	“exemplary”
SCS_CleaningActive	The sensor cleaning is active.	“exemplary”
SCS_CleaningNeeded	The sensor cleaning should be performed.	“exemplary”

A.5.37Sensor time sync

Table A.481 — Signal: Sensor time sync

Name	Sensor time sync		
Description	The signal “Sensor time sync” (A.5.37) provides the status of the sensor time synchronisation.		
Value type	enumeration	**Unit**	1

Table A.482 — Enumeration: Sensor time sync – Example enumerators

Name	Description	RL enumerator
STS_WithinLimits	The time synchronisation is inside limits.	“exemplary”
STS_OutOfLimits	The time synchronisation time accuracy limits are violated.	“exemplary”
STS_Timeout	The time synchronisation timeout elapsed (no valid time synchronisation cycle within timeout interval).	“exemplary”
STS_Offset	The sensor time synchronisation offset value is defined. This enumerator requires the signal “Sensor time sync offset value” (A.5.38).	“exemplary”

A.5.38 Sensor time sync offset value

Table A.483 — Signal: Sensor time sync offset value

Name	Sensor time sync offset value		
Description	The signal “Sensor time sync offset value” (A.5.38) provides the value of the sensor time synchronisation offset. Additional information: The signal “Sensor time sync offset value” (A.5.38) is used, if the signal “Sensor time sync” (A.5.37) has the enumerator “STS_Offset”. Otherwise, the signal “Sensor time sync offset value” (A.5.38) is 0 s or signal is not implemented.		
Value type	real value	**Unit**	s

A.5.39 Number of valid sensor-calibratable components

Table A.484 — Signal: Number of valid sensor-calibratable components

Name	Number of valid sensor-calibratable components		
Description	The signal “Number of valid sensor-calibratable components” (A.5.39) provides the current number of valid tuples for different sensor-calibratable components which may be calibrated. The tuples are defined by the signals “Sensor-calibratable component” (A.5.40) and “Sensor calibration status” (A.5.41).		
Value type	[0…] integer value	**Unit**	1

A.5.40 Sensor-calibratable component

Table A.485 — Signal: Sensor-calibratable component

Name	Sensor-calibratable component		
Description	The signal “Sensor-calibratable component” (A.5.40) provides an enumeration for the sensor component which may be calibrated.		
Value type	enumeration	**Unit**	1

Table A.486 — Enumeration: Sensor-calibratable component – Example enumerators

Name	Description	RL enumerator
SCC_Intrinsic	The signal “Sensor calibration status” (A.5.41) is defined for the intrinsic parameters of the sensor.	“exemplary”
SCC_Extrinsic	The signal “Sensor calibration status” (A.5.41) is defined for the extrinsic parameters of the sensor.	“exemplary”
SCC_Online	The signal “Sensor calibration status” (A.5.41) is defined for the online parameters of the sensor.	“exemplary”

A.5.41 Sensor calibration status

Table A.487 — Signal: Sensor calibration status

Name	Sensor calibration status

Description	The signal “Sensor calibration status” (A.5.41) provides an enumeration for the current calibration status of the signal “Sensor-calibratable component” (A.5.40) and the calibratable component.		
Value type	enumeration	**Unit**	1

Table A.488 — Enumeration: Sensor calibration status – Example enumerators

Name	**Description**	**RL enumerator**
SCS_Calibrated	The sensor calibration was successful and within nominal tolerance range for the calibratable component.	“exemplary”
SCS_NotCalibrated	The calibration was not done, or the calibration failed. The sensor is in an uncalibrated state for the calibratable component.	“exemplary”
SCS_Degraded	The sensor was calibrated, however performance degraded due to limited correction accuracy for the calibratable component.	“exemplary”

A.5.42 Calibration process state

Table A.489 — Signal: Calibration process state

Name	Calibration process state		
Description	The signal “Calibration process state” (A.5.42) provides an enumeration for the current state of the signal’s “Sensor-calibratable component” (A.5.40) calibratable component.		
Value type	enumeration	**Unit**	1

Table A.490 — Enumeration: Calibration process state – Example enumerators

Name	**Description**	**RL enumerator**
CPS_InitialCalibrationPerformed	The sensor initial calibration has been performed for the calibratable component.	“exemplary”
CPS_InitialCalibrationNotPerformed	The sensor initial calibration has not been performed yet for the calibratable component.	“exemplary”
CPS_InitialCalibrationFailed	The sensor initial calibration process failed for the calibratable component.	“exemplary”
CPS_RecalibrationNeededIntrinsic	The recalibration of sensor’s intrinsic parameters is required for the calibratable component.	“exemplary”
CPS_RecalibrationNeededExtrinsic	The recalibration of sensor’s extrinsic parameters is required for the calibratable component.	“exemplary”
CPS_RecalibrationNeededFull	The recalibration of the complete sensor’s parameters is required for the calibratable component.	“exemplary”

A.5.43 Sensor origin point – correction {x, y, z}

Table A.491 — Signal: Sensor origin point – correction {x, y, z}

Name	Sensor origin point – correction {x, y, z}

Description	The signal “Sensor origin point – correction {x, y, z}” (A.5.43) provides the correction of the current sensor origin point with respect to the designed position. The correction is determined, for example, by extrinsic calibration. Additional information: The signal “Sensor origin point {x, y, z} – header” (A.1.21) includes the signal “Sensor origin point – correction {x, y, z}” (A.5.43).		
Value type	3D vector real value	**Unit**	(m, m, m)

A.5.44 Sensor origin point – correction {x, y, z} – error

Table A.492 — Signal: Sensor origin point – correction {x, y, z} – error

Name	Sensor origin point – correction {x, y, z} – error		
Description	The signal “Sensor origin point – correction {x, y, z} – error” (A.5.44) provides the estimated error of the current sensor origin point correction from the signal “Sensor origin point – correction {x, y, z}” (A.5.43), for example, determined by internal calibration.		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Sensor origin point – correction {x, y, z}” (A.5.43).

A.5.45 Sensor origin translation – correction limit {x_{begin}, x_{end}, y_{begin}, y_{end}, z_{begin}, z_{end}}

Table A.493 — Signal: Sensor origin translation – correction limit {x_{begin}, x_{end}, y_{begin}, y_{end}, z_{begin}, z_{end}}

Name	Sensor origin translation – correction limit {x_{begin}, x_{end}, y_{begin}, y_{end}, z_{begin}, z_{end}}		
Description	The signal “Sensor origin translation – correction limit {x_{begin}, x_{end}, y_{begin}, y_{end}, z_{begin}, z_{end}}” (A.5.45) provides the limits of independent position corrections. Begin (minimum) and end (maximum) positions could be defined for each axis {x, y, z} separately.		
Value type	6D vector real value	**Unit**	(m, m, m, m, m, m)

A.5.46 Sensor orientation – correction {yaw, pitch, roll}

Table A.494 — Signal: Sensor orientation – correction {yaw, pitch, roll}

Name	Sensor orientation – correction {yaw, pitch, roll}		
Description	The signal “Sensor orientation – correction {yaw, pitch, roll}” (A.5.46) provides the correction of the current sensor orientation with respect to the designed orientation. The correction is determined, for example, by extrinsic calibration. Additional information: The signal “Sensor orientation {yaw, pitch, roll} – header” (A.1.23) includes the signal “Sensor orientation – correction {yaw, pitch, roll}” (A.5.46).		
Value type	3D vector real value	**Unit**	(rad, rad, rad)

A.5.47 Sensor orientation – correction {yaw, pitch, roll} – error

Table A.495 — Signal: Sensor orientation – correction {yaw, pitch, roll} – error

Name	Sensor orientation – correction {yaw, pitch, roll} – error

Description	The signal "Sensor orientation – correction {yaw, pitch, roll} – error" (A.5.47) provides the estimated error of the current sensor orientation correction (see signal "Sensor orientation – correction {yaw, pitch, roll}" (A.5.46)], for example, determined by internal calibration.		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Sensor orientation – correction {yaw, pitch, roll}" (A.5.46).

A.5.48 Sensor pose angle – correction limit {yaw_{begin}, yaw_{end}, $pitch_{begin}$, $pitch_{end}$, $roll_{begin}$, $roll_{end}$}

Table A.496 — Signal: Sensor pose angle – correction limit {yaw_{begin}, yaw_{end}, $pitch_{begin}$, $pitch_{end}$, $roll_{begin}$, $roll_{end}$}

Name	Sensor pose angle – correction limit {yaw_{begin}, yaw_{end}, $pitch_{begin}$, $pitch_{end}$, $roll_{begin}$, $roll_{end}$}		
Description	The signal "Sensor pose angle – correction limit {yaw_{begin}, yaw_{end}, $pitch_{begin}$, $pitch_{end}$, $roll_{begin}$, $roll_{end}$}" (A.5.48) provides the limits of independent angle corrections. Begin (minimum) and end (maximum) angles could be defined for each angle {yaw, pitch, roll} separately.		
Value type	6D vector real value	**Unit**	(rad, rad, rad, rad, rad, rad)

A.5.49 Number of valid sensors

Table A.497 — Signal: Number of valid sensors

Name	Number of valid sensors		
Description	The signal "Number of valid sensors" (A.5.49) provides the number of valid sensors of the whole sensor cluster.		
Value type	[0…] integer value	**Unit**	1

A.5.50 Sensor ID reference

Table A.498 — Signal: Sensor ID reference

Name	Sensor ID reference		
Description	The signal "Sensor ID reference" (A.5.50) uniquely identifies a sensor of the sensor cluster [see signal "Sensor ID" (A.1.4)].		
Value type	integer value	**Unit**	1

A.6 Sensor input interface signals

Signals are defined for the entities of the subclause 11.3 in this subclause (see Table A.499-Table A.588). These interfaces are located at SII. Sensors and sensor clusters receive sensor input interfaces (SII). In this clause for SII, the term sensor is always used, even if a sensor cluster is receiving the interface.

A.6.1 Sensor operation mode command

Table A.499 — Signal: Sensor operation mode command

Name	Sensor operation mode command		
Description	The signal "Sensor operation mode command" (A.6.1) defines the command from the sending unit to change the operation mode of the sensor or sensor cluster.		
Value type	enumeration	**Unit**	1

Table A.500 — Enumeration: Sensor operation mode command – Example enumerators

Name	Description	RL enumerator
SOMC_Initializing	Initialize the sensor or sensor cluster.	“exemplary”
SOMC_Off	Switch off the sensor or sensor cluster.	“exemplary”
SOMC_Dormancy	Put the sensor or sensor cluster into dormancy.	“exemplary”
SOMC_LowPowerMode	Use low power mode for operating the sensor or sensor cluster.	“exemplary”
SOMC_NormalMode	Resume normal mode for operating the sensor or sensor cluster.	“exemplary”
SOMC_StartCalibration	Start the sensor or sensor cluster calibration.	“exemplary”
SOMC_StartCleaning	Start the sensor or sensor cluster cleaning/heating.	“exemplary”

A.6.2 Weather condition

Table A.501 — Signal: Weather condition

Name	Weather condition		
Description	The signal “Weather condition” (A.6.2) defines the weather information to the sensor or sensor cluster to improve the performance of the sensor’s or the sensor cluster’s algorithm.		
Value type	enumeration	**Unit**	1

Table A.502 — Enumeration: Weather condition – Example enumerators

Name	Description	RL enumerator
WC_Rain	The sensor operates in rainy conditions.	“exemplary”
WC_Snow	The sensor operates in snowy conditions.	“exemplary”
WC_Fog	The sensor operates in foggy conditions.	“exemplary”
WC_Dust	The sensor operates in dusty conditions.	“exemplary”
WC_Mist	The sensor operates in misty conditions.	“exemplary”

A.6.3 Fog

Table A.503 — Signal: Fog

Name	Fog		
Description	The signal “Fog” (A.6.3) provides the fog status (in the terms of human perception). The definition of discretised fog states is according to [14].		
Value type	enumeration	**Unit**	1

Table A.504 — Enumeration: Fog – Example enumerators

Name	Description	RL enumerator
F_ExcellentVisibility	The visibility is excellent, and the range of visibility is [40 000; infinity[m.	“exemplary”
F_Good_Visibility	The visibility is good, and the range of visibility is [10 000; 40 000[m.	“exemplary”
F_ModerateVisibility	The visibility is moderate, and the range of visibility is [4 000; 10 000[m.	“exemplary”

Name	Description	RL enumerator
F_PoorVisibility	The visibility is poor, and the range of visibility is [2 000; 4 000[m.	“exemplary”
F_Mist	The visibility is misty, and the range of visibility is [1 000; 2 000[m.	“exemplary”
F_Light	The visibility is foggy, and the range of visibility is [200; 1 000[m.	“exemplary”
F_Thick	The visibility is thick foggy, and the range of visibility is [50; 200[m.	“exemplary”
F_Dense	The visibility is dense foggy, and the range of visibility is [0; 50[m.	“exemplary”

A.6.4 Precipitation

Table A.505 — Signal: Precipitation

Name	Precipitation		
Description	The signal “Precipitation” (A.6.4) provides the precipitation status. The definition of the discretised precipitation states is according to [15] (I = Intensity of precipitation in mm/h).		
Value type	enumeration	**Unit**	1

Table A.506— Enumeration: Precipitation – Example enumerators

Name	Description	RL enumerator
P_None	There is no precipitation, and the range of precipitation is [0; 0,1[mm/h.	“exemplary”
P_VeryLight	The precipitation has a very light intensity, and the range of precipitation is [0,1; 0,5[mm/h.	“exemplary”
P_Light	The precipitation has a light intensity, and the range of precipitation is [0,5; 1,9[mm/h.	“exemplary”
P_Moderate	The precipitation has a moderate intensity, and the range of precipitation is [1,9; 8,1[mm/h.	“exemplary”
P_Heavy	The precipitation has a heavy intensity, and the range of precipitation is [8,1; 34[mm/h.	“exemplary”
P_VeryHeavy	The precipitation has a very heavy intensity, and the range of precipitation is [34; 149[mm/h.	“exemplary”
P_Extreme	The precipitation has an extreme intensity, and the range of precipitation is [149; infinity[mm/h.	“exemplary”

A.6.5 Number of valid absorption models

Table A.507 — Signal: Number of valid absorption models

Name	Number of valid absorption models
Description	The signal’s “Number of valid absorption models” (A.6.5) value defines the number of valid absorption models as tuples [specifically the signal “Absorption coefficient” (A.6.6) and “Absorption wavelength” (A.6.7)]. Additional information: The maximum number of entries could be limited. The entries in the list may or may not be sorted. All those entities of the list which can be used by the sensor are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal’s “Time stamp – <…>” (A.1.5) value and not only a differential list between two sequential time stamps.

Value type	[0...] integer value	**Unit**	1

A.6.6 Absorption coefficient

Table A.508 — Signal: Absorption coefficient

Name	Absorption coefficient		
Description	The signal "Absorption coefficient" (A.6.6) provides the exponent α that describes the decrease of intensity I for an electromagnetic wave that passes a medium of length r as defined by the Lambert-Beer law: $I(r) = I_0 \cdot e^{(-\alpha \cdot r)}$. For automotive sensors the medium is air. The absorption coefficient depends on the absorption model.		
Value type	real value	**Unit**	(1/m)

A.6.7 Absorption wavelength

Table A.509 — Signal: Absorption wavelength

Name	Absorption wavelength		
Description	The signal "Absorption wavelength" (A.6.7) provides additional information about the physical model the absorption coefficient relates to. These conditions are the wavelength or frequency and the type of wave.		
Value type	enumeration	**Unit**	1

Table A.510— Enumeration: Absorption wavelength – Example enumerators

Name	**Description**	**RL enumerator**
AW_VisibleLight	Absorption coefficient relates to wavelength of visible light.	"exemplary"
AW_NIR900nm	Absorption coefficient relates to wavelength of NIR light around 900 nm.	"exemplary"
AW_NIR1550nm	Absorption coefficient relates to wavelength of NIR light around 1550 nm.	"exemplary"
AW_24GHz	Absorption coefficient relates to wavelength of radio waves around 24 GHz.	"exemplary"
AW_77GHz	Absorption coefficient relates to wavelength of radio waves around 77 GHz.	"exemplary"
AW_Ultrasonic	Absorption coefficient relates to wavelength of ultrasonic waves.	"exemplary"

A.6.8 Ambient illumination

Table A.511 — Signal: Ambient illumination

Name	Ambient illumination		
Description	The signal "Ambient illumination" (A.6.8) provides the ambient illumination status. The ambient light is any light in the vehicle's environment that is not emitted by the vehicle itself. It can include sun/moon light, light from other vehicles, street lights and so forth (the illumination has the unit Lux).		
Value type	enumeration	**Unit**	1

Table A.512 — Enumeration: Ambient illumination – Example enumerators

Name	Description	RL enumerator
AI_Level1	The ambient illumination is in the range of [0,001; 0,01[lx, for example, night with no artificial light.	“exemplary”
AI_Level2	The ambient illumination is in the range of [0,01; 1[lx, for example, night full moon.	“exemplary”
AI_Level3	The ambient illumination is in the range of [1; 3[lx, for example, deep to average twilight.	“exemplary”
AI_Level4	The ambient illumination is in the range of [3; 10[lx, for example, average to full twilight.	“exemplary”
AI_Level5	The ambient illumination is in the range of [10; 20[lx, for example, minimum lighting on major and expressway roads.	“exemplary”
AI_Level6	The ambient illumination is in the range of [20; 400[lx, for example, roads with more lighting.	“exemplary”
AI_Level7	The ambient illumination is in the range of [400; 1000[lx, for example, sunrise or sunset on a clear day.	“exemplary”
AI_Level8	The ambient illumination is in the range of [1000; 10000[lx, for example, average to full daylight.	“exemplary”
AI_Level9	The ambient illumination is in the range of [10000; 120000[lx, for example, full daylight to intense sunlight.	“exemplary”

A.6.9 Air temperature

Table A.513 — Signal: Air temperature

Name	Air temperature		
Description	The signal “Air temperature” (A.6.9) provides the temperature of the surrounding air.		
Value type	real value	**Unit**	K

A.6.10 Air temperature – error

Table A.514 — Signal: Air temperature – error

Name	Air temperature – error		
Description	The signal “Air temperature – error” (A.6.10) provides the error value of the signal “Air temperature” (A.6.9).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Air temperature” (A.6.9).

A.6.11 Atmospheric pressure

Table A.515 — Signal: Atmospheric pressure

Name	Atmospheric pressure		
Description	The signal “Atmospheric pressure” (A.6.11) provides the atmospheric pressure.		
Value type	real value	**Unit**	Pa

A.6.12 Atmospheric pressure – error

Table A.516 — Signal: Atmospheric pressure – error

Name	Atmospheric pressure – error		
Description	The signal "Atmospheric pressure – error" (A.6.12) provides the error value of the signal "Atmospheric pressure" (A.6.11).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Atmospheric pressure" (A.6.11).

A.6.13 Relative humidity

Table A.517 — Signal: Relative humidity

Name	Relative humidity		
Description	The signal "Relative humidity" (A.6.13) provides the relative air humidity.		
Value type	[0…100] real value	**Unit**	%

A.6.14 Relative humidity – error

Table A.518 — Signal: Relative humidity – error

Name	Relative humidity – error		
Description	The signal "Relative humidity – error" (A.6.14) provides the error value of the signal "Relative humidity" (A.6.13).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Relative humidity" (A.6.13).

A.6.15 Global time stamp

Table A.519 — Signal: Global time stamp

Name	Global time stamp		
Description	The signal "Global time stamp" (A.6.15) provides the external time of day information (for example, from GPS information). There is no change in the time zone during operation of the sensor cluster and the time zone is defined during the system design phase.		
Value type	real value	**Unit**	s

A.6.16 Road type – input level

Table A.520 — Signal: Road type – input level

Name	Road type – input level		
Description	The signal "Road type – input level" (A.6.16) provides the road characteristics to improve the performance of the sensor's or the sensor cluster's algorithm.		
Value type	enumeration	**Unit**	1

Table A.521 — Enumeration: Road type – input level – Example enumerators

Name	Description	RL enumerator
RT_Motorway	The road characteristics meet motorway/highway/expressway/dual carriageway conditions.	"exemplary"

Name	Description	RL enumerator
RT_Interurban	The road characteristics meet interurban road conditions.	“exemplary”
RT_Rural	The road characteristics meet rural conditions.	“exemplary”
RT_City	The road characteristics meet city/urban conditions.	“exemplary”
RT_Suburb	The road characteristics meet suburb conditions.	“exemplary”
RT_ParkingPlace	The road characteristics meet parking place conditions.	“exemplary”
RT_EnclosedPark	The road characteristics meet enclosed park conditions.	“exemplary”
RT_OffRoad	The road characteristics meet off road conditions.	“exemplary”

A.6.17 Road surface temperature

Table A.522 — Signal: Road surface temperature

Name	Road surface temperature		
Description	The signal “Road surface temperature” (A.6.17) provides the surface temperature of the road surface which is relevant for the ego-vehicle.		
Value type	real value	**Unit**	K

A.6.18 Road surface water film

Table A.523 — Signal: Road surface water film

Name	Road surface water film		
Description	The signal “Road surface water film” (A.6.18) provides the thickness of the water film of the road surface which is relevant for the ego-vehicle.		
Value type	real value	**Unit**	mm

A.6.19 Road surface freezing point

Table A.524 — Signal: Road surface freezing point

Name	Road surface freezing point		
Description	The signal “Road surface freezing point” (A.6.19) provides the freezing point of the road surface which is relevant for the ego-vehicle.		
Value type	real value	**Unit**	K

A.6.20 Road surface ice coverage

Table A.525 — Signal: Road surface ice coverage

Name	Road surface ice coverage		
Description	The signal “Road surface ice coverage” (A.6.20) provides the coverage of the road surface with ice which is relevant for the ego-vehicle.		
Value type	real value	**Unit**	%

A.6.21 Road surface classification type – input level

Table A.526 — Signal: Road surface classification type – input level Road surface roughness

Name	Road surface classification type – input level		
Description	The signal “Road surface classification type – input level” (A.6.21) provides the relevant type of the road surface for the ego-vehicle.		
Value type	enumeration	**Unit**	1

Table A.527— Enumeration: Road surface classification type – input level – Example enumerators

Name	**Description**	**RL enumerator**
RSCT_Flat	The road is a smooth surface road.	“exemplary”
RSCT_Concrete	The road is a concrete road with a smooth surface.	“exemplary”
RSCT_Asphalt	The road is an asphalt road with a smooth surface.	“exemplary”
RSCT_Bumpy	The road is bumpy.	“exemplary”
RSCT_RomanRoad	The road is a cobblestone street.	“exemplary”
RSCT_Gravel	The road has a gravel surface.	“exemplary”
RSCT_Soil	The road has a soil surface.	“exemplary”
RSCT_Sand	The road has a sand surface.	“exemplary”
RSCT_OffRoad	The road is an off-road road.	“exemplary”
RSCT_Vegetation	The road has a vegetation surface.	“exemplary”

A.6.22 Road surface roughness – input level

Table A.528 — Signal: Road surface roughness – input level

Name	Road surface roughness – input level		
Description	The signal “Road surface roughness – input level” (A.6.22) provides the relevant roughness or unevenness of the road surface for the ego-vehicle. Additional information: The International Roughness Index (IRI) has a value range from 0 = smooth surface (equivalent to driving on a plate of glass) up to 20 mm/m (a very rough road).		
Value type	real value	**Unit**	mm/m

A.6.23 Road surface condition classification type – input level

Table A.529 — Signal: Road surface condition classification type – input level

Name	Road surface condition classification type – input level		
Description	The signal “Road surface condition classification type – input level” (A.6.23) provides the relevant condition of the road surface for the ego-vehicle.		
Value type	enumeration	**Unit**	1

Table A.530— Enumeration: Road surface condition classification type – input level – Example enumerators

Name	**Description**	**RL enumerator**
RSCCT_Dry	The road surface is dry.	“exemplary”

Name	Description	RL enumerator
RSCCT_Wet	The road surface is wet.	“exemplary”
RSCCT_Water	The road surface is covered with water.	“exemplary”
RSCCT_Snow	The road surface is covered with snow.	“exemplary”
RSCCT_Ice	The road surface is covered with ice.	“exemplary”
RSCCT_Leaves	The road surface is covered with leaves.	“exemplary”
RSCCT_Dust	The road surface is covered with dust.	“exemplary”
RSCCT_Dirt	The road surface is covered with dirt.	“exemplary”

A.6.24Road surface texture – input level

Table A.531 — Signal: Road surface texture – input level

Name	Road surface texture – input level		
Description	The signal “Road surface texture – input level” (A.6.24) provides the surface texture or fine roughness [16] measures only wavelengths below 0,5 m, compared to the signal’s value “Road surface roughness – input level” (A.6.22) (0,5 m – 100 m).		
Value type	real value	**Unit**	m

A.6.25Vehicle coordinate system type – input level

Table A.532 — Signal: Vehicle coordinate system type – input level

Name	Vehicle coordinate system type – input level		
Description	The signal “Vehicle coordinate system type – input level” (A.6.25) defines the reference ego-vehicle coordinate system.		
Value type	enumeration	**Unit**	1

Table A.533 — Enumeration: Vehicle coordinate system type – input level

Name	Description	RL enumerator
VCST_RearAxle	Use definition “vehicle rear-axle coordinate system” (3.7.12) for the ego-vehicle coordinate system.	Mandatory
VCST_RoadLevel	Use definition “vehicle road-level coordinate system” (3.7.15) for the ego-vehicle coordinate system.	Mandatory

A.6.26Vehicle state reference point type

Table A.534 — Signal: Vehicle state reference point type

Name	Vehicle state reference point type		
Description	The signal “Vehicle state reference point type” (A.6.26) defines the coordinate system for the motion signals of the LSG. Additional information: The default value for the signal “Vehicle state reference point type” (A.6.26) is the enumerator “VSRPT_VehicleCoordinateSystem”.		
Value type	enumeration	**Unit**	1

Table A.535 — Enumeration: Vehicle state reference point type

Name	Description	RL enumerator
VSRPT_VehicleCoordinateSystem	The signal “Vehicle coordinate system type – input level” (A.6.25) defines the coordinate system for the LSG “Vehicle state”.	Mandatory
VSRPT_CentreOfGravity	The centre of gravity defines the origin, and the ego-vehicle axis system defines the axes of the coordinate system for the LSG “Vehicle state”.	Optional
VSRPT_SensorCoordinateSystem	The LSG “Information: sensor pose” (see Table 51) in: SPI defines the coordinate system for the LSG “Vehicle state”.	Optional

A.6.27Velocity {x, y, z} – input level

Table A.536 — Signal: Velocity {x, y, z} – input level

Name	Velocity {x, y, z} – input level		
Description	The signal “Velocity {x, y, z} – input level” (A.6.27) provides the absolute velocity of the ego-vehicle in the ego-vehicle axis system [see signal “Vehicle coordinate system type – input level” (A.6.25)].		
Value type	3D vector real value	**Unit**	(m/s, m/s, m/s)

A.6.28Velocity {x, y, z} – error – input level

Table A.537 — Signal: Velocity {x, y, z} – error – input level

Name	Velocity {x, y, z} – error – input level		
Description	The signal “Velocity {x, y, z} – error – input level” (A.6.28) provides the error value of the signal “Velocity {x, y, z} – input level” (A.6.27).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Velocity {x, y, z} – input level” (A.6.27).

A.6.29Acceleration {x, y, z} – input level

Table A.538 — Signal: Acceleration {x, y, z} – input level

Name	Acceleration {x, y, z} – input level		
Description	The signal “Acceleration {x, y, z} – input level” (A.6.29) provides the absolute acceleration along the axes of the ego-vehicle in the ego-vehicle axis system [see signal “Vehicle coordinate system type – input level” (A.6.25)].		
Value type	3D vector real value	**Unit**	(m/s^2, m/s^2, m/s^2)

A.6.30Acceleration {x, y, z} – error – input level

Table A.539 — Signal: Acceleration {x, y, z} – error – input level

Name	Acceleration {x, y, z} – error – input level
Description	The signal “Acceleration {x, y, z} – error – input level” (A.6.30) provides the error value of the signal “Acceleration {x, y, z} – input level” (A.6.29).

Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Acceleration {x, y, z} – input level” (A.6.29).

A.6.31 Jerk {x}

Table A.540 — Signal: Jerk {x}

Name	Jerk {x}		
Description	The signal “Jerk {x}” (A.6.31) provides the absolute jerk along the *X*-axis of the ego-vehicle in the ego-vehicle axis system [see signal “Vehicle coordinate system type – input level” (A.6.25)].		
Value type	real value	**Unit**	m/s^3

A.6.32 Jerk {x} – error

Table A.541 — Signal: Jerk {x} – error

Name	Jerk {x} – error		
Description	The signal “Jerk {x} – error” (A.6.32) provides the error value of the signal “Jerk {x}” (A.6.31).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Jerk {x}” (A.6.31).

A.6.33 Rotation rate {yaw, pitch, roll} – input level

Table A.542 — Signal: Rotation rate {yaw, pitch, roll} – input level

Name	Rotation rate {yaw, pitch, roll} – input level		
Description	The signal “Rotation rate {yaw, pitch, roll} – input level” (A.6.33) provides the absolute rotation rate of the ego-vehicle in world coordinate reference system. Additional information: The signal “Rotation rate {yaw, pitch, roll} – input level” (A.6.33) is given with {yaw, pitch, roll} angles, which have to be separated in a defined procedure. For example, the rotations are to be performed yaw first (around the *Z*-axis), pitch second (around the new *Y*-axis) and roll third (around the new *X*-axis) following the definition according to ISO 8855:2011.		
Value type	3D vector real value	**Unit**	(rad/s, rad/s, rad/s)

A.6.34 Rotation rate {yaw, pitch, roll} – error – input level

Table A.543 — Signal: Rotation rate {yaw, pitch, roll} – error – input level

Name	Rotation rate {yaw, pitch, roll} – error – input level		
Description	The signal “Rotation rate {yaw, pitch, roll} – error – input level” (A.6.34) provides the error value of the signal “Rotation rate {yaw, pitch, roll} – input level” (A.6.33).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Rotation rate {yaw, pitch, roll} – input level” (A.6.33).

A.6.35 Angular wheel position {FLP, FRP, RLP, RRP}

Table A.544 — Signal: Angular wheel position {FLP, FRP, RLP, RRP}

Name	Angular wheel position {FLP, FRP, RLP, RRP}		
Description	The signal “Angular wheel position {FLP, FRP, RLP, RRP}” (A.6.35) provides the angular position of the wheels, that means the rotation angle at the front-left (FLP), the front-right (FRP), the rear-left (RLP) and the rear-right (RRP) wheel.		
Value type	4D vector real value	**Unit**	(rad, rad, rad, rad)

A.6.36 Angular wheel velocity {FLP, FRP, RLP, RRP}

Table A.545 — Signal: Angular wheel velocity {FLP, FRP, RLP, RRP}

Name	Angular wheel velocity {FLP, FRP, RLP, RRP}		
Description	The signal “Angular wheel velocity {FLP, FRP, RLP, RRP}” (A.6.36) provides the angular velocity of the wheels, that means the rotation rate at the front-left (FLP), the front-right (FRP), the rear-left (RLP) and the rear-right (RRP) wheel.		
Value type	4D vector real value	**Unit**	(rad/s, rad/s, rad/s, rad/s)

A.6.37 Angular wheel velocity {FLP, FRP, RLP, RRP} – error

Table A.546 — Signal: Angular wheel velocity {FLP, FRP, RLP, RRP} – error

Name	Angular wheel velocity {FLP, FRP, RLP, RRP} – error		
Description	The signal “Angular wheel velocity {FLP, FRP, RLP, RRP} – error” (A.6.37) provides the error value of the signal “Angular wheel velocity {FLP, FRP, RLP, RRP}” (A.6.36).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal “Angular wheel velocity {FLP, FRP, RLP, RRP}” (A.6.36).

A.6.38 Slip angle {FLP, FRP, RLP, RRP}

Table A.547 — Signal: Slip angle {FLP, FRP, RLP, RRP}

Name	Slip angle {FLP, FRP, RLP, RRP}		
Description	The signal “Slip angle {FLP, FRP, RLP, RRP}” (A.6.38) provides the slip angle of the wheels, that means the slip angle at the front-left (FLP), the front-right (FRP), the rear-left (RLP) and the rear-right (RRP) wheel.		
Value type	4D vector real value	**Unit**	(rad, rad, rad, rad)

A.6.39 Active suspension {FLP, FRP, RLP, RRP}

Table A.548 — Signal: Active suspension {FLP, FRP, RLP, RRP}

Name	Active suspension {FLP, FRP, RLP, RRP}		
Description	The signal “Active suspension {FLP, FRP, RLP, RRP}” (A.6.39) provides the displacement of the sprung mass, that means the displacement of the active suspension at the front-left (FLP), the front-right (FRP), the rear-left (RLP) and the rear-right (RRP).		
Value type	4D real vector	**Unit**	(m, m, m, m)

A.6.40 Steering angle

Table A.549 — Signal: Steering angle

Name	Steering angle		
Description	The signal "Steering angle" (A.6.40) provides the wheel steering angle.		
Value type	real value	**Unit**	rad

A.6.41 Steering angle – error

Table A.550 — Signal: Steering angle – error

Name	Steering angle – error		
Description	The signal "Steering angle – error" (A.6.41) provides the error value of the signal "Steering angle" (A.6.40).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Steering angle" (A.6.40).

A.6.42 Vehicle global position {latitude, longitude, altitude}

Table A.551 — Signal: Vehicle global position {latitude, longitude, altitude}

Name	Vehicle global position {latitude, longitude, altitude}		
Description	The signal "Vehicle global position {latitude, longitude, altitude}" (A.6.42) provides the location of the ego-vehicle in the world coordinate reference system.		
Value type	3D vector real value	**Unit**	(°, °, m)

A.6.43 Vehicle global position {latitude, longitude, altitude} – error

Table A.552 — Signal: Vehicle global position {latitude, longitude, altitude} – error

Name	Vehicle global position {latitude, longitude, altitude} – error		
Description	The signal "Vehicle global position {latitude, longitude, altitude} – error" (A.6.43) provides the error value of the signal "Vehicle global position {latitude, longitude, altitude}" (A.6.42).		
Value type	scalar/vector/matrix real value (see B.4.1)	**Unit**	See signal "Vehicle global position {latitude, longitude, altitude}" (A.6.42).

A.6.44 Vehicle global orientation {yaw, pitch, roll}

Table A.553 — Signal: Vehicle global orientation {yaw, pitch, roll}

Name	Vehicle global orientation {yaw, pitch, roll}

Description	The signal "Vehicle global orientation {yaw, pitch, roll}" (A.6.44) provides the orientation of the ego-vehicle in the world coordinate reference system. Additional information: The signal "Vehicle global orientation {yaw, pitch, roll}" (A.6.44) is given with {yaw, pitch, roll} angles, which have to be separated in a defined procedure. For example, the rotations are to be performed yaw first (around the *Z*-axis), pitch second (around the new *Y*-axis) and roll third (around the new *X*-axis) following the definition according to ISO 8855:2011.		
Value type	3D vector real value	**Unit**	(rad, rad, rad)

A.6.45 Wheel rotation direction {FLP, FRP, RLP, RRP}

Table A.554 — Signal: Wheel rotation direction {FLP, FRP, RLP, RRP}

Name	Wheel rotation direction {FLP, FRP, RLP, RRP}		
Description	The signal "Wheel rotation direction {FLP, FRP, RLP, RRP}" (A.6.45) provides information about the wheel rotation direction for 4 wheels at the front-left (FLP), the front-right (FRP), the rear-left (RLP) and the rear-right (RRP).		
Value type	4D vector enumeration	**Unit**	(1, 1, 1, 1)

Table A.555 — Enumeration: Wheel rotation direction {FLP, FRP, RLP, RRP} – Example enumerators

Name	**Description**	**RL enumerator**
WD_Forward	The wheel direction is forward.	"exemplary"
WD_Standstill	The wheel direction is standstill.	"exemplary"
WD_Backward	The wheel direction is backward.	"exemplary"

A.6.46 Wheel tick count {FLP, FRP, RLP, RRP}

Table A.556 — Signal: Wheel tick count {FLP, FRP, RLP, RRP}

Name	Wheel tick count {FLP, FRP, RLP, RRP}		
Description	The signal "Wheel tick count {FLP, FRP, RLP, RRP}" (A.6.46) provides the number of position pulses (ticks) per wheel at the front-left (FLP), the front-right (FRP), the rear-left (RLP) and the rear-right (RRP).		
Value type	4D real vector	**Unit**	(1, 1, 1, 1)

A.6.47 Gear position

Table A.557 — Signal: Gear position

Name	Gear position		
Description	The signal "Gear position" (A.6.47) provides the information of the current gear position.		
Value type	enumeration	**Unit**	1

Table A.558 — Enumeration: Gear position – Example enumerators

Name	**Description**	**RL enumerator**

Name	Description	RL enumerator
GP_Neutral	Gear is in neutral position or in transition phase.	“exemplary”
GP_Parking	Automatic transmission gear is in parking position.	“exemplary”
GP_Forward	Automatic transmission gear is in drive position.	“exemplary”
GP_Reverse	Gear is in reverse position.	“exemplary”
GP_LowGear	Gear is in low gear position.	“exemplary”
GP_2ndGear	Gear is in 2nd gear position.	“exemplary”
GP_3rdGear	Gear is in 3rd gear position.	“exemplary”
GP_4thGear	Gear is in 4th gear position.	“exemplary”
GP_5thGear	Gear is in 5th gear position.	“exemplary”
GP_6thGear	Gear is in 6th gear position.	“exemplary”

A.6.48Brake activation level

Table A.559 — Signal: Brake activation level

Name	Brake activation level		
Description	The signal “Brake activation level” (A.6.48) provides the information about brake activation level (including recuperation).		
Value type	enumeration	**Unit**	1

Table A.560 — Enumeration: Gear position – Example enumerators

Name	Description	RL enumerator
BAL_Inactive	Brake is not active.	“exemplary”
BAL_PreFill	Brake is pre-filled.	“exemplary”
BAL_PreBrake	Brake deceleration request between (0 and 5) m/s^2.	“exemplary”
BAL_FullBrake	Brake deceleration request value exceeds 5 m/s^2.	“exemplary”

A.6.49Vehicle motion state

Table A.561 — Signal: Vehicle motion state

Name	Vehicle motion state		
Description	The signal “Vehicle motion state” (A.6.49) provides the current motion state of the ego-vehicle.		
Value type	enumeration	**Unit**	1

Table A.562 — Enumeration: Vehicle motion state – Example enumerators

Name	Description	RL enumerator
VMS_Standstill	The motion state of the ego-vehicle is standstill.	“exemplary”
VMS_MovingForward	The motion state of the ego-vehicle is moving forward.	“exemplary”
VMS_MovingBackward	The motion state of the ego-vehicle is moving backward.	“exemplary”
VMS_IsBeingMovedForward	The motion state of the ego-vehicle is being moved forward.	“exemplary”

VMS_IsBeingMovedBackward	The motion state of the ego-vehicle is being moved backward.	“exemplary”

A.6.50 Current region

Table A.563 — Signal: Current region

Name	Current region		
Description	The signal “Current region” (A.6.50) provides the current residence area of the ego-vehicle to improve the performance of the sensor’s or the sensor cluster’s algorithm.		
Value type	enumeration	**Unit**	1

Table A.564 — Enumeration: Current region – Example enumerators

Name	Description	RL enumerator
CR_China	The current residence area is China.	“exemplary”
CR_Germany	The current residence area is Germany.	“exemplary”
CR_UnitedStatesOfAmerica	The current residence area is United States of America.	“exemplary”
CR_UnitedKingdom	The current residence area is United Kingdom.	“exemplary”

A.6.51 Current traffic flow type

Table A.565 — Signal: Current traffic flow type

Name	Current traffic flow type		
Description	The signal “Current traffic flow type” (A.6.51) provides the current type of the traffic flow.		
Value type	enumeration	**Unit**	1

Table A.566 — Enumeration: Current traffic flow type – Example enumerators

Name	Description	RL enumerator
CTFT_RightHandTraffic	The current traffic flow is right-hand traffic.	“exemplary”
CTFT_LeftHandTraffic	The current traffic flow is left-hand traffic.	“exemplary”

A.6.52 Trailer type

Table A.567 — Signal: Trailer type

Name	Trailer type		
Description	The signal “Trailer type” (A.6.52) provides the information of an attached trailer.		
Value type	enumeration	**Unit**	1

Table A.568 — Enumeration: Trailer type – Example enumerators

Name	Description	RL enumerator
TT_WithTrailer	A trailer is attached to the ego-vehicle.	“exemplary”
TT_WithoutTrailer	No trailer is attached to the ego-vehicle.	“exemplary”

A.6.53 Park brake state

Table A.569 — Signal: Park brake state

Name	Park brake state		
Description	The signal “Park brake state” (A.6.53) provides the information of the park brake state.		
Value type	enumeration	**Unit**	1

Table A.570 — Enumeration: Park brake state – Example enumerators

Name	**Description**	**RL enumerator**
PBS_Inactive	Park brake is not activated.	“exemplary”
PBS_Active	Park brake is activated.	“exemplary”

A.6.54 Vehicle body position {z}

Table A.571 — Signal: Vehicle body position {z}

Name	Vehicle body position {z}		
Description	The signal “Vehicle body position {z}” (A.6.54) indicates the current vertical offset {z} of the ego-vehicle body compared to the position defined during the system design phase (the defined vertical offset between the ego-vehicle coordinate systems [see signal “Vehicle coordinate system type – input level” (A.6.25)]. The offsets {x, y} of the ego-vehicle coordinate systems are always 0 m.		
Value type	real vector	**Unit**	m

A.6.55 Vehicle body orientation {pitch, roll}

Table A.572 — Signal: Vehicle body orientation {pitch, roll}

Name	Vehicle body orientation {pitch, roll}		
Description	The signal “Vehicle body orientation {pitch, roll}” (A.6.55) indicates the current offset of the orientation {pitch, roll} of the ego-vehicle body compared to the orientation defined during the system design phase. The angular offset {yaw} of the ego-vehicle coordinate systems is always 0 rad. Additional information: The signal “Vehicle body orientation {pitch, roll}” (A.6.55) is given with {yaw := 0, pitch, roll} angles, which have to be separated in a defined procedure. For example, the rotations are to be performed yaw first (around the *Z*-axis), pitch second (around the new *Y*-axis) and roll third (around the new *X*-axis) following the definition according to ISO 8855:2011.		
Value type	2D real vector	**Unit**	(rad, rad)

A.6.56 Sensor origin point {x, y, z} – input level

Table A.573 — Signal: Sensor origin point {x, y, z} – input level

Name	Sensor origin point {x, y, z} – input level

Description	The signal "Sensor origin point {x, y, z} – input level" (A.6.56) provides the position of the origin of the sensing element's sensor coordinate system in the ego-vehicle coordinate system [see signal "Vehicle coordinate system type – input level" (A.6.25)].		
Value type	3D vector real value	**Unit**	(m, m, m)

A.6.57 Sensor orientation {yaw, pitch, roll} – input level

Table A.574 — Signal: Sensor orientation {yaw, pitch, roll} – input level

Name	Sensor orientation {yaw, pitch, roll} – input level		
Description	The signal "Sensor orientation {yaw, pitch, roll} – input level" (A.6.57) provides the relative orientation of the sensor axis system with respect to the ego-vehicle axis system [see signal "Vehicle coordinate system type – input level" (A.6.25)].		
Value type	3D vector real value	**Unit**	(rad, rad, rad)

A.6.58 Reporting interface <...> – command

Table A.575 defines the command to change the reporting interface of the sensor or sensor cluster. All interfaces use the same list of example enumerators.

Table A.575 — Enumeration: Reporting interface <...> – command – Example enumerators

Name	**Description**	**RL enumerator**
RI<...>C_Enable	Enables the reporting interface of the sensor or the sensor cluster.	"exemplary"
RI<...>C_Disable	Disables the reporting interface of the sensor or the sensor cluster.	"exemplary"

A.6.58.1 Reporting interface PMOI – command

Table A.576 — Signal: Reporting interface PMOI – command

Name	Reporting interface PMOI – command		
Description	The signal "Reporting interface PMOI – command" (A.6.58.1) provides the requested reporting status of the PMOI of the sensor.		
Value type	enumeration	**Unit**	1

A.6.58.2 Reporting interface RDOI – command

Table A.577 — Signal: Reporting interface RDOI – command

Name	Reporting interface RDOI – command		
Description	The signal "Reporting interface RDOI – command" (A.6.58.2) provides the requested reporting status of the RDOI of the sensor.		
Value type	enumeration	**Unit**	1

A.6.58.3 Reporting interface SOI – command

Table A.578 — Signal: Reporting interface SOI – command

Name	Reporting interface SOI – command
Description	The signal "Reporting interface SOI – command" (A.6.58.3) provides the requested reporting status of the SOI of the sensor.

Value type	enumeration	**Unit**	1

A.6.58.4 Reporting interface FSAOI – command

Table A.579 — Signal: Reporting interface FSAOI – command

Name	Reporting interface FSAOI – command		
Description	The signal "Reporting interface FSAOI – command" (A.6.58.4) provides the requested reporting status of the FSAOI of the sensor.		
Value type	enumeration	**Unit**	1

A.6.58.5 Reporting interface FLI – command

Table A.580 — Signal: Reporting interface FLI – command

Name	Reporting interface FLI – command		
Description	The signal "Reporting interface FLI – command" (A.6.58.5) provides the requested reporting status of the FLI of the sensor.		
Value type	enumeration	**Unit**	1

A.6.58.6 Reporting interface DLI – command

Table A.581 — Signal: Reporting interface DLI – command

Name	Reporting interface DLI – command		
Description	The signal "Reporting interface DLI – command" (A.6.58.6) provides the requested reporting status of the DLI of the sensor.		
Value type	enumeration	**Unit**	1

A.6.58.7 Reporting interface SPI – command

Table A.582 — Signal: Reporting interface SPI – command

Name	Reporting interface SPI – command		
Description	The signal "Reporting interface SPI – command" (A.6.58.7) provides the requested reporting status of the SPI of the sensor.		
Value type	enumeration	**Unit**	1

A.6.58.8 Reporting interface SHII – command

Table A.583 — Signal: Reporting interface SHII – command

Name	Reporting interface SHII – command		
Description	The signal "Reporting interface SHII – command" (A.6.58.8) provides the requested reporting status of the SHII of the sensor.		
Value type	enumeration	**Unit**	1

A.6.59Number of valid region-of-interest segments

Table A.584 — Signal: Number of valid region-of-interest segments

Name	Number of valid region-of-interest segments

Description	The signal's "Number of valid region-of-interest segments" (A.6.59) value defines the number of valid entities in the regions of interest segments (FOV) of the sensor of the CSII. Additional information: The maximum number of entries could be limited. The entries in the list may or may not be sorted. All those entities of the list which can be used by the sensor are regarded as valid. The list includes a complete and prioritised set of valid entities for the signal's "Time stamp – <…>" (A.1.5) value and not only a differential list between two sequential time stamps.		
Value type	[0…] integer value	**Unit**	1

A.6.60 Segment azimuth – input level {begin, end}

Table A.585 — Signal: Segment azimuth – input level {begin, end}

Name	Segment azimuth – input level {begin, end}		
Description	The signal "Segment azimuth – input level {begin, end}" (A.6.60) provides the requested FOV defined by opening angles in the sensor *XY*-plane (see Figure A.31). Additional information: The values are given in the sensor coordinate system.		
Value type	2D vector real value	**Unit**	(rad, rad)

A.6.61 Segment elevation – input level {begin, end}

Table A.586 — Signal: Segment elevation – input level {begin, end}

Name	Segment elevation – input level {begin, end}		
Description	The signal "Segment elevation – input level {begin, end}" (A.6.61) provides the requested FOV defined by opening angles in sensor *XZ*-plane (see Figure A.32). Additional information: The values are given in the sensor coordinate system.		
Value type	2D vector real value	**Unit**	(rad, rad)

A.6.62 Resolution type {azimuth, elevation}

Table A.587 — Signal: Resolution type {azimuth, elevation}

Name	Resolution type {azimuth, elevation}		
Description	The signal "Resolution type {azimuth, elevation}" (A.6.62) provides the requested change of the sensor's resolution within the specified FOV segment.		
Value type	2D vector enumeration	**Unit**	(1, 1)

Table A.588 — Enumeration: Resolution type {azimuth, elevation} – Example enumerators

Name	Description	RL enumerator
RT_High	Set the sensor resolution for the FOV segment to high.	"exemplary"
RT_Normal	Set the sensor resolution for the FOV segment to normal.	"exemplary"

Name	**Description**	**RL enumerator**
RT_Low	Set the sensor resolution for the FOV segment to low.	“exemplary”
RT_Focus	Set the sensor resolution for the FOV segment to focus.	“exemplary”

Annex B
(normative)

Options and constraints

B.1 Options for interface optimisation

This subclause provides definitions of alternative implementation options of the defined interfaces.

B.1.1 List length optimisation

If the number of list entities is fixed, the signal "Number of valid <…>" (A.1.12) is not mandatory anymore. Unused list entities shall be marked as invalid, specifically by an additional, mandatory signal, for example, "entity is valid".

This measure could be combined with measure "Alternative value representation optimisation" (B.1.3).

Definition: Optimise LL

B.1.2 Redundancy optimisation

If a signal can be calculated from one or more other signals by a mathematical formula, the signal can be omitted.

EXAMPLE 1 The signal "Cycle counter" (A.1.6.1) of an interface message can be derived from the time stamp of the measurement if the interface's first time-stamp and the time interval of a single measurement cycle are known.

EXAMPLE 2 The signal "Observation status – object level" (A.2.7) can be calculated of the entity's existence in the previous transferred (for example, the last 32 cycles) messages. The precondition is that the entity always has the same ID during the observed time.

Definition: Redundancy – Signal: <related signal name>

B.1.3 Alternative value representation optimisation

As an alternative representation for values or value ranges, a signal for an index value in combination with a lookup table can be used instead of the values or value ranges themselves.

EXAMPLE 1 Angle elevation, angle azimuth → index to angle elevation and/or angle azimuth that refers to angles in a lookup table.

EXAMPLE 2 The value ranges of the signals "Segment azimuth – supportive sensor level {begin, end}" (A.5.1) and "Segment elevation – supportive sensor level {begin, end}" (A.5.2) → index to horizontal and/or vertical angle range that refers to an angle range in a lookup table.

This measure could be combined with measure "Implicit values" (B.1.5). The index can be omitted if the index can be derived implicitly from the position of the entity in a list.

EXAMPLE 3 The sensor can detect no or exact one entity at a fixed angle combination. The sensor has a fixed grid of angle combinations. Therefore, the number of possible entities and the angle grid (angle azimuth and angle elevation) are fixed. The index of the entity in the list could define the measurement angle of the entity.

Definition: Alternative VRO

B.1.4 Alternative entity representation optimisation

This measure uses the measure “Redundancy optimisation” (B.1.2).

As an alternative representation for a set of entities of an entity list, some of which have the same signal values, the interface may group these signals with the same values, transmit this group of signals only once and transmit the subset of varying signals in an array.

EXAMPLE A lidar sensor can detect several detections with the same direction (for example, same azimuth, elevation and so forth; but different radial distance, height and so forth). It is possible that the interface does not transmit each detection separately. Instead, it can transmit a number of valid detection-sets with signals azimuth, elevation and so forth and for each detection-sets a number of valid detections with the signals radial distance, height and so forth. The fusion unit will receive exactly the same information, but in an optimised and redundance-free way.

Definition: Optimise AER

B.1.5 Implicit values

Values that are implicitly known at both sites, the sensor cluster and the fusion unit, do not have to be transferred. The signals and values shall be defined during the system design phase.

EXAMPLE 1 When the relationship of the list position of an entity is always associated statically with the same geometric direction in space.

EXAMPLE 2 If a signal is not measured or does not occur in the measurement method used, the same value for this measurement is always sent. An example is the time stamp difference of each detection within the measurement. If all detections are measured in parallel, the time difference is zero. The signal time stamp difference can be omitted in this case.

EXAMPLE 3 When the relationship of the list position of an entity is always associated statically with the same entry of a referred lookup table. For example, entities with index 1 … 10 have a signal “Height” value of 0 m; with index 11 … 20 a value of 1 m; with index 21 … 30 a value of 2 m and so forth.

Definition: Optimise IV

B.1.6 Unrolling tuple-lists

This measure combines measures “List length optimisation” (B.1.1), “Alternative value representation optimisation” (B.1.3) and “Implicit values” (B.1.5).

If a dynamic list of tuples (for example, a classification type and values) always contains the same count of tuples and these tuples always use the same order of the classification types, the list can be expanded and only the values can be transferred. Here, the assignment and ordering of the classification types shall be implicitly known and shall be defined during the system design phase.

EXAMPLE 1 If a classification type confidence is specified for each possible object classification type, the sensor can only transfer the classification type confidence values for a fixed number of classification types (for example, the classification type confidence values for the classification types 1. pedestrian, 2. car, 3. bicycle). During the system design phase, it will be defined that the first classification type confidence value corresponds to the classification type pedestrian, the second value to car and so forth.

EXAMPLE 2 If an interface provides an entity’s observations of the last n messages (for example, the last 32 cycles) and the observation status has only two possible enumerators (for example, true and false), then the observations can be implemented as a n-bit bit-vector.

Definition: Alternative UTL – Key: <enumeration signal name>

NOTE Each enumerator can at most occur once in the list.

B.1.7 Default enumerators

An enumeration may provide default enumerators, which are not added to the definition of the signal's list of enumerators:

— the enumerator "<Enumeration name>_Unknown" is used for a classification with low confidences;

— the enumerator "<Enumeration name>_Other" is used for a classification with a high confidence that the available enumerators do not apply.

Definition: Default enumerators

B.2 Requirement level conditional reasons

This subclause provides definitions of constraints for conditional requirement levels of signals, LSG, signal's identifier or signal's enumerator.

B.2.1 Sensor technology specific conditional requirements

A signal or LSG becomes mandatory, if the considered sensor or sensor cluster is capable of providing the requested information due to the sensor technology. Other sensor technologies may or may not provide the signal or the LSG. If a sensor provides the signal or the LSG then the requirement level status conditional becomes mandatory.

Definition (optional): Relevant: <sensor technology>

B.2.2 Signal dependencies

Signals shall be available when other optional signals are provided by the implementation of the interface.

EXAMPLE If the object's signal "Height" is an optional signal and there is another conditional (B.2.2) signal for the measurement error of the signal "Height", then the measurement error is always specified as soon as the signal "Height" is implemented by the interface. However, the measurement error shall not be implemented by the interface if the signal "Height" is not implemented.

Definition Signal: <dependent signal name>

or

Definition * The signal <dependent signal name> has <enumeration signal name>

B.2.3 Multiple entity types for one interface

An interface provides more than one different entity type or entity type list. A sensor shall provide at least one entity type (list) per interface.

Each entity type/entity type list may be implemented as a separate implementation of the interface, but no entity type/entity type list may be implemented twice. It may be necessary to add a signal to differentiate the specific implementation of the interface (for example, necessary for a service-oriented architecture).

EXAMPLE 1 The road object interface provides the entity types of road markings, road boundaries and road surface. It is possible that a sensor provides only the entity types of road markings and road surface but no road boundaries (specifically no LSG road boundaries and so forth).

EXAMPLE 2 The road object interface provides the entity types of road markings, road boundaries and road surface. It is possible that a sensor implements one road marking interface with the entity types of road markings and road surface and a second road marking interface with the entity type road boundaries. It is important that the sensor ensures that both interfaces can be distinguished.

Definition multiple <entity definition> types

B.3 Cross interface optimisation

Common dependencies, which can occur between two or more interfaces of a sensor cluster, are defined in this subclause.

B.3.1 Link between interfaces

The implementation of interfaces is optional. If an interface LSG is linked to a second interface or if an interface's entity is linked to an entity of a second interface, the link shall only be available if both interfaces are provided by the sensor. If the LSG of an interface is relevant for other interfaces, the LSG in the interface is mandatory if one of the affected interfaces is provided (see also B.3.2).

EXAMPLE 1 Link between features and objects via signal “Object ID” (A.2.2) and signal “Object ID reference – feature level” (A.3.3).

EXAMPLE 2 LSG “Reference target recognition capabilities” of SPI provides information for FLI and DLI, if at least a FLI or a DLI is provided.

Definition Exist: <necessary interface>

B.3.2 Assignment of information to one interface

If a signal or an LSG can be associated to different interfaces, the signal/LSG is only defined and implemented by one interface. The alternative implementation in a second, third and so forth interface is not shown.

EXAMPLE Each detection provides an ID as signal “Object ID reference – feature level” (A.3.3) that describes the logical relationship between detections on DLI and objects on OLI. This relation is a 1:n relation, specifically each detection refers to at most one object with the highest probability, but one object can consist of several detections.

Alternative implementations:

ALTERNATIVE 1 This relation can be implemented in a separate third interface if DLI interfaces provide a signal “Detection ID”, OLI interfaces provide a signal “Object ID” (A.2.2) and a third interface provides a list of associations with signals “Object ID references” and “Detection ID references”.

ALTERNATIVE 2 This relation 1:n can also be implemented the other way round between the two interfaces. Each DLI interface detection provides a signal “Detection ID”, and each OLI interface object provides a list of “Detection ID references”.

Definition Alternative A2I

B.3.3 Need of logical signal group

If an LSG is important for several interfaces, this document defines the LSG only in one interface. Since it is allowed that an interface can be omitted (each interface is optional), it could happen that a relevant LSG for the implemented sensor cluster interfaces would be omitted. Since this is not allowed for a relevant LSG, this LSG is implemented by at least another predefined interface.

It is also allowed that the LSG is provided by several interfaces in parallel (and therefore, redundantly).

EXAMPLE The SHII's LSG “Calibration” that provides the calibration state of the sensor is important for the interpretation of detections. If SHII is not implemented by the sensor or sensor cluster, the LSG “Calibration” is implemented in another interface. The order of the interfaces which implement the LSG is given:

1) interface: SPI; LSG: “Information: interface”;

2) interface: DLI; LSG: “Information: interface”;

3) interface: FLI; LSG: “Information: interface”;

4) interface: redundant on OLI; LSG: “Information: interface”.

The LSG “Calibration” could be implemented, for example, by SHII and DLI and all OLI of one sensor cluster.

Definition Need of logical signal group – <ordered list of interface(s)>

B.3.4 Source entities of a derived signal

This measure is related to the measures “Alternative value representation optimisation” (B.1.3) and “Link between interfaces” (B.3.1).

If it is necessary to reference entities on other lower interface levels to indicate that they have generated one or several signals, it is allowed to link the signals with these entities (see template LSG in Table B.1 and required template signals in Table B.2-Table B.5). Table B.1 provides a template LSG to reference detections of the DLIs. If the sensor as well as the sensor cluster provides different DLIs, the LSG must distinguish between the different DLIs (see 6.4).

This measure is defined in an additional profile subclause of the interface, for example, during the system design phase.

EXAMPLE A position of an entity on object level is defined by cartesian coordinates and is generated by multiple measurements on detection level in spherical coordinates from, for example, two camera sensing elements. The fusion unit can benefit, if it receives the underlying representation of the signal in a sensing element specific description.

Table B.1 — Template LSG for a signal “xxx” to reference source entities

Detections to generate signal “xxx”	O	Number of valid sensing elements which generate the signal “xxx” – Annex B.3.4 (Table B.2)	M	Optimise LL (B.1.1) Alternative UTL (B.1.6) Key: Number of valid serving sensors – Annex B.3.4 (Table B.3), Sensor ID reference – Annex B.3.4 (Table B.4)
		Size type: dynamic/fixed Size #: Number of valid sensing elements which generate the signal “xxx” – Annex B.3.4 (Table B.2)		
		Number of valid serving sensors – Annex B.3.4 (Table B.3)	O	Alternative VRO (B.1.3) a
		Size type: dynamic/fixed Size #: Number of valid serving sensors – Annex B.3.4 (Table B.3)		
		Sensor ID reference – Annex B.3.4 (Table B.4)	M	a
		Time stamp – measurement (A.1.5.2)	O	b

				Cycle counter (A.1.6.1)	O	Redundancy (B.1.2) Signal: Time stamp – measurement (A.1.5.2) b
				Detection ID reference – Annex B.3.4 (Table B.5)	M	

a Signals are required if the signal “Detection ID” (A.4.2) is not unique for different DLIs of the sensor cluster.

b Signals are required if the signal “Detection ID” (A.4.2) is not unique for different measurement cycles of the DLI.

Table B.2 Number of valid sensing elements which generate the signal “xxx” – Annex B.3.4

Name	Number of valid sensing elements which generate the signal “xxx” – Annex B.3.4		
Description	The signal “Number of valid sensing elements which generate the signal “xxx” – Annex B.3.4” (Table B.2) provides the number of valid sensing elements which provide detections to generate the signal “xxx”.		
Value type	[0…] integer value	**Unit**	1

Table B.3 Number of valid serving sensors – Annex B.3.4

Name	Number of valid serving sensors – Annex B.3.4		
Description	The signal “Number of valid serving sensors – Annex B.3.4” (Table B.3) provides the number of valid serving sensors to identify the DLI of a sensor or a sensor cluster.		
Value type	[0…] integer value	**Unit**	1

Table B.4 Sensor ID reference – Annex B.3.4

Name	Sensor ID reference – Annex B.3.4		
Description	The signal “Sensor ID reference – Annex B.3.4” (Table B.4) uniquely identifies a sensor of the sensor cluster.		
Value type	integer value	**Unit**	1

Table B.5 Detection ID reference – Annex B.3.4

Name	Detection ID reference – Annex B.3.4		
Description	The signal’s “Detection ID” (A.4.2) value defines the detection to which this detection is associated to; invalid = “no associated detection”. Additional information: Refers to a detection (for example, camera detection points) with the highest probability. Alternative A2I (B.3.2): The mapping of objects signal “Detection ID” (A.4.2) and detections signal “Detection ID reference – Annex B.3.4” (Table B.5) could be provided in a separate interface.		
Value type	[0…] integer value	**Unit**	1

B.4 Cross interface definition

Common definitions, which are valid for all interfaces of a sensor, are defined in this subclause.

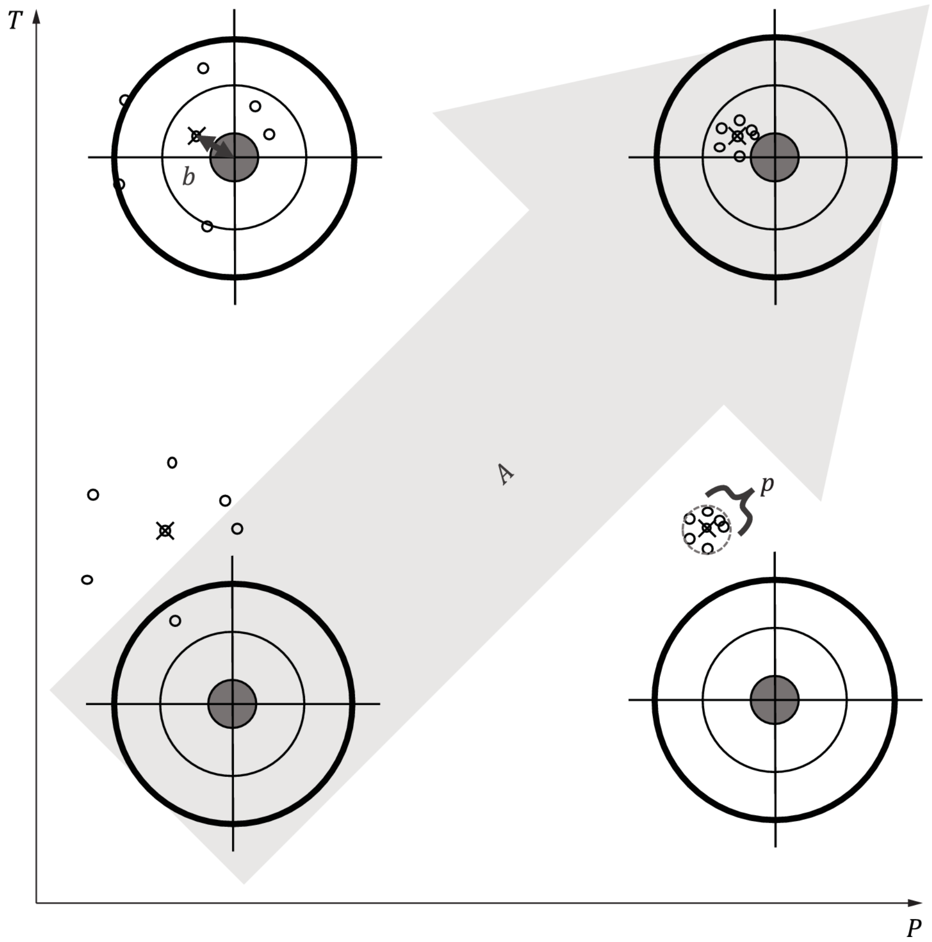
B.4.1 Error model implementation

Properties of an entity on detection level or on feature level might be measured. The measured signal includes measurement errors with causes such as sensor noise, quantisation effects, systematic offset, drifts and so forth.

Properties of an entity on object level might be tracked or predicted, calculated by the applied algorithms and includes tracking errors or prediction errors.

The challenge is to estimate the property's true value with the help of the observations. Therefore, the knowledge of the total sensor error, so called accuracy, is required for proper association of observations with the prediction or tracking of fusion models.

The error model (EM) can be a complex model which cannot be covered only by statistical data from current variations (see Figure B.1). Moreover, information to the trueness needs to be added to describe the sensor error. Trueness describes the average offset versus ground truth (so called bias) and requires a highly accurate reference system.



Key

T trueness axis: increasing trueness – less bias – less systematic errors

P precision axis: increasing precision – less precision error – less random errors

A accuracy: increasing accuracy – less uncertainty – less errors

b bias

p precision error

o values of a population (measured, tracked or predicted quantity value) average of values (reference quantity value)

reference value (true quantity value)

Figure B.1 — Error classes using four examples of populations

Trueness, precision and accuracy can be described by same statistical models.

Definition Implementation EM

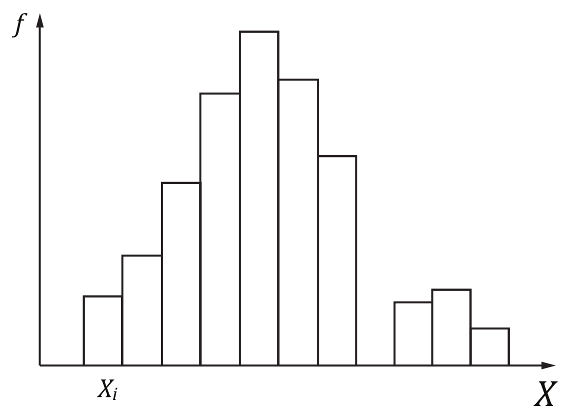
B.4.1.1 Statistic

When measuring (specifically historical values or blurred measurement), the user is interested in getting knowledge of a physical property. If a set of independent theoretical measurements of a specific physical property was performed with different or the same sensors, the sensor would not always obtain the same value for that property. Instead, the sensor would observe that the values are, in general, distributed to the measured objects true physical properties. Depending on the track modelling of the fusion unit corresponding error distribution description is best, for example, for a Kalman-filter based fusion a unimodality error distribution model is sufficient. However, high-resolution sensors provide usually a non-unimodal error distribution, also including dependencies to the type of object represented. Out of the measurements, which are denoted as the population as $\{x_1, \ldots, x_N\}$, a histogram can be built.

A histogram is a 2D plot in which the *X*-axis includes the values, or classes of values, representing the observed values of the population. Its *Y*-axis includes the frequency each value or class of values was observed (see Figure B.2). If sensors are good and measure a well-defined magnitude, it is expected that many values of the population appear close to a well-defined value or class. This behaviour is called central tendency. Since the sensor will not be perfect, the distance of the values of the population to the well-defined value or class will be different from measured, tracked or predicted population to population. This behaviour is called dispersion.

A histogram is used to approximate the theoretical population distribution from the values of the population, which corresponds to the process of obtaining values with that sensor. This population distribution would be useful in the computation of probabilities associated to some values of the population. The complete determination of the population distribution is impossible in practice, since infinite values of a population would be required.

The next subclauses propose different methods in order to define the value of a signal and the corresponding error value.



Key

f frequency-axis with frequency of values

X *X*-axis with values x_i of the population

Figure B.2 — Example for a histogram of a population

B.4.1.2 Signal values and associated signal error value calculation method

In order to assess the value of a signal and its associated error value from measured, tracked or predicted data, there are different possibilities to define statistical estimators for both quantities.

Depending on the definition of the mean average this statistical concept can be applied to precision statistics and as well to trueness statistics. For trueness statistics the reference for the mean value is the ground truth from a known reference system. Usually, series vehicles do not have additional equipment as reference system and therefore, the statistical mean can only refer to the mean of the acquired measurements or calculated trackings or predictions. In that case the statistical model provides only precision statistics without information to the sensor trueness.

B.4.1.2.1 Signal value as sample mean, signal error value as sample standard deviation

If it is assumed that the signal error value is independent of the current value of the physical property, then it makes sense to consider a population of N different values $\{x_1, \ldots, x_N\}$ and determine the signal value as the sample mean $\bar{x}$. Further, the signal error value can be determined as the sample standard deviation s (see Table B.6 and Figure B.3) or the normalised maximum likelihood s^2 (see Table B.6).

Table B.6 — Estimator names and formulas for the signal value and signal error value

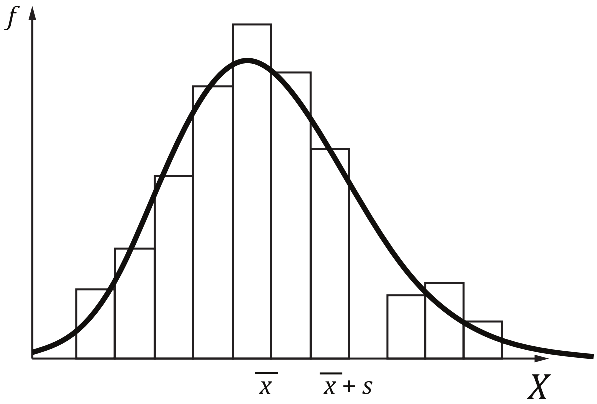
	Estimator name	Symbol and formula
Signal value	Sample mean	$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$
Signal error value	Sample standard deviation	$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}$
	Normalised maximum likelihood	$s^2 = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2$

Some other properties of these estimators can be summarised as:

— the sample mean does not necessarily coincide with a value of the population. It does not even need to be valid for a measurement, tracking or prediction;

— if the population distribution of the signal is assumed to be normal, the knowledge of $\bar{x}$ and s allows the computation of the probability of obtaining a sample within the interval $[\bar{x} - k \cdot s,\ \bar{x} + k \cdot s]$, for some positive number k;

— the presence of outliers can affect the computation of $\bar{x}$ and s. The statistician might have to eliminate suspicious samples before proceeding computations.



Key

f frequency-axis with frequency of values

X X-axis with values of the population

$\bar{x}$ sample mean

s sample standard deviation

Figure B.3 — Example for mean value and standard deviation value

B.4.1.2.2 Signal value as sample median, signal error value as sample interquartile range

Another method to define the signal value is to consider the sample median v of the N values of the population $\{x_1, \dots, x_N\}$ as signal values and let the sample interquartile range denote the signal error value.

In order to determine the sample median, the values of the population are firstly sorted in ascending order. If N is odd, the value x_j falling exactly in the middle of the sorted list is the sample median v ($j = \frac{N+1}{2}$). If N is even, there are different rules to determine the sample median. The sample median is also known as the 0,5-quantile. This means that the sample median is a value of the sample that it is greater than or exactly equal to the half [specifically ≤0,5-quantile ($Q_{0,5}$)] of the N sample values considered. Analogously, one can obtain any q -quantile Q_q as, for example, $Q_q = x_{\lfloor q \cdot N + 0,5 \rfloor}$.

In order to define the interquartile range IQR, the 0,25-quantile ($Q_{0,25}$) and the 0,75-quantile ($Q_{0,75}$) are determined using the same sorted list as before. The IQR (represented by symbol I_{QR}) is given by the formula $I_{\mathrm{QR}} = Q_{0,75} - Q_{0,25}$ (see Table B.7 and Figure B.4).

Table B.7 — Estimator names and formulas for the signal value and signal error value

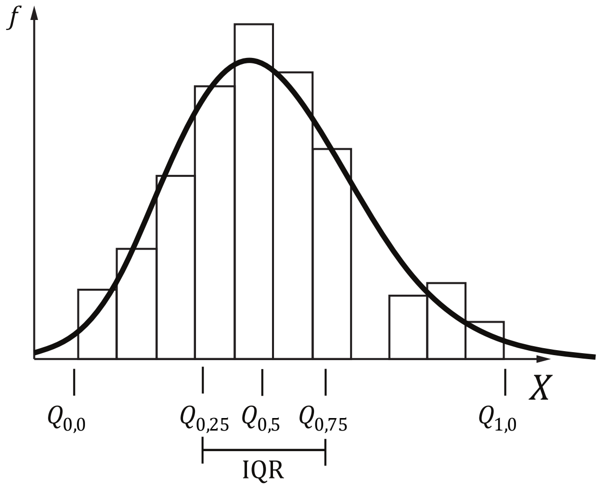
	Estimator name	Symbol and formula
Signal value	Sample median	$v = Q_{0,5}$
Signal error value	Sample interquartile range (IQR)	$I_{\mathrm{QR}} = Q_{0,75} - Q_{0,25}$

The median exhibits some convenient properties:

— if the formulas are used (see Table B.7), then the sample median v always corresponds to an observed value;

— if the population distribution of the signal is assumed normal, there will be a well-known relationship between the IQR and the probability of obtaining a sample within an interval of width IQR centred on the median (specifically $\left[Q_{0,5} - 0,5 \cdot I_{\mathrm{QR}}, Q_{0,5} + 0,5 \cdot I_{\mathrm{QR}}\right]$);

— both, $Q_{0,5}$ and the IQR are not affected by isolated outliers (specifically outline values are in the interval $\left[Q_{0,0}, Q_{0,25}\right[$ or in the interval $\left]Q_{0,75}, Q_{1,0}\right]$).



Key

f frequency-axis with frequency of values

X X-axis with values of the population

Figure B.4 — Example for quartiles, median value and IQR value

B.4.1.2.3 Signal value as sample mean vector, signal error value as sample covariances

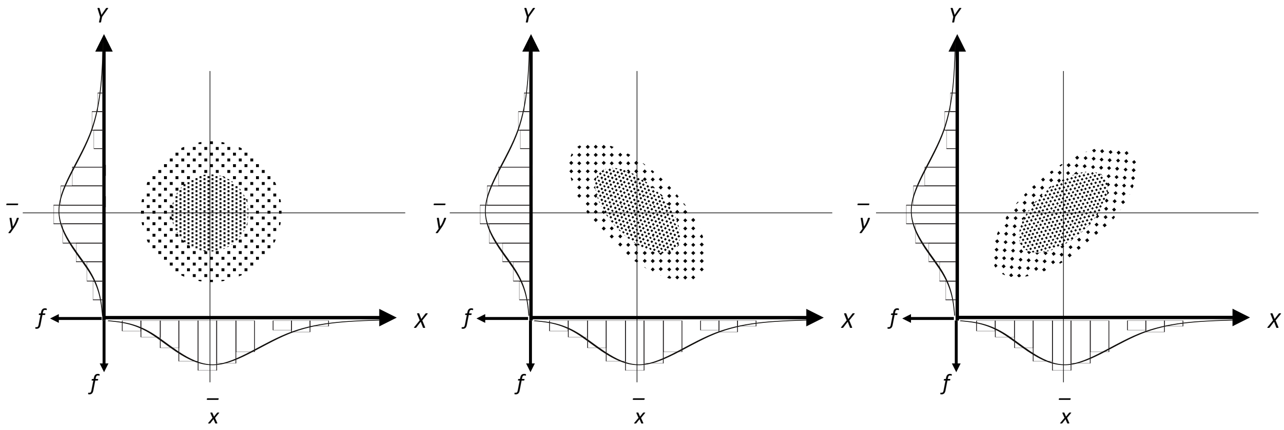
If it is assumed that the measurement error is independent of the actual value of the measured physical property, then it makes sense to consider N different measurements $\boldsymbol{F}_{\hat{x}} = [\hat{\boldsymbol{x}}_1, \hat{\boldsymbol{x}}_2, \ \ldots, \ \hat{\boldsymbol{x}}_N]$ where $\hat{\boldsymbol{x}}_i \in \mathbb{R}^M$ is a vector of M signals. From the series of N values of the population, a sample mean vector $\boldsymbol{\mu}_{\hat{x}}$ can be calculated. Further, the signal error can be determined as the sample covariance matrix $\boldsymbol{C}_{\hat{x}}$ (see Table B.8 and Figure B.5).

Table B.8 — Estimator names and formulas for the signal values and signal error values

	Estimator name	Symbol and formula
Signal values	Sample mean vector $\boldsymbol{\mu}_{\hat{x}}$ of N values of the population vectors $\hat{\boldsymbol{x}}_i$ composed each of M individual measurement signals	$\boldsymbol{\mu}_{\hat{x}} = \frac{1}{N} \boldsymbol{F}_{\hat{x}} \cdot \mathbf{1}$ where $\boldsymbol{\mu}_{\hat{x}} \in \mathbb{R}^M$, $\mathbf{1} = \{1\}^N$, $\hat{\boldsymbol{x}}_i \in \mathbb{R}^M$ and $\boldsymbol{F}_{\hat{x}} = [\hat{\boldsymbol{x}}_1, \hat{\boldsymbol{x}}_2, \ \ldots, \ \hat{\boldsymbol{x}}_N] \in \mathbb{R}^{MxN}$
Signal error values	Sample covariance matrix $\boldsymbol{C}_{\hat{x}}$ for N measurements described by measurement series $\boldsymbol{F}_{\hat{x}}$.	$\boldsymbol{C}_{\hat{x}} = \frac{1}{N-1} (\boldsymbol{F}_{\hat{x}} - \boldsymbol{\mu}_{\hat{x}} \cdot \mathbf{1}^T) \cdot (\boldsymbol{F}_{\hat{x}} - \boldsymbol{\mu}_{\hat{x}} \cdot \mathbf{1}^T)^T$ where $\boldsymbol{C}_{\hat{x}} \in \mathbb{R}^{MxM}$, $\mathbf{1} = \{1\}^N$, $\hat{\boldsymbol{x}}_i \in \mathbb{R}^M$ and $\boldsymbol{F}_{\hat{x}} = [\hat{\boldsymbol{x}}_1, \hat{\boldsymbol{x}}_2, \ \ldots, \ \hat{\boldsymbol{x}}_N] \in \mathbb{R}^{MxN}$

EXAMPLE 2x2 covariance matrix for signals x, y: $\boldsymbol{C}_{\begin{bmatrix} x \\ y \end{bmatrix}} = \begin{pmatrix} \sigma_x^2 & \sigma_{xy} \\ \sigma_{yx} & \sigma_y^2 \end{pmatrix}$. Non-diagonal elements are symmetrical.

Figure B.5 shows the XY-distribution of, for example, measurement points and the related covariance σ_{xy} range.



a) covariance value is zero b) covariance value is negative c) covariance value is positive

Key

f frequency-axis with frequency of values of the measured *X* or *Y*

X *X*-axis with values of the population *X*

Y *Y*-axis with values of the population *Y*

Figure B.5 — Example for mean values and covariance values of a population with two signals x and y

B.4.1.2.4 Customised error value calculation method

The error value calculation method(s) shall be defined during the system design phase and applies to the sensor's interfaces.

B.4.1.3 Error value classification method

Error values can have different sources. If the error value can be divided into classes, the contribution of each class may be estimated. The error signal RL and the error model define the RL information for the error values according to the corresponding signal or signal's identifiers. The RL for additional error values, for example, correlated values or additional classes, of the error model will be defined in the following classification method.

B.4.1.3.1 Unspecific error value

The error value is not further specified and subdivided. One error value calculation method, for example, for accuracy of the error is used (see Figure B.1) and may include systematic and random errors.

The error signal's RL defines the requirements upon this error value.

B.4.1.3.2 Multiple error value types

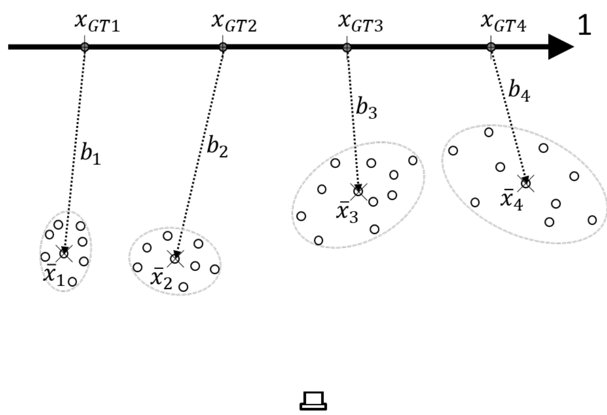
For each signal-value there are two error values of different sources. One describes the precision error and the other describes the bias (see Figure B.1). Both error sources, each characterised by a class, are calculated with the same error calculation method (see B.4.1.2). The bias calculation method requires an association of measurements between different observations. In case objects or features are classified, this can usually be calculated.

The trueness bias value may be subdivided due to different sources (for example, sensor error, calibration error, coordinate transformation error) and the specific amount of the bias for each class is transferred by separated error values.

The error signal's RL defines only the requirements for option "Unspecific error value" (B.4.1.3.1). All error classes of this method are affected by the defined RL in the same way.

EXAMPLE A signal "Position {x, y, z} – error" has the default RL {M, M, O}. A sensor with error model option "Multiple error value types" (B.4.1.3.2) implements two error signals: "Position – bias {x, y, z}" with RL {M, M, O} and "Position – precision error {x, y, z}" with RL {M, M, O}.

Trueness bias values may be constant, for example, the calibration data to ground truth (see Figure B.6). Therefore, the trueness bias values may not be transmitted every cycle [see optimisation "Implicit values" (B.1.5) and "Alternative value representation optimisation" (B.1.3) – see Figure B.7] and therefore, the trueness bias values may be stored in the fusion unit.



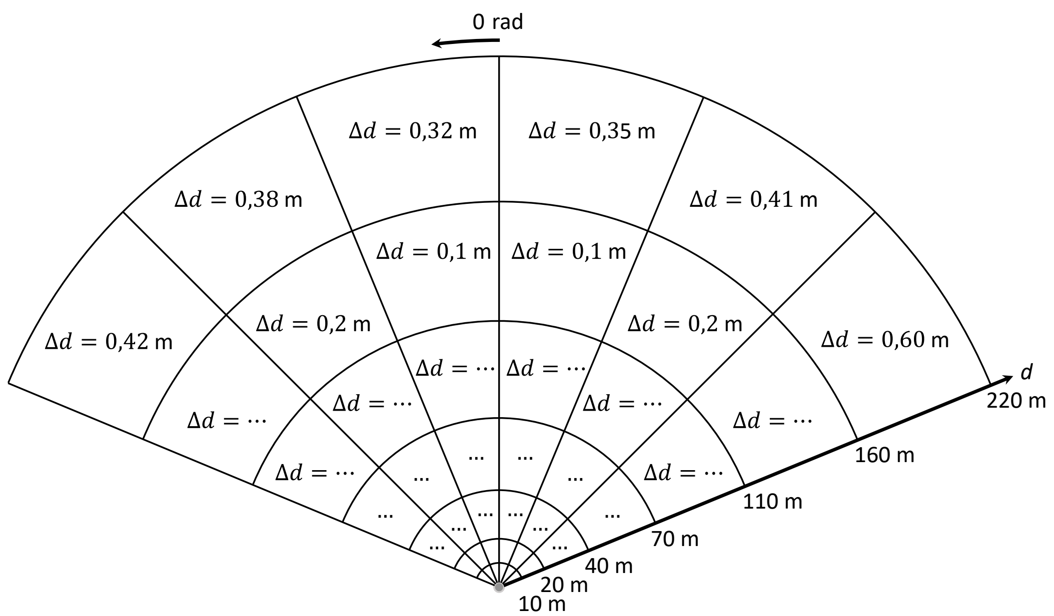
Key

x_{GT} ground truth reference point

$\bar{x}$ signal value of the measurement population of a reference point

b bias of a reference point

Figure B.6 — Example for calibration data of the sensor



Key

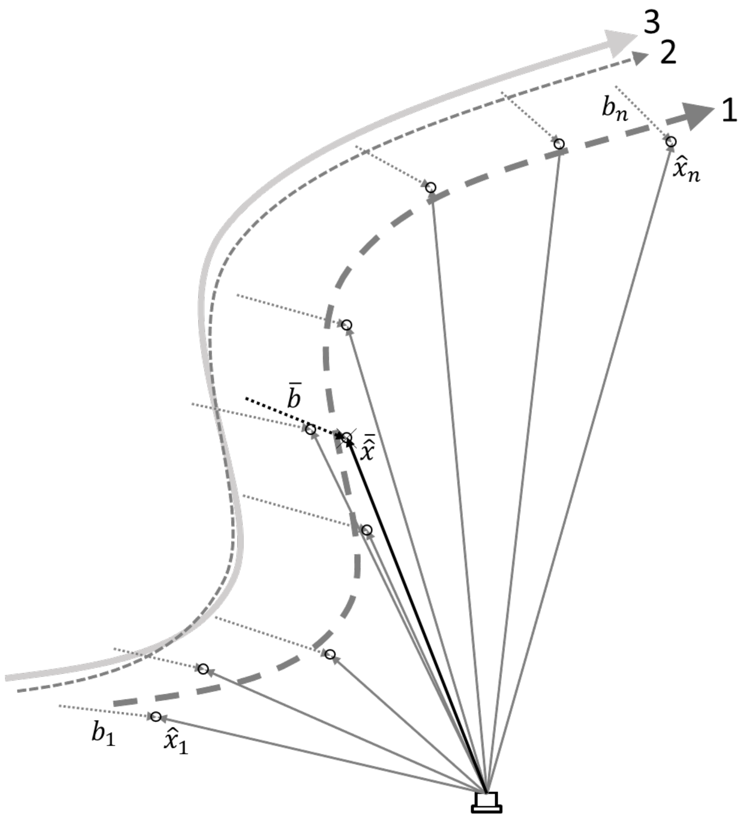
d radial distance of a sensor coordinate system

Δd error value of the radial distance d in a FOV segment

Figure B.7 — Example for field of view segmentation of static trueness bias values (Δd of segments) in sensor coordinate system

B.4.1.3.3 Multi measurement cycle error values

For each signal-value the error model may regard values from more than one measurement cycle to include a time series of the signal, for example, the history of x cycles of a measurand. The error model may provide two error signals on the interface, one for the time series signal value and one for the time series error value. As example, the residual error of a signal with the mean value as signal value, which may be zero, and the covariance matrix of the signal as error value (see Figure B.8). The RL for both signals is the same as defined for the error value signal of the interface.



Key

1 interpolated path of the values

2 interpolated path of the values without bias

3 ground truth path

$\hat{x}$ value of a time series

b bias of a signal value

$\bar{\hat{x}}$ value for the time series, for example, mean value

$\bar{b}$ bias for the time series, for example, mean value

Figure B.8 — Example of time series bias and values

B.4.1.3.4 Variant and covariant error values

Independent error values (specifically independent of other signal values) are calculated and error values that are dependent upon other error values are calculated too. For this purpose, variances for the independent error values and covariances for the dependent error values are used.

NOTE The covariance matrix is a symmetric, positive defined matrix.

The error signal's RL defines only the requirements for option "Unspecific error value" (B.4.1.3.1). This RL will define the requirements for the variances. Covariances are always optional.

EXAMPLE 1 A signal "Position {x, y, z} – error" has the RL {M, M, O}. A sensor with error model option "Variant and covariant error values" (B.4.1.3.4) implements one error signal: "Position $\begin{Bmatrix} xx & xy & xz \\ yx & yy & yz \\ zx & zy & zz \end{Bmatrix}$ – error" with RL $\begin{Bmatrix} M & O & O \\ O & M & O \\ O & O & O \end{Bmatrix}$.

EXAMPLE 2 For OLIs the sensor signal of the object originates from the internal tracker which provides the state vector and enriches data additional with, for example, classification. The uncertainty of the state vector is described by the state covariance matrix. The state vector $\hat{\boldsymbol{x}}_{\boldsymbol{i}}$ depends on a small amount of historic data.

EXAMPLE 3 The knowledge of the residual error, in terms of the mean deviation, is also essential for a fusion unit. The evaluation of the residual error requires additional high quality reference data systems. Therefore, sensors can only be characterised in, for example, reference test setups for a selected parameter set which was tested. Processing of these test data and additional modelling supports building an enhanced sensor error model which can be later (during run-time) used as look-up table for calculating associated residual error range as covariance matrix. Since a fixed look-up table is used this residual error is usually stored in the fusion unit and not transmitted via sensor interface. An ideal tracking system is considered to have residual errors which are zero.

EXAMPLE 4 Additional information about precision can also be provided as covariance matrix. From time series covariances are calculated by using the mean error of a time series (see B.4.1.3.3).

EXAMPLE 5 In most system and sensor setups a combination of residual error information (allocated in the fusion unit) and state covariance (allocated in the sensor) is useful (see Table B.9). The error model will be defined during the system design phase.

Table B.9 — Error model with different covariances

	Trueness error value or static error value (see B.4.1.3.2)	**Precision error value or dynamic error value** (see B.4.1.3.2)
One measurement cycle (small amount of history)/one static value [default]	The error value is, for example, the value of the sensor's calibration with a reference system. For example, the static bias $\boldsymbol{b}_{\boldsymbol{i}}$, for the current state vector $\hat{\boldsymbol{x}}_{\boldsymbol{i}}$ and the cycle *i*.	The error value is, for example, a covariance matrix for the state vector $\hat{\boldsymbol{x}}_{\boldsymbol{i}}$ for the cycle *i.*
Multi measurement cycles (see B.4.1.3.3)	The error value is the residual error, for example, of the biases for a state vector time series $i \in [1, \dots, \quad N]$. Signal value: Current state vector $\hat{\boldsymbol{x}}_{\boldsymbol{i}}$ Population of the time series:	The error value is the precision error, for example, of the statistic error of a state vector time series $i \in [1, \dots, \quad N]$. Signal value: Current state vector $\hat{\boldsymbol{x}}_{\boldsymbol{i}}$

	$\mathbf{F}_{\boldsymbol{e}} = [\boldsymbol{e}_1, \boldsymbol{e}_2, \ \ldots, \ \boldsymbol{e}_N]$ for example, the bias $\boldsymbol{b}_i$ as $\boldsymbol{e}_i$ Signal value of the time series: $\boldsymbol{\mu}_{\boldsymbol{e}} = \frac{1}{N} \sum_{i=1}^{N} \boldsymbol{e}_i$ Signal error value of the time series: $\boldsymbol{C}_{\boldsymbol{e}} = \frac{1}{N-1} (\boldsymbol{F}_{\boldsymbol{e}} - \boldsymbol{\mu}_{\boldsymbol{e}} \cdot \mathbf{1}^T) \cdot (\boldsymbol{F}_{\boldsymbol{e}} - \boldsymbol{\mu}_{\boldsymbol{e}} \cdot \mathbf{1}^T)^T$	Population of the time series: $\mathbf{F}_{\widehat{\boldsymbol{x}}} = [\widehat{\boldsymbol{x}}_1, \widehat{\boldsymbol{x}}_2, \ \ldots, \ \widehat{\boldsymbol{x}}_N]$ for example, the state vector $\widehat{\boldsymbol{x}}_{\boldsymbol{i}}$ Signal value of the time series: $\boldsymbol{\mu}_{\widehat{\boldsymbol{x}}} = \frac{1}{N} \sum_{i=1}^{N} \widehat{\boldsymbol{x}}_i$ Signal error value of the time series: $\boldsymbol{C}_{\widehat{\boldsymbol{x}}} = \frac{1}{N-1} (\boldsymbol{F}_{\widehat{\boldsymbol{x}}} - \boldsymbol{\mu}_{\widehat{\boldsymbol{x}}} \cdot \mathbf{1}^T) \cdot (\boldsymbol{F}_{\widehat{\boldsymbol{x}}} - \boldsymbol{\mu}_{\widehat{\boldsymbol{x}}} \cdot \mathbf{1}^T)^T$
	where $\boldsymbol{\mu}_{\boldsymbol{e}}, \boldsymbol{\mu}_{\widehat{\boldsymbol{x}}} \in \mathbb{R}^M$, $\mathbf{1} = \{1\}^N$, $\boldsymbol{b}_{\boldsymbol{i}}, \boldsymbol{e}_{\boldsymbol{i}}, \widehat{\boldsymbol{x}}_{\boldsymbol{i}} \in \mathbb{R}^M$, $\boldsymbol{F}_{\boldsymbol{e}}, \boldsymbol{F}_{\widehat{\boldsymbol{x}}} \in \mathbb{R}^{MxN}$ and $\boldsymbol{C}_{\boldsymbol{e}}, \boldsymbol{C}_{\widehat{\boldsymbol{x}}} \in \mathbb{R}^{NxN}$	

B.4.1.3.5 Cross-covariant error values

Sensor measurement physical principles and algorithm dependencies in the calculation of sensor output signals, as well as tracking algorithms and related motion models introduce cross-signal dependencies. Quality of fusion and tracking systems benefits from knowledge of such cross-signal dependencies. A measure for these cross-signal dependencies is the calculation of cross-covariances. To provide cross-covariances between two or more signals the interface shall provide additionally cross-covariance signals of these signals. Additional signals may be grouped in a separate LSG for these cross-covariances.

NOTE 1 An interface can provide different covariant error values for one signal (see B.4.1.3.4, EXAMPLE 5 and Table B.9).

Cross-covariances could be provided for signals on the same nesting level of an interface or for signal depending on signals on outer nesting levels.

NOTE 2 The (cross-)covariance matrix is a symmetric, positive defined matrix.

EXAMPLE 1 The signal "Position {x, y, z} – error" and the signal "Velocity {x, y, z} – error" are on the same nesting level of an interface (for example, PMOI). A sensor with error model option "Cross-covariant error values" (B.4.1.3.5) can provide additional optional signals "Position {x, y, z} Velocity {x, y, z} – error" to provide the cross-covariances of the position and the velocity error.

EXAMPLE 2 It is possible that the signal "Person pose {yaw, pitch, roll} – error" and the signal "Orientation {yaw, pitch, roll} – error" are on the different nesting levels of an interface because a sensor can provide several person's poses on one nesting level and the orientation of the entity on an outer nesting level (for example, PMOI). A sensor with error model option "Cross-covariant error values" (B.4.1.3.5) can provide on the most inner nesting level for each person pose additional optional signals "Person pose {yaw, pitch, roll} Orientation {yaw, pitch, roll} – error" to provide the cross-covariances of each specific person pose and the common orientation of the potentially moving object "person".

B.4.1.3.6 Customised error value classification method

The semantic partitioning of the error values shall be defined during the system design phase.

The RL defines only the requirements for option "Unspecific error value" (B.4.1.3.1). Customised error value classes are affected on a defined way which is defined by the sensor manufacturer during the system design phase.

Bibliography

[1] ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

[2] ISO/IEC 2382:2015, *Information technology — Vocabulary*

[3] ISO 3864-1:2011, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

[4] ISO 5725-1:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*

[5] ISO 6707-1:2020, *Buildings and civil engineering works — Vocabulary — Part 1: General terms*

[6] ISO 8855:2011, *Road vehicles — Vehicle dynamics and road-holding ability — Vocabulary*

[7] ISO 15007:2020; *Road vehicles — Measurement and analysis of driver visual behaviour with respect to transport information and control systems*

[8] ISO/IEC 11179-3:2023, *Information technology — Metadata registries (MDR) — Part 3: Metamodel for registry common facilities*

[9] ISO 11270:2014, *Intelligent transport systems — Lane keeping assistance systems (LKAS) — Performance requirements and test procedures*

[10] ISO/SAE PAS 22736:2021, *Intelligent transport systems — Taxonomy and definitions for terms related to driving automation systems for on-road motor vehicles*

[11] ISO 80000-1:2009/COR 1:2011, *(E), Quantities and units — Part 1: General*

[12] ISO 80000-2:2019, *Quantities and units — Part 2: Mathematics*

[13] SAE J3016_*201806, Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles*

[14] SHEPARD, Frank D., *Reduced visibility due to fog on the highway*. Transportation Research Board, 1996.

[15] PAULAT, Marcus, et al., *A gridded dataset of hourly precipitation in Germany: Its construction, climatology and application*. Meteorologische Zeitschrift, 2008, edition 17. number 6, pages 719-732.

[16] SCHNEIDER, R., *Modellierung der Wellenausbreitung für ein bildgebendes Kfz-Radar*, Dissertation, University of Karlsruhe, May 1998.

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Copyright in BSI publications

All the content in BSI publications, including British Standards, is the property of and copyrighted by BSI or some person or entity that owns copyright in the information used (such as the international standardization bodies) and has formally licensed such information to BSI for commercial publication and use.

Save for the provisions below, you may not transfer, share or disseminate any portion of the standard to any other person. You may not adapt, distribute, commercially exploit or publicly display the standard or any portion thereof in any manner whatsoever without BSI's prior written consent.

Storing and using standards

Standards purchased in soft copy format:

- A British Standard purchased in soft copy format is licensed to a sole named user for personal or internal company use only.
- The standard may be stored on more than one device provided that it is accessible by the sole named user only and that only one copy is accessed at any one time.
- A single paper copy may be printed for personal or internal company use only.

Standards purchased in hard copy format:

- A British Standard purchased in hard copy format is for personal or internal company use only.
- It may not be further reproduced – in any format – to create an additional copy. This includes scanning of the document.

If you need more than one copy of the document, or if you wish to share the document on an internal network, you can save money by choosing a subscription product (see 'Subscriptions').

Reproducing extracts

For permission to reproduce content from BSI publications contact the BSI Copyright and Licensing team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member.**

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email cservices@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Useful Contacts

Customer Services
Tel: +44 345 086 9001
Email: cservices@bsigroup.com

Subscriptions
Tel: +44 345 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.