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

Part 1: General information and principles

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

Partie 1: Informations générales et principles

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Foreword

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

This first edition of ISO 23150-1, together with ISO 23150-2 [1], ISO 23150-11 [2], ISO 23150-12 [3], ISO 23150-13 [4], ISO 23150-14 [5], ISO 23150-15 [6] and ISO 23150-20 [7], cancels and replaces ISO 23150:2023, which has been technically revised.

The main changes are as follows:

— This document forms a structural revision of ISO 23150:2023 and replaces mainly Clauses 1 to 6 and Annex B.

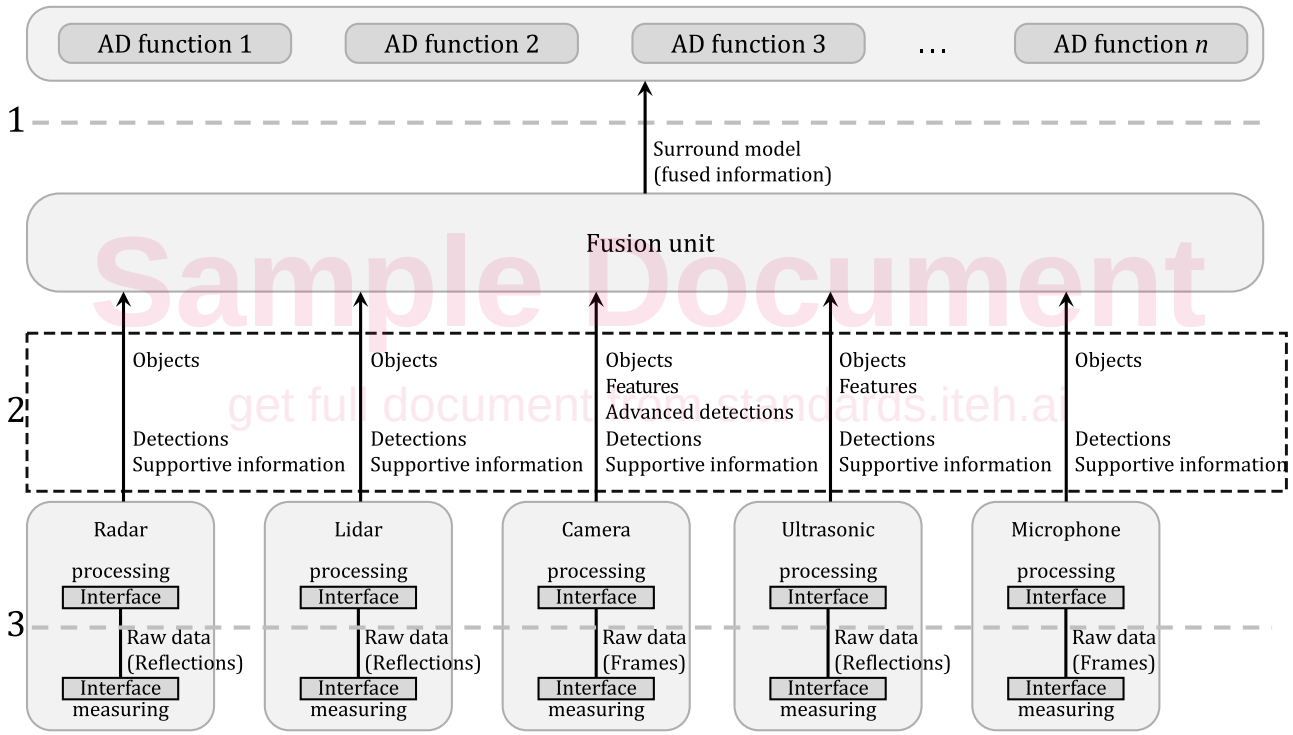
A list of all parts in the ISO 23150 series can be found on the ISO website.

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

Introduction

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

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

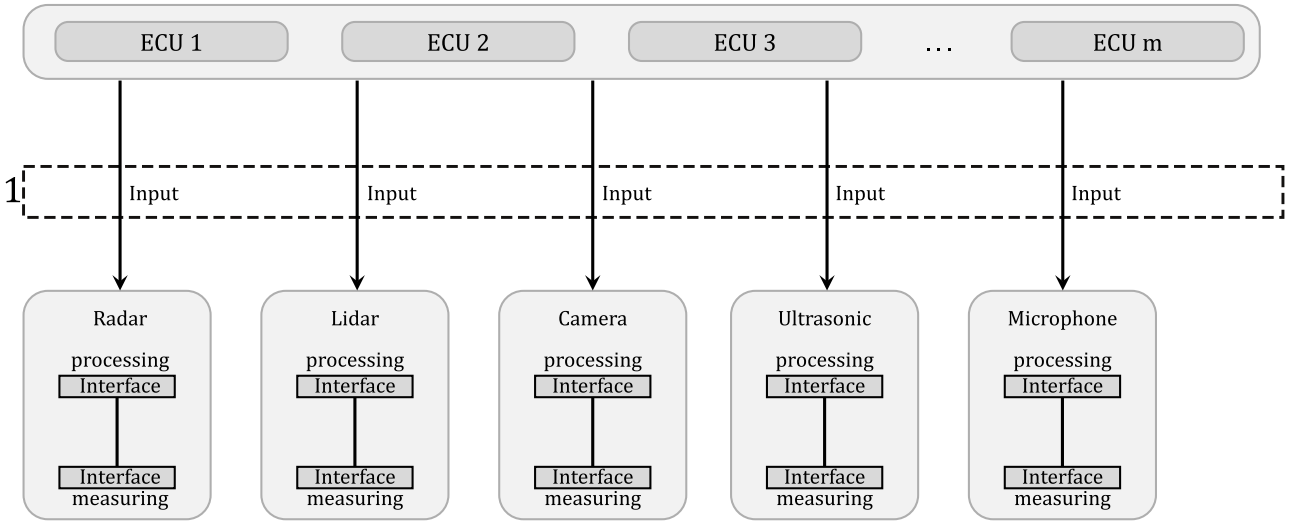


Key

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

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

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



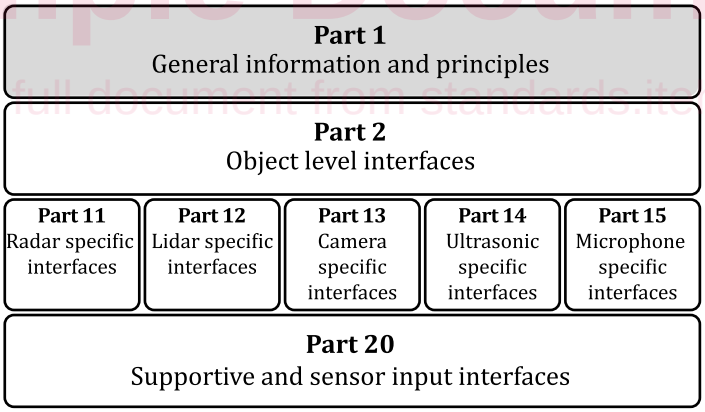
Key

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

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

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

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



Key

Scope of this document

Figure 3 — Relationship of the ISO 23150 series

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

Part 1: General information and principles

1 Scope

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

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

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

2 Normative references

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 [8], 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
advanced detection
sensor technology specific entity represented in the *sensor coordinate system* (3.7.18) based on multiple *measurements* (3.4.5) of a *sensor* (3.1.5)

Note 1 to entry: Multiple measurements can originate from multiple *measurement cycles* (3.4.1).

3.2.4
advanced detection level
set of *logical interfaces* (3.1.4) that provides *advanced detections* (3.2.3)

3.2.5
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 [9].

3.2.6
feature level
set of *logical interfaces* (3.1.4) that provides *features* (3.2.5)

3.2.7
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* (3.6.6), a *free-space object* (3.6.13).

3.2.8
object level
set of *logical interfaces* (3.1.4) that provides *objects* (3.2.7)

3.2.9
recognition
representation of a recognized entity on *object level* (3.2.8), *feature level* (3.2.6), *advanced detection level* (3.2.4) or *detection level* (3.2.2)

3.2.10
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 [10], 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 value (3.4.3)s* 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 ISO 5725-1:2023 [11].

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 [10], 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) s* or *predicted quantity value (3.4.4)s* 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 5725-1:2023 [11]).

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 [10], 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 [10], 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 [12], 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 [13], 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 [13], 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 [13], 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 signal group* (3.3.2) a *signal* (3.3.1) as well as the signal's identifiers or a signal's enumerators

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).

Note 2 to entry: The requirement level of a logical signal group or a signal as well as the signal's identifiers are defined in the *logical interfaces* (3.1.4).

Note 3 to entry: No default requirement level is defined for signal enumerators of an exemplary enumerator list. The requirement level is specified during the system design phase. Enumerators of mandatory enumerator lists are mandatory.

3.5.5
system design
process of defining the hardware and software architecture, components, modules, interfaces and data for a system to satisfy specified requirements

[SOURCE: ISO/IEC 2382:2015 [8], modified — Note to entries have been removed.]

3.6 Road user relevant entity types

3.6.1
potentially moving object
real-world entity which can potentially move and is relevant for driving situations

Note 1 to entry: A representation of a potentially moving object is part of *logical interfaces* (3.1.4) on *object level* (3.2.8).

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 interface (3.1.4)s* on *object level* (3.2.8).

EXAMPLE A *road marking* (3.6.3), a *road boundary* (3.6.4), the *road surface* (3.6.5).

3.6.3
road marking
line, symbol or other mark on the surface of a road or a structure intended to limit, regulate, warn, guide or inform road users

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

EXAMPLE A lane marking, Botts' dots.

[SOURCE: ISO 6707-1:2020 [14], 3.3.5.80, modified — "user" was modified to "road users", "limit" was added and the Note 1 to entry and EXAMPLE have been added.]

3.6.4
road boundary
structure that limits the road

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