FINAL DRAFT

INTERNATIONAL STANDARD

ISO/FDIS 23150

ISO/TC **22**/SC **31**

Secretariat: **DIN**

Voting begins on:
2023-03-01

Voting terminates on:
2023-04-26

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/FDIS 23150:2023(E)

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Foreword

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

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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 interface level – 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;

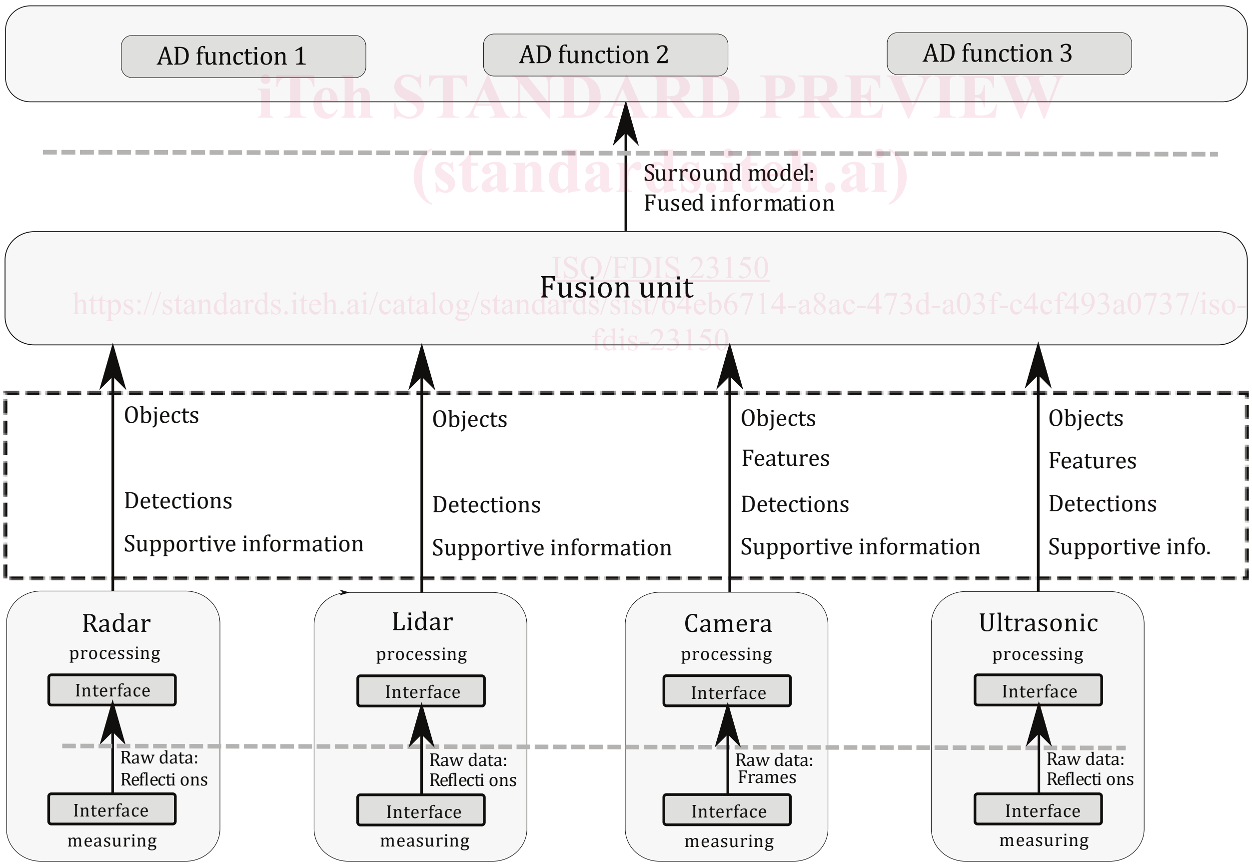
— update and add figures for clarification.

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

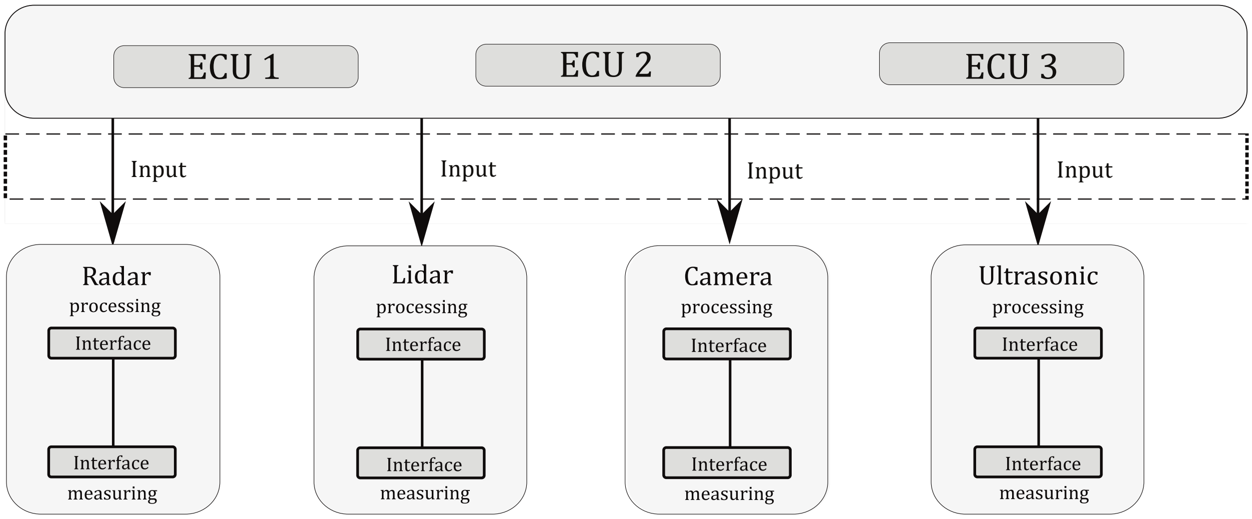
1 logical interface layer between the fusion unit and AD functions

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