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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

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Foreword

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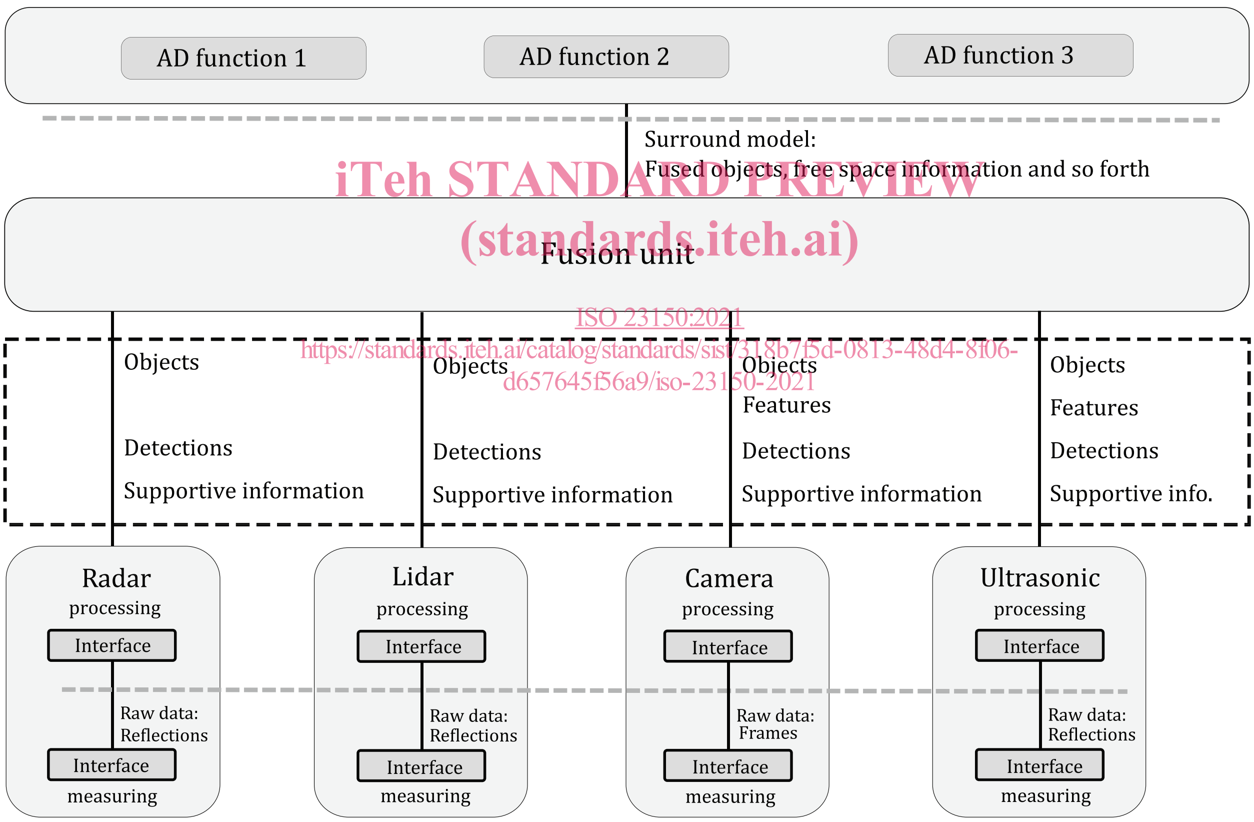
This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 31, *Data communication*.

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 a, preferably, 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 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 is worthwhile and beneficial for both the sensor and the system supplier.



Key

1 logical interface layer between the fusion unit and automated driving 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

Figure 1 — Architecture: sensors/sensor clusters – fusion unit – automated driving functions

The logical interface layer between a single sensor as well as a single sensor cluster and the fusion unit [see key 2 in Figure 1] addresses the encapsulation of technical complexity as well as objects, 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.

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 terminological 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 preprocessing 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 a common *logical interface* (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

3.2 Level of detail terms

3.2.1
detection
sensor technology specific entity represented in the *sensor coordinate system* (3.7.18) based on a single *measurement* (3.4.1) 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* (3.4.1)

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* (3.4.2).

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[1)].

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

1) Under preparation. Stage at the time of publication: ISO/SAE DPAS 22736:2021.

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).

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

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
measuring and processing result of a *measurement cycle* (3.4.2)

3.4.2
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.

3.4.3
accuracy
closeness of agreement between a measured quantity value and a true quantity value

Note 1 to entry: The concept accuracy is not a quantity and is not given a numerical quantity value. A *measurement* (3.4.1) is said to be more accurate when it offers a smaller *error* (3.4.6).

Note 2 to entry: The term accuracy should not be used for *trueness* (3.4.4) and the term *precision* (3.4.5) 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 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 and the Notes to entry have been adapted.]

3.4.4
trueness
closeness of agreement between the average of an infinite number of replicated measured quantity values and a reference quantity value

Note 1 to entry: Trueness is not a quantity and thus cannot be expressed numerically, but measures for closeness of agreement are given in the ISO 5725 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* (3.4.3) 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 and the Notes to entry have been adapted.]

3.4.5
precision
closeness of agreement between indications or measured quantity values obtained by replicate *measurements* (3.4.1) on the same or similar measurands under specified conditions

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

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 repeatability, intermediate measurement precision and measurement reproducibility.

Note 4 to entry: Sometimes precision is erroneously used to mean *accuracy* (3.4.3).

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”, the Notes to entry have been adapted and Note 5 to entry has been added.]

3.4.6
error
measured quantity value minus a reference quantity value

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

Note 2 to entry: a) when there is a single reference quantity value to refer to, which occurs if a calibration is made by means of a measurement standard with a measured quantity value having a negligible measurement uncertainty or if a conventional quantity value is given, in which case the error is known, and

Note 3 to entry: 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 4 to entry: Error should not be confused with production error or mistake.

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

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 11179-3:2013, 3.2.22, modified — Notes to entry have been adapted.]

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 11179-3:2013, 3.2.71, modified — Notes to entry have been adapted.]

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 11179-3:2013, 3.2.89, modified — Notes to entry have been adapted.]

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 potentially can move and is relevant for driving situations

Note 1 to entry: A representation of a potentially moving object is part of *object level* (3.2.6) *logical interfaces* (3.1.4).

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 *object level* (3.2.6) *logical interfaces* (3.1.4).

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", “a road surface” was modified to “the surface of a road” 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 *object level* (3.2.6) *logical interfaces* (3.1.4).

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

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* (3.6.3.3) 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 light
traffic relevant, official lights

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

EXAMPLE A pedestrian traffic light.

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 three orthogonal directions associated with *X*, *Y* and *Z* axes

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

[SOURCE: ISO 8855:2011, 2.3, modified — Notes to entry have been adapted.]

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

3.7.5
spherical coordinate system
set of two angles and a distance vector associated with radial distance, azimuth and elevation

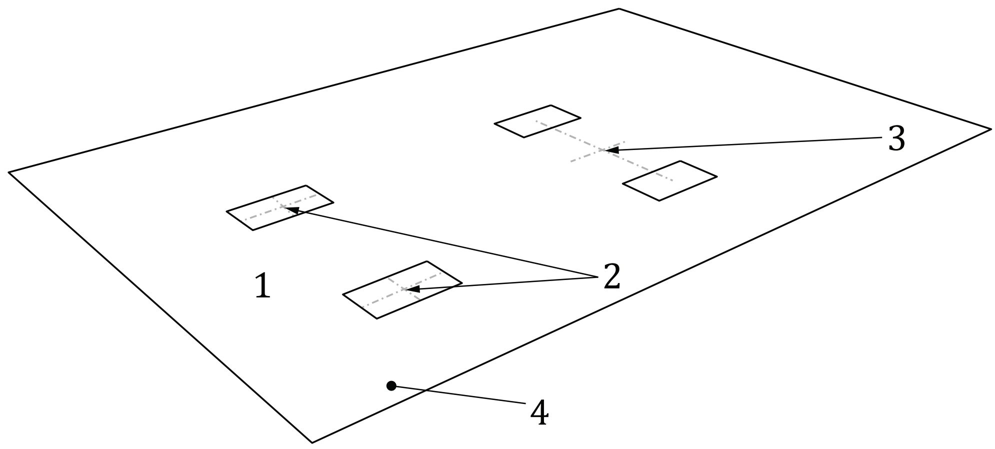
Note 1 to entry: The azimuth angle is the angle in *XY*-plane of the *axis system* (3.7.2) counted from the *X*-axis. The elevation angle is the angle from the azimuth direction in the *XY*-plane of the axis system towards the direction of the distance vector, that is *XY*-plane has an elevation angle = 0 rad.

Note 2 to entry: The angles of the spherical coordinate system have increasing values in counter-clockwise 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 2.

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



Key

1 vehicle front

2 vehicle's front tyre contact patches

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

4 vehicle *road plane* (3.7.6)

Figure 2 — Road plane

[SOURCE: ISO 8855:2011, 2.7, modified — The phrase "and the vehicle road-level reference point" and the figure have 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.]

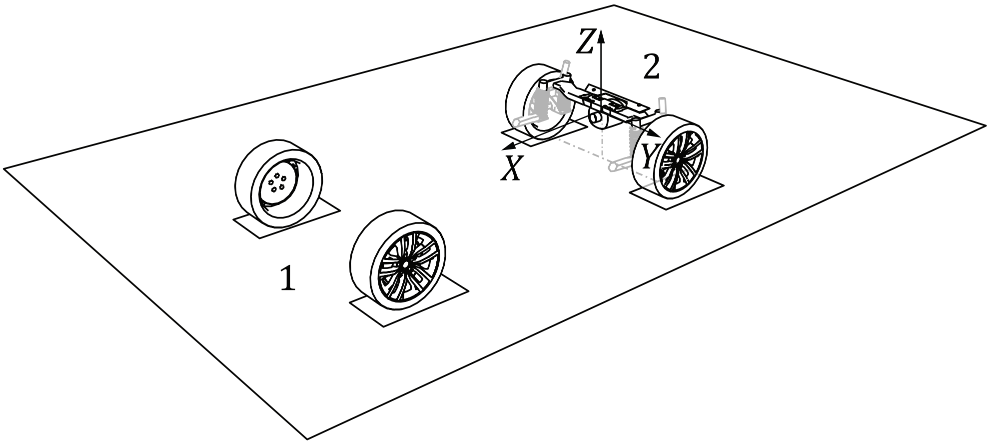
3.7.10
vehicle rear-axle reference point
point fixed in the *vehicle sprung mass* (3.7.9) and located at the centre of the rear-axle

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, 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

3.7.12
vehicle rear-axle coordinate system
coordinate system (3.7.3) 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 3.



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

Figure 3 — 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).

3.7.15
vehicle road-level coordinate system
coordinate system (3.7.3) 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 4.