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Road vehicles — Test scenarios for automated driving systems - Scenario categorization

*Véhicules routiers — Scénarios d'essai pour les systèmes de conduite
automatisée — Catégorisation des scénarios*

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 33, *Vehicle dynamics, chassis components and driving automation systems testing*.

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Introduction

Test and verification of Automated Driving Systems (ADS) is one of the main challenges for the introduction of ADS into the market. Scenario-based testing is an approach for prospective verification of ADS that is broadly supported by the automotive field. It is expected that many test scenarios will be used to conduct the validation and verification of ADS, e.g. see ISO 34502. It is common practice to use some form of categorization of the scenarios.

The goal of this document is to propose a way to categorize scenarios. Scenario databases, such as the German In-Depth Accident Study (GIDAS)^[2], the Community database on Accidents on the Roads in Europe (CARE)^[3], the Initiative for the GLobal harmonization of Accident Data (IGLAD)^[4], road safety from the government of the United Kingdom^[5], and the National Automotive Sampling System (NASS) General Estimates System (GES) from the United States^[6], already contain categories, but these categories are generally not shared among different databases. This document provides a method to harmonize the way scenarios are categorized. To enable the scenario categorization, “tags” are defined as a meta-attribute that provides an additional source of information for each of the scenarios. A scenario category is defined using tags, such that all scenarios that share the same tags are considered to belong to that scenario category.

NOTE This document does not provide a hierarchical structure for the scenarios. There are infinitely many ways to provide a hierarchical structure and there is no best way to do this. For example, scenarios can be structured based on the road layout or based on the driving behaviour of a vehicle. The most suitable way to structure the scenarios depends on the application.

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Road vehicles — Test scenarios for automated driving systems - Scenario categorization

1 Scope

This document defines an approach for the categorization of the scenarios by providing tags that carry information about the scenarios.

This document is applicable to SAE level 3 to SAE level 5 Automated Driving System (ADS)^[19].

2 Normative references

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

ISO 34501, *Road vehicles — Test scenarios for automated driving systems — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 34501 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 <https://www.electropedia.org/>

4 Categorization

4.1 Objectives

The objective of this clause is to provide a way to categorize scenarios.

4.2 General

A scenario category refers to a set of scenarios that share one or more characteristics. Tags are attached to a scenario for the purpose of categorizing the scenarios. A given scenario is part of a scenario category if all tags of the scenario category are also part of the tags that are applicable to the given scenario. Scenario categories do not need to be mutually exclusive. A standardized set of tags for defining scenario categories makes sharing and transferring scenario (categories) between different entities easier.

Scenario categorization can be used to structure the test cases for ADS. Another application of scenario categorization is the scenario assignment for the assessment of ADS within a given Operational Design Domain (ODD) because it might be easier to relate an ODD to scenario categories instead of relating an ODD to all possible scenarios. Scenario categorization can also be used to select scenarios from a scenario database or scenario library by using tags or a combination of tags.

In some cases, there is a need of having generic scenario categories – and thus a wide variety among the scenarios belonging to the scenario category – and, in other cases, there is a need of having specific scenario categories without much variety among the scenarios in the scenario category. For some systems, one may be interested in very specific set of scenarios, while for another system one might

be interested in a set of scenarios with a high variety. To accommodate this, tags can be structured in hierarchical trees. The different layers in a tree can be regarded as different abstraction levels.

If the provided tags do not adequately represent a specific characteristic of a scenario, stakeholders may extend the provided tags. These may be tags that provide a more specific description of a characteristic described by one of the tags of this clause. This may also be tags that describe a characteristic of a scenario that is not addressed in this document.

The actual implementation of the tags into a specification is out of scope of this document. Stakeholders may choose to support, for example, scenario hierarchy whereby a specific scenario (category) inherits tags from another scenario (category). It is also possible to combine tags of the same level to create a new scenario category, e.g. a definition of a scenario category that includes the wind tag “light breeze”, “gentle breeze”, “moderate breeze”, or “fresh breeze”.

4.3 Inputs to this clause

4.3.1 Informative references

- a) ISO 34502^[1]
- b) ISO 34503 ^[7]
- c) ASAM OpenLABEL^[8]
- d) Scenario Categories for the Assessment of Automated Vehicles^[9]
- e) Proposal for a second iteration of the New Assessment/Test Method for Automated Driving – Master Document, ECE/TRANS/WP.29/GRVA/2022/2^[10]
- f) HEADSTART deliverable on the integration of simulation and physical testing^[11]

4.4 Requirements and recommendations

4.4.1 General

A scenario category shall be defined by a collection of tags, where this collection contains one or multiple tags. A scenario category shall comprise scenarios for which these tags are applicable. A scenario category Y shall include a scenario category X if this scenario category X contains the same (structure of) tags as this scenario category Y.

NOTE 1 This implies that if scenario category X includes scenario category Y, then scenario category X comprises all scenarios that scenario category Y comprises.

EXAMPLE [Figure 1](#) illustrates this, where three scenario categories are shown:

- a) the red circle denotes the scenario category with the tag “daytime”;
- b) the green circle denotes the scenario category with the tag “heavy rain”;
- c) the overlap of the red and green circles denotes the scenario category with the tags “daytime” and “heavy rain”.

In this example, let X be the scenario category with tags “daytime” and “heavy rain” and let Y be the scenario category with the tag “daytime”. Since X contains the same tag as Y, X includes Y. [Figure 1](#) illustrates this, as X (the circle with tag “daytime”) fully overlaps the area that represents Y (the intersection area of both circles). As a result, both the X and Y comprise the scenario occurring at daytime with heavy rain, i.e. Y comprises all scenarios of X.

NOTE 2 [Figure 1](#) is simplified in the sense that there are typically many other characteristics considered for categorizing scenarios.

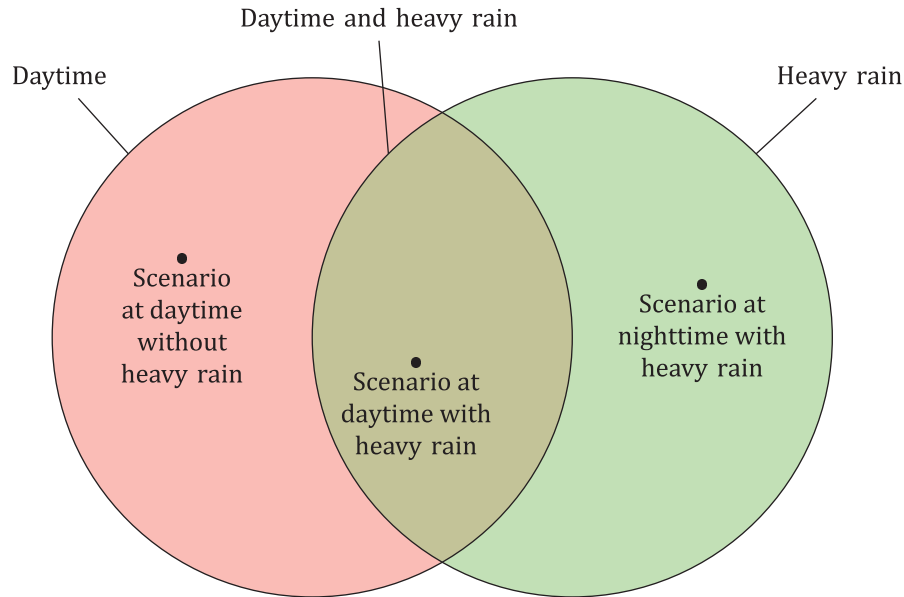


Figure 1 — An example of a relation between scenarios and scenario categories

Additional to tags, the scenario attributes can be used for categorizing the scenarios into scenario categories. In that case, a scenario attribute shall be considered as equivalent to as tag. For example, a scenario that contains heavy rain can be categorized into the scenario category “heavy rain” even though the scenario does not contain the tag “heavy rain”.

4.4.2 Purpose of tags

The tags of a scenario contain information about the scenario. In order to indicate the purpose of a tag, it shall be indicated what kind of information the tag provides. A tag shall address any of the following topics, but not limited to:

- a) dynamic entities;
- b) scenery elements;
- c) environmental conditions;
- d) additional information of a scenario;
- e) intended test usage.

NOTE 1 [Figure 2](#) visualizes the different purposes of the tags.

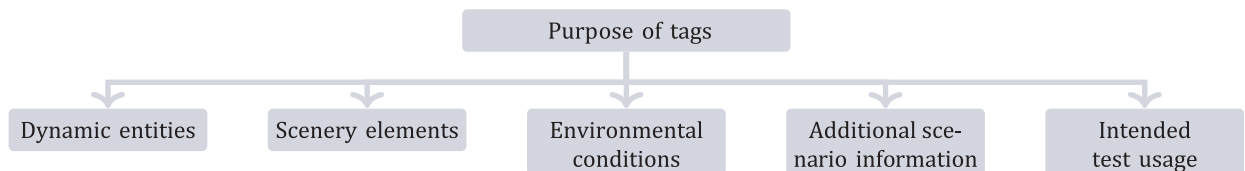
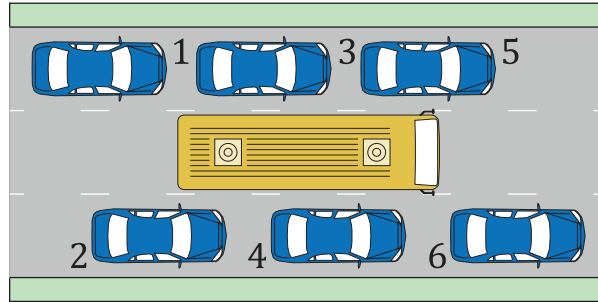


Figure 2 — Tree of tags for the possible purposes of tags

NOTE 2 In most cases, the purpose of the tags is to provide qualitative information. Stakeholders can specify more details regarding the quantification of tags. For example, the tag “faster” can be applied to a dynamic entity that is moving “faster” than the subject vehicle. The exact meaning of “faster” is not further specified in this document. A stakeholder can choose to apply the tag if the dynamic entity is moving at a higher speed than the subject vehicle, but it can also, for example, apply the tag only when a dynamic entity is moving with a speed faster than 1 m/s for a duration of at least 1 s.

NOTE 3 To illustrate that the meaning of the tags can be ambiguous, consider the tag “in front of subject”, which is used to indicate that a dynamic entity is in front of the subject vehicle. Consider the bus in [Figure 3](#) as the subject vehicle. Clearly, the tag “in front of subject” does not apply to the most-left car, indicated with the label “Car 1”, of [Figure 3](#). However, for “Car 6”, the tag applies, since this passenger car is fully in front of the subject vehicle. For the remaining four passenger cars, it depends on how “in front of” is defined. For example, the front of “Car 2” is behind the front of the bus, but the front of “Car 2” is in front of the rear of the bus. The rear of “Car 3” is in front of the rear of the bus. Similarly, the centre of “Car 4” is ahead of the centre of the bus and the front of “Car 5” is in front of the bus.



Key

- 1 car 1
- 2 car 2
- 3 car 3
- 4 car 4
- 5 car 5
- 6 car 6

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Figure 3 — A bus and six passenger cars; it is unclear which cars are in front of the bus

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4.4.3 Extension of tags and trees of tags

The tags shall be structured into trees and each layer shall represent a different abstraction level. If a scenario category contains a tag at a certain level, all the lower-level tags may be applicable.

Stakeholders may extend the list of tags if those tags that are specified do not adequately describe a scenario characteristic. While the tags are extensible, any extension which conflicts with the specified tags shall be avoided.

NOTE Even if tags are at the same layer in the same tree of tags, they do not need to be mutually exclusive.

4.4.4 Tags for a dynamic entity

For a dynamic entity, the tags shall address:

- a) road user type;
- b) longitudinal action;
- c) lateral action;
- d) mixed action;
- e) state or initial state;
- f) role of a dynamic entity with respect to the subject vehicle;
- g) enhancing conspicuity;
- h) visibility;

i) collision information.

If, for a dynamic entity, no tags are mentioned for one or more of the aforementioned items, it shall be assumed that any of the tags of that item may be or may not be applicable for the scenarios that are comprised by the scenario category.

EXAMPLE A dynamic entity of a scenario category only contains tags for the “road user type”. As a result, the scenarios that are comprised by the scenario category contain at least one dynamic entity with the tags for the “road user type” as specified and this dynamic entity can contain any tag related to “longitudinal action”, “lateral action”, etc.

4.4.4.1 Road user type

At the top level, the tags for the road user type should be:

- a) vehicle;
- b) pedestrian;
- c) cyclist;
- d) animal;
- e) inanimate obstacle.

To further specify a vehicle, the following tags can be used:

- passenger car;
- bus;
- school bus;
- truck;
- tram;
- goods vehicle;
- dangerous goods vehicle;
- long, large vehicle;
- vehicle transporting protruding cargo;
- vehicle towing trailers;
- vehicle towing combination trailers;
- special convoy, slow-moving vehicle;
- caravan/recreational vehicle, including towing trailers;
- agricultural vehicle;
- fire truck;
- ambulance;
- police vehicle;
- rescue vehicle;
- street sweeper;

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- road sprinkler;
- training car;
- crane, Non-Road Mobile Machinery (NRMM);
- other automated/connected (V2V) vehicle;
- disabled (broken-down) vehicle.

To further specify a pedestrian, the following tags can be used:

- child;
- adult;
- person with disabilities;
- hearing-impaired pedestrian;
- visually-impaired pedestrian;
- road-works crew;
- police officer (on foot);
- person directing traffic;
- person pushing stroller;
- person in wheelchair;
- motorists on the roadside (e.g. stranded vehicle, changing tire).

To further specify a cyclist, the following tags can be used:

- bicyclist;
- e-Bike user;
- skater (roller, skateboard);
- motorcycle;
- moped/scooter;
- powered three-wheeler;
- quadricycle;
- self-balancing scooter.

To further specify an animal, the following tags can be used:

- small size animal;
- medium size animal;
- large size animal.

To further specify an inanimate obstacle, the following tags can be used:

- stationary vehicle;
- debris;

- construction equipment;
- moving obstacle.

NOTE 1 [Figure 4](#) visualizes the tree of tags for the road user type.

NOTE 2 The tags for the road user type are based on ongoing VMAD/FRAV UNECE discussions in the Other Road User workstream^[12].

NOTE 3 A moving obstacle can refer to blowing debris like a tumbleweed or a plastic tarp.

NOTE 4 A disabled (broken-down) vehicle can have its emergency lights on, and an emergency triangle can be located behind this vehicle. A stationary vehicle can refer to a parked vehicle.

NOTE 5 For categorizing animals based on their size, the tag “small size animal” can apply to animals shorter and thinner than 0,5 m, while animals larger or wider than 1 m can be tagged with “large size animal”. All other animals are then tagged with “medium size animal”.

NOTE 6 A combination of the tags is also possible, e.g. both “passenger car” and “disabled (broken-down) vehicle” can apply.

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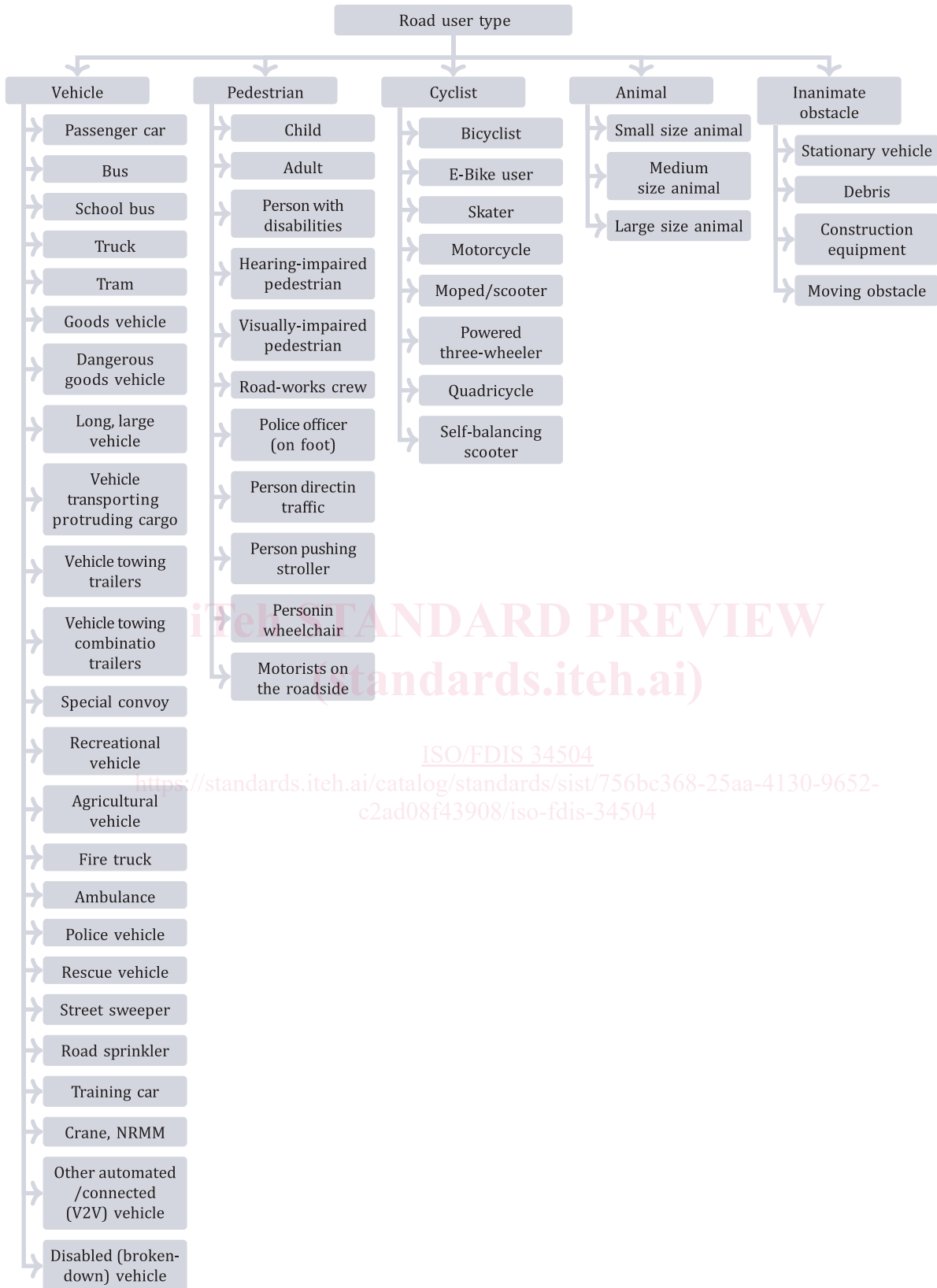


Figure 4 — Tree of tags for the road user type

4.4.4.2 Longitudinal action

At the top level, the tags for the longitudinal action should be:

- a) standing still;
- b) driving forward;
- c) reversing.

To further specify driving forward and reversing, the following tags can be used:

- decelerating;
- keeping speed;
- accelerating.

NOTE 1 The longitudinal action refers to the behaviour of a dynamic entity in the direction in which the dynamic entity is travelling.

NOTE 2 [Figure 5](#) visualizes the tree of tags for the longitudinal action.

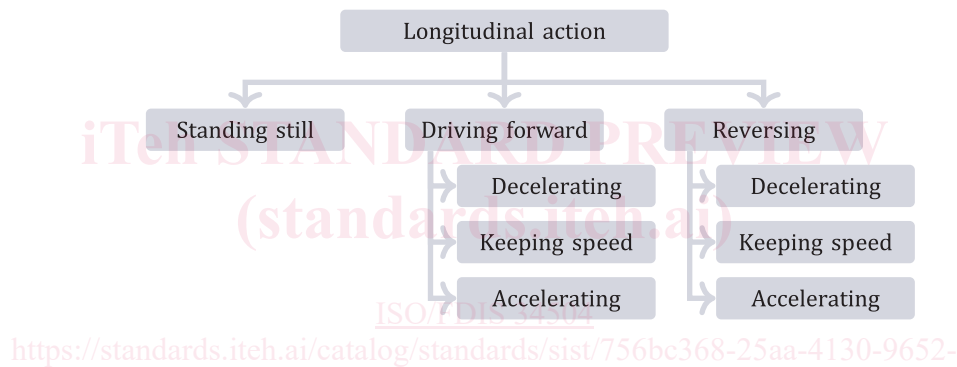


Figure 5 — Tree of tags for the longitudinal action

4.4.4.3 Lateral action

At the top level, the tags for the lateral action should be:

- a) following lane;
- b) changing lane;
- c) turning;
- d) swerving;
- e) other.

NOTE 1 The lateral action refers to the direction perpendicular to the direction of travel of the dynamic entity. The tag “following lane” is applicable if the dynamic entity stays in its lane. When a dynamic entity changes lane to an adjacent lane, the tag “changing lane” is applicable. The tag “turning” is applicable if the dynamic entity turns. The tag “swerving” is applicable if the dynamic entity moves partly into its adjacent lane without performing a lane change. The tag “other” can be applicable if the dynamic entity performs manoeuvres that are not necessarily related to a lane, such as parking.

To further specify changing lane, the following tags can be used:

- a) left;
- b) right;