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Road vehicles — Test scenarios for automated driving systems — Scenario evaluation and test case evaluationgeneration

Véhicules routiers — Scénarios d'essai pour les systèmes de conduite automatisée — Évaluation de scénarios et génération de cas de test

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Foreword

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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.*

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

The rapid development of the automated driving technology with the goal of improving safety and comfort has become an important aspect in the development of modern automobile technology. In addition, the evaluation of tests of automated driving systems (ADSs) based on test scenarios has become a common method.

A scenario is a sequence of scenes usually including the ADS(s)/subject vehicle(s), and their interactions in the process of performing a dynamic driving task (DDT). A test scenario is a scenario intended for the testing and assessment of ADS(s) or subject vehicle(s) in their operational environment (see ISO 34501). A test case is a set of test inputs (stimulation), steps, test platform and expected results (pass / fail criteria) developed for a particular test objective (test case is defined later in this document). In order to execute the test, some additional items are needed to supplement the scenario. Another important topic is how to choose the right test scenario for a particular automated driving system (ADS) function.

This document is the basis of generating and evaluating scenario-based test cases for ADSs.

This document is intended to be used to harmonize and standardize the evaluation of scenarios and the procedure and methodology of the generation of test cases for ADSs.

Road vehicles — Test scenarios for automated driving systems ~~—~~ Scenario evaluation and test case ~~evaluation~~generation

1 Scope

This document defines a methodology to evaluate scenarios and provides a procedure extending test scenarios to test cases. This document also defines the necessary characteristics of test cases, which include but are not limited to unified identifier, test objectives, inputs, steps, platforms and expected results.

This document describes methods and criteria to evaluate test cases (e.g. frequency, criticality, complexity of a scenario), the coverage concerning functional and technical requirements, operational domain (OD), test criteria, and also the optimization of sets of prioritized test cases.

This document is applicable to Level 3 and higher ADS as defined in ISO/SAE PAS 22736. The focus of this document is on scenarios, which will be tested to evaluate safety (functional safety and safety of the intended functionality (SOTIF)). Nevertheless, the content, in general, is also applicable to non-safety related test scenarios.

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 21448:2022, *Road vehicles — Safety of the intended functionality*

ISO 26262-3:2018, *Road vehicles — Functional safety — Part 3: Concept phase*

ISO 26262-8:2018, *Road vehicles — Functional safety — Part 8: Supporting processes*

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

ISO 34502:2022, *Road vehicles — Test scenarios for automated driving systems — Scenario based safety evaluation framework*

ISO 34503:2023, *Road vehicles — Test scenarios for automated driving systems ~~— Taxonomy~~ — Specification for operational design domain*

ISO 34504, *Road vehicles — Test scenarios for automated driving systems ~~—~~ — Scenario categorization*

~~ISO 26262-8:2018, *Road vehicles — Functional safety — Part 8: Supporting Processes*~~

~~ISO 26262-3:2018, *Road vehicles — Functional safety — Part 3: Concept phase*~~

~~ISO 21448:2022, *Road vehicles — Safety of the intended functionality*~~

~~6~~3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 34501, ISO 34502, ISO 34503 ~~and~~, ISO 34504 and the following 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/

~~6.1~~3.1 ~~3.1~~

prospective scenario criticality

measurable criteria to reflect the number and weighting of the risk factors in the scenario

Note 1 to entry: This definition is focus on field of safety, for other field like to test the energy economy of ADS could have other criteria.

Note 2 to entry: The prospective scenario criticality describes in prospective the possible collision and its impact to the safety of the traffic participants and the passenger(s) of the automated driving system (ADS) equipped vehicle, and is based on ISO 34502:2022, 3.1.

Note 3 to entry: The measurement for the prospective scenario criticality can be a weighted sum of the expected time to collision and expected relative velocity at the collision time.

Note 4 to entry: Knowledge of the ADS can be considered while estimating the criticality of the scenario, but it is not necessary to consider it as the real safety assessment of ADS is done after testing the scenario.

Note 5 to entry: Due to the different operational design domain (ODD) and DDT definition of each ADS, the prospective scenario criticality rating may be different for each ADS.

Note 6 to entry: For some ODD attributes, the scenarios at the boundary of ODD are more critical compared to the non-ODD boundary. Nevertheless, attributes inside ODD can also cause risks.

EXAMPLE ~~:~~ A rather uncritical scenario is driving with low velocity (e.g. on traffic jam) on a highway with a leading vehicle and nominal weather conditions and standard road infrastructure [see *nominal scenario* (3.6~~(3.6)~~)]. A rather critical scenario is driving with an ADS at higher velocity on a multi-city road having a cut in with a much lower velocity close in front of the ADS. The relative velocity of the ADS and the cut in vehicle is high and thus the probability of a collision and impact is potentially high. In this example the prospective scenario criticality metric as described in Note 2 to entry can be used.

~~6.2~~3.2 ~~3.2~~

scenario complexity

measurable criteria to reflect dimensionality factors

Note 1 to entry: Dimensionality factors are factors or conditions of a scenario that, if present, increases the number of possible combinations of relevant scenario parameters that may influence the ADS driving task.

EXAMPLE 1 ~~:~~ Dimensionality factors can describe the behaviour of the participating road users, the defined road infrastructure and the environmental conditions.

Note 2 to entry: The more dimensionality factors there are, the more complex the scenario typically is.

Note 3 to entry: Factors, influencing the complexity, can be systematically classified into the following (see ISO 34502:2022 Annexes A, B, C and D):

— ~~—~~the complexity factor information of road, e.g. road construction;

— ~~—~~the complexity factor information of infrastructure;

— ~~—~~the complexity factor information of temporary modifications and events;

— ~~—~~the complexity factor information of objects, e.g. the number and the type of dynamic traffic participants and their behaviours;

— ~~—~~the complexity factor information of environment, e.g. various weather conditions;

— ~~—~~the complexity factor information of digital information.

Note 4 to entry: The complexity of a scenario can correlate with the amount of effort that is necessary to realise the scenario because of the high number of scenario attributes to be considered.

Note 5 to entry: As far as virtual testing is concerned, a higher scenario complexity means a bigger effort to implement the higher number of scenario attributes. When the scenario is tested in the real world, the effort can be defined by the time or costs to realise the scenario.

EXAMPLE 2 ~~:~~A rather noncomplex scenario is driving on main road way of a 2-lane highway without other influencing traffic participants. A rather complex scenario is driving on a 4-lane highway with dense traffic in rainy conditions while other traffic participants change the speed and lane frequently.

~~6.3~~3.3 ~~3.3~~

scenario exposure

measurable criteria to reflect the probability of occurrence of a scenario

Note 1 to entry: From a mathematical perspective the probability of a concrete scenarios (concrete values of continuous parameters) is zero. Nevertheless, a scenario can represent a set of concrete scenarios such that this scenario has a probability greater than zero.

Note 2 to entry: It can be measured via calculating the occurrence frequency of a scenario in real driving.

~~6.4~~3.4 ~~3.4~~

scenario evaluation

systematic determination of the extent to which a scenario meets a specified criterion

[SOURCE: ISO/IEC 25040:2011, 4.16, modified — Term was originally "evaluation", "entity" was replaced by "scenario" in the definition.]

~~6.5~~3.5 ~~3.5~~

test case

set of test inputs (stimulation), steps, platform and expected results (pass~~-~~/fail criteria) developed for a particular test objective

Note 1 to entry: Test objectives can be used to exercise a particular programme path or to verify compliance of the system under test (SUT) with a specific requirement or architectural element (e.g. software unit level or vehicle level).

Note 2 to entry: The test case includes test scenarios and considers the ODD or target operational domain (TOD). Details on TOD are provided in ISO 34503.

Note 3 to entry: Subclause 6.4 ~~Subclause 6.4~~ describes how to extend scenarios to test cases and defines the characteristics of test cases.

Note 4 to entry: Depending on the detailed definition of a test scenario, the test case can be equal to the test scenario or a superset of a test scenario. For example, the pass/fail criteria can be included in the test scenario or can be added to the test scenario such that the test case compound by the test scenario and the pass/fail criteria.

Note 5 to entry: The evaluation of the testcase can be ADS specific.

Note 6 to entry: The effectiveness of a testcase depends on the overall test goal. The overall test goals can be to give evidence for argumentation (safety, laws, regulations) or find failure / /error/problems or challenge the ADS.

6.63.63.6
nominal scenario
traffic scenario containing reasonably foreseeable situations that reflect normal condition and non-critical driving manoeuvres

Note 1 to entry: Traffic scenario means a description of one or more real-world driving situations that may occur during a given trip.

[SOURCE: Reference [12 [12]]]

6.73.73.7
macroscopic evaluation
evaluation of the performance of an ADS based on multiple executed test scenarios

Note 1 to entry: Details on macroscopic evaluation are stated in ISO 34502:2022 Annex , F.3 Criteria and natural metrics.

6.83.83.8
microscopic evaluation
evaluation of the performance of an ADS based on a single, executed test scenario

Note 1 to entry: Details on microscopic evaluation are statestated in ISO 34502 Annex F :2022, F.3 Criteria and natural metrics.

6.93.93.9
ADS feature
ADS's design-specific functionality at a given level of driving automation within a particular ODD, if applicable

[SOURCE: ISO/TS 5083, 3.4, modified — Notes to entry and the example were removed.]

6.103.10 3.10
diagnostics
process including the detection process of possible malfunctions, the identification of the likely root cause of these malfunctions and the appraisal of its relevance for the operation of the vehicle

[SOURCE: ISO 20077 1.2017,3.2] 1:2017, 3.2, modified — The original term entry included the admitted term "diagnostics process".]

3.11
3.11 In
in-vehicle information and control system
Inin-vehicle system that manages the information from inside the vehicle and from its environment to influence the state or behaviorbehaviour of the vehicle

Note 1 to entry: The system includes hardware (e.g., physical sensors, actuators, and hardware controller) and software.

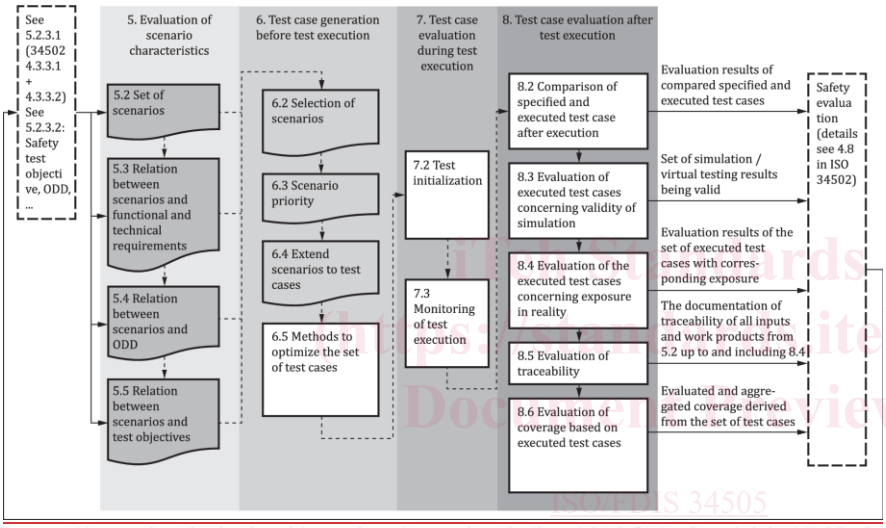
Note 2 to entry: The system refers to subsystems or the entire system.

74 Introduction and overview

7.14.1 General

In this clause an overview is given. The traceability over all artefacts is a clause-overarching topic which is further described in ISO 26262-2:2018. In Clause 5Clause 5 the inputs are defined to evaluate the scenarios.

Before the scenario evaluation the test objective will be defined. In Clause 6~~Clause 6~~ the scenario evaluation activities that need to be performed before the test execution are described, this is done by evaluating the scenario characteristics, extending the scenarios to test cases and optimizing the set of test cases. The relations between the scenarios and other ~~artifacts~~artefacts which are defined in Clause 5~~Clause 5~~ will be used as an input to Clause 6~~Clause 6,~~ to evaluate whether the selected scenarios are appropriate for the tested ADS feature. The test case generation is described in chapter 6.4~~6.4.~~. The investigations to analyse the test cases concerning initialization of the test run and monitoring during test execution are described in Clause 7~~Clause 7.~~. After test execution, the comparison of the initial specified and the resulting test case, the evaluation of the resulting test case concerning physical principle and probability in reality can be found in Clause 8~~Clause 8.~~. A detailed representation of the workflow described in this document can be found in Figure 1~~Figure 1.~~.



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