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Road vehicles — Test scenarios for automated driving systems — Qualification of virtual test environments

Véhicules routiers — Scénarios d'essai pour les systèmes de conduite automatisée — Qualification des environnements d'essai virtuels

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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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.

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Introduction

The development, verification and validation of automated driving systems (ADS) presents a significant challenge for both industry and regulatory authorities. Conventional physical testing methods can no longer provide the necessary test coverage to assure safety with an acceptable degree of statistical significance. Regulatory bodies such as the United Nations Economic Commission for Europe (UNECE) and the US Department of Transportation (USDOT) have already recognized virtual testing as a complementary methodology alongside track testing, real-world testing, and in-service monitoring and reporting (see References [1] [2]). However, several open questions should be addressed before virtual testing can be applied as evidence for the assessment of the ADS. Some of these questions, identified in References [2] and [3], include: (a) how reliability is defined in relation to automated operation, (b) the minimum degree of fidelity required for simulation models to enable virtual testing, (c) how these simulation models are validated, and (d) logistical considerations, such as which models are used, who supplies these models, and how, or if proprietary algorithms may be included. See ISO/TS 21934-2 [4] for complementary standards on virtual simulation.

While simulation models play a crucial role in the evaluation process, this document focuses on another important element: the assessment of the credibility of the virtual test environments (VTEs). The approach outlined in this document aims to ensure that VTEs can accurately and reliably replicate real-world conditions, which is critical for trusting the validity of the virtual test results. Therefore, it is important to determine whether a VTE can produce reliable and accurate representations of real-world testing for pre-defined purposes, for example sensing and/or planning and/or acting, or end-to-end-simulations. The purpose of this document is to propose metrics that can be used as quantitative measures to assess whether a VTE accurately represents real-world conditions.

The document provides recommendations and requirements for the development and evaluation of VTEs. The methods described can be part of a quality assurance framework for VTEs to meet certain requirements of adequacy. Figure 1 illustrates an example methodology for the qualification of the VTE by comparing outputs from real-world data with output data from simulation.

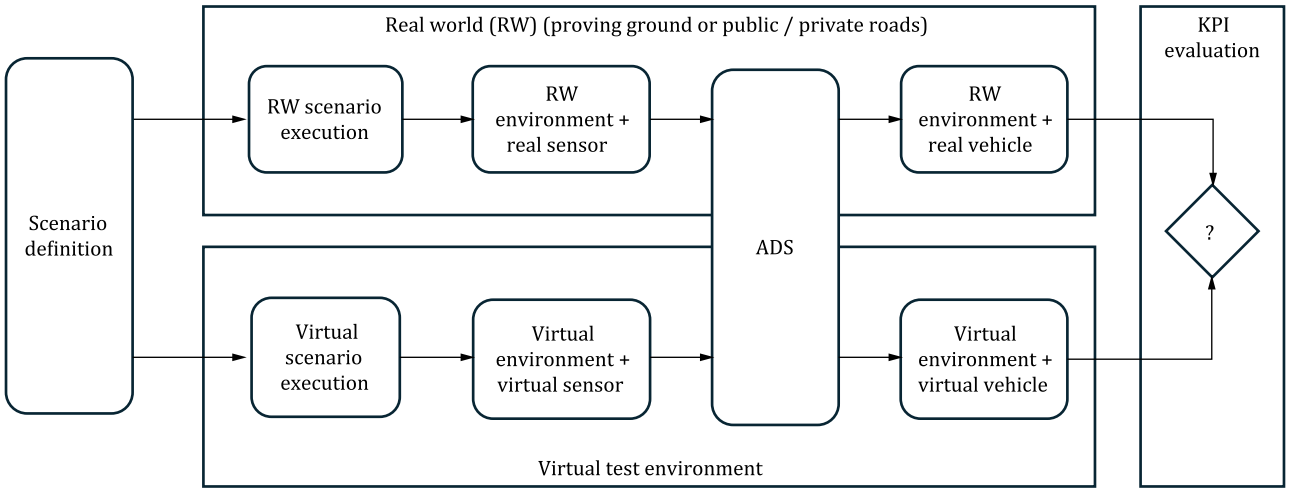

Figure 1 — Example schematic view of VTE evaluation process. Real world includes proving ground testing

NOTE 1 This document is part of a set of documents (ISO 34501 [5], ISO 34502 [6], ISO 34503 [7], ISO 34504 [8] and ISO 34505 [9]), which provides guidance and an overview of the scenario-based testing approach for ADS.

NOTE 2 Examples of applicable VTE configurations include model-in-the-loop (MiL) and software-in-the-loop (SiL) testing methodologies and can extend to hybrid testing techniques, such as hardware-in-the-loop (HiL) and vehicle-in-the-loop (ViL).

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Road vehicles — Test scenarios for automated driving systems — Qualification of virtual test environments

1 Scope

This document establishes a qualification scheme for virtual test environments (VTE) used in the evaluation of automated driving systems (ADS). It specifies criteria and procedures for assessing the VTE in open-loop and closed-loop configurations.

This document does not apply to the validation or assessment of individual simulation models (for example, sensor or vehicle dynamics models) and does not apply to the evaluation of ADS performance.

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*

ISO 34503, *Road Vehicles — Test scenarios for automated driving systems — Specification for operational design domain*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 34501, ISO 34503 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
virtual test environment
VTE
simulation toolchain and associated data enabling testing according to the test objectives

Note 1 to entry: The virtual test environment (VTE) enables resimulation based on recorded data and/or simulation based on artificial data.

Note 2 to entry: The virtual test environment (VTE) may include models or representations of scenery elements (e.g. roadway environment, such as road lanes, traffic signs), dynamic elements (e.g. vehicles and other actors, like pedestrians), and environmental conditions (e.g. time of day, rainfall, etc.).

Note 3 to entry: A virtual test environment (VTE) may also have a framework of algorithms showing other dynamic elements, such as vehicles, pedestrians, active traffic signals interacting with the static elements and with each other.

Note 4 to entry: A virtual test environment (VTE) can be fully virtual or a combination of virtual and hardware components combined to form a test environment.

Note 5 to entry: A virtual test environment (VTE) can enable simulated interactions with a function or a feature of the automated driving system (ADS).

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3.2
scenario
sequence of scenes usually including the automated driving system(s) (ADS) /subject vehicle(s), and its/their interactions in the process of performing the dynamic driving task (DDT)

[SOURCE: ISO 34501:2022 [10], 3.4, modified — Note 1 to entry and the Example have been deleted.]

4 Abbreviated terms

ADS	automated driving system
API	application programming interface
DDT	dynamic driving task
GNSS	global navigation satellite system
HiL	hardware-in-the-loop
IMU	inertial measurement unit
LiDAR	light detection and ranging
MiL	model-in-the-loop
ML	machine learning
OBU	on-board unit
ODD	operational design domain
RTK	real time kinematic
SDL	scenario description language
SiL	software-in-the-loop
SUT	system under test
ViL	vehicle-in-the-loop
VTE	virtual test environment

5 Virtual test environment

5.1 Types and purposes

Depending upon the purpose of the VTE, various configurations may exist for a VTE with different components being virtualised. For the testing of an ADS, irrespective of the software architecture (e.g. end-to-end artificial intelligence or modular configuration), the ADS has the perception, planning and actuation functionalities. In order to execute the test, the ADS needs to be stimulated by and connected to a test environment which may or may not have the driver-in-the-loop. Depending on the ADS under test, its interfaces, and the availability of information (white-, grey-, black box), different virtual test methods may be used to test the ADS. For example, the "New Assessment/Test Method for Automated Driving (NATM) Guidelines for Validating Automated Driving System (ADS)" [11] includes MiL/SiL, HiL and ViL as simulation approaches. In addition, open-loop simulation approaches can also serve as a form of VTE, wherein recorded or simulated stimuli are provided to the sensor to observe the outputs of the ADS, while keeping these outputs isolated from the driving environment for test-specific reasons, such as reduced complexity. Refer to ISO 34505 [9] for more details on test scenario evaluation and test case generation.

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