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Road vehicles — Test object monitoring and control for active safety and automated/autonomous vehicle testing — Functional requirements, specifications and communication protocol

Véhicules routiers – Surveillance et contrôle des objets de test pour l'évaluation de la sécurité active et des véhicules automatisés/autonomes – Exigences fonctionnelles, caractéristiques et protocole de communication

~~DTS stage~~

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Contents

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 33, *Vehicle dynamics and chassis components*~~, Working Group 16, *Active safety test equipment*~~.

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Introduction

Testing of collision avoidance systems, active safety functions and more advanced autonomous functions in vehicles require testing on proving grounds. The purpose is to expose the vehicle under test to potentially dangerous traffic situations in a safe manner. The evaluation is done during development, and in voluntary and mandatory test procedures.

To orchestrate these traffic scenarios, various impactable targets representing traffic actors ~~have to be~~are controlled. The number of controlled targets may be one or many depending on the required traffic situation scenario. Several requirements are important ranging from safety, to position and speed precision, to logging capabilities.

This document specifies requirements, functionality and a protocol allowing for multivendor target carrier systems to be controlled according to the required traffic situation scenario, to report expected information for logging purposes and other functions required.

Road vehicles — Test object monitoring and control for active safety and automated/autonomous vehicle testing — Functional requirements, specifications and communication protocol

1 Scope

This document specifies requirements, procedures and message formats for controlling and monitoring of test targets, used for testing of active safety functions and autonomous vehicles.

The document specifies functionality and messaging for monitoring and controlling of test objects by a control centre facilitating an interoperable test object environment. This document defines a communication protocol which allows for the control centre to safely execute tests using test objects from multiple vendors.

This document does not specify the internal architecture of the test object nor control centre.

This document does not specify how testing of the vehicles shall be performed.

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 8601~~:2004, *Data elements*~~ (all parts), *Date and time — Representations for information interchange* ~~*formats — Information interchange — Representation of dates and times*~~

ISO 8855, *Road vehicles — Vehicle* ~~*coordinate system orientation*~~ *dynamics and road-holding ability — Vocabulary*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain ~~terminological~~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/

3.1
test object
entity, as defined in ISO 34501, part of a traffic scenario under monitoring and control by the *control centre* (3.5)

Note 1 to entry: Two types of test objects exist; moveable and *stationary test objects*~~.~~ (3.4).

Note 2 to entry: A test object can have several attributes, see Figure 1.

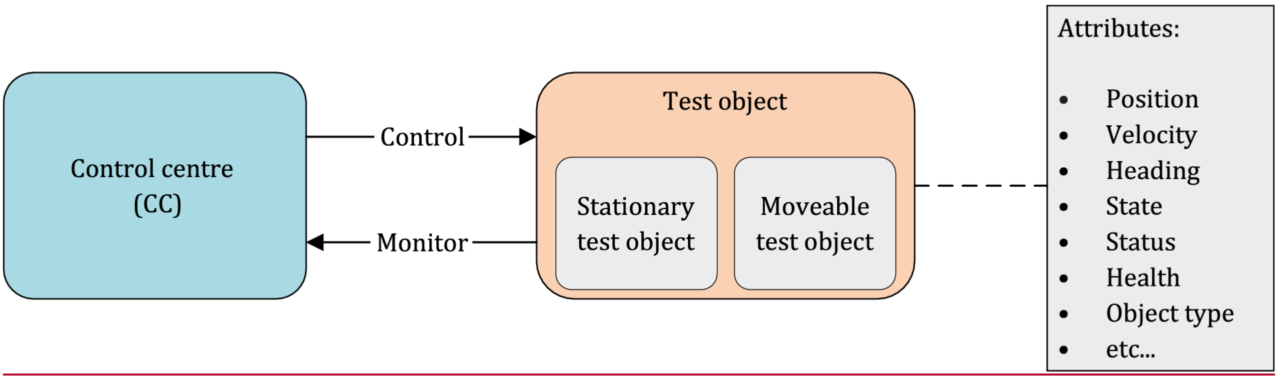


Figure 1 — Relations and inheritance view

3.2
subject vehicle
SV
vehicle to be tested with the system

Note 1 to entry: The subject vehicle, SV, is also known as vehicle under test, VUT.

Note 2 to entry: There may be one subject vehicle (standard setup) or a set of subject vehicles in the specific traffic scenario.

Note 3 to entry: The subject vehicle may be under safety-driver control and/or under *control-centre* (3.5) control.

Note 4 to entry: The subject vehicle is an instantiated *test object* (3.1) in either type of~~;~~: *stationary test object* (3.4) or *moveable test object* (3.3).

3.3
moveable test object
object under control by the *control centre* (3.5) which has the capability of activation of physical movement

Note 1 to entry: The *subject vehicle* (3.2) is typically a moveable test object.

Note 2 to entry: Various levels of control are possible~~;~~: open-loop control (using no feedback from the real-time activities of other *test objects* (3.1) or environment~~),~~) and closed-loop control (taking into account activities of other test objects in real-time and environment). One other type of controlling/triggering is related to test object unique features like~~;~~: turn indicator, headlight beam, etc.

EXAMPLE Traffic simulation vehicles, also known as traffic support vehicles (TSV), soft crash targets (SCT).

3.4
stationary test object
part of a traffic scenario, which is not moveable but may be under control by the *control centre* (3.5)

Note 1 to entry: A VUT may also be a stationary test object.

Note 2 to entry: Different stationary test objects can exist. Normally they are divided in to two groups: ~~Active~~active and passive infrastructure elements (ISE).

EXAMPLE Active ISE: ~~Traffic~~traffic lights, lighting, rain/snow/fog simulator. Passive ISE: ~~Elements~~elements of construction area, road signs, guardrails, etc.

3.5
control centre
CC
centralized or distributed service for *test-object* (3.1) control and safety monitoring including provision of communication services to the test objects

3.6
path
set of local or global positions in respect to a point of origin and in respect to the orientation to the axes of a defined coordinate system (x,y,z)

3.7
lateral path deviation
position error of the target vehicle relative to the planned *path* (3.6) measured perpendicular from the planned path direction

[SOURCE: ISO 19206-3:2021, 3.8~~]~~, modified — Notes to entry and figure removed.]

3.8
trajectory
path ~~which~~(3.6) where a *test object* (3.1) is or is intended to move along including test-object dynamics (i.e. including timing)

Note 1 to entry: A trajectory contains a path and additionally the test-object dynamics (such as time, yaw, velocity, acceleration, etc.) for each position on the path.

Note 2 to entry: All test-object parameters related to test-object dynamic (e.g. limitations in acceleration) are described in the corresponding DIDX-file.

3.9
static trajectory
offline pre-planned *trajectory* (3.8) including *test-object* (3.1) position and test-object motion dynamics for a single *moveable test object* (3.3) as part of the traffic scenario

Note 1 to entry: The trajectory is downloaded to the test object utilizing the trajectory object message (TRAJ).

Note 2 to entry: The parameters used by the test object are described in the DIDX-file.

Note 3 to entry: The ~~Control~~*control centre* ~~extract~~(3.5) extracts information from the trajectory file and ~~build~~builds a trajectory message, TRAJ, that is understandable by the test object.

3.10
dynamic trajectory
trajectory (3.8) which at the start of the scenario execution is not known by the *test object(s)* (3.1) nor the *control centre* (*CC*) (3.5)

Note 1 to entry: The dynamic trajectory is created based on events and actions during the ongoing test.

Note 2 to entry: The dynamic trajectory is continuously sent by the CC or gated through the CC in smaller pieces/fragments utilizing the trajectory object message (TRAJ).

Note 3 to entry: In the case where the test object(s) or other systems (e.g. a simulation environment) are generating the dynamic trajectory this information shall be gated by sending to the CC and then from the CC to the test object.

3.11
test scenario
~~test~~ scenario, as defined in ISO 34501, including all *test objects*~~,~~ (3.1), moveable and stationary, and the definition of the planned activities over time or/and location

Note 1 to entry: The traffic scenario can be formally represented by two complementary descriptions enabling test execution, a *scenario description*~~,~~ (3.12), and a map of the test area.

3.12
scenario description
textual representation of a scenario

Note 1 to entry: A scenario description can be used in combination with a *scenery description* (3.13) to generate *trajectories* (3.8) (static or dynamic) by the ~~CC~~*control centre* (3.5) or at a *test object*~~.~~ (3.1).

EXAMPLE: *Test scenario* (3.11) described using OpenSCENARIO or iSCAML [~~10~~17].

3.13

scenery description

representation of the test area ~~including but~~ limited to the road geometry (e.g. lanes and junctions) and *stationary test objects* (3.4) (e.g. road signs and markings)

Note 1 to entry: A scenery description can be used in combination with a *scenario description* (3.12) to generate *trajectories* (3.8) (static or dynamic) by the ~~CC~~*control centre* (3.5) or at a *test object*~~.~~ (3.1).

EXAMPLE: Temporary lane-setup on a proving ground, described using OpenDRIVE.

3.14

safety speed limit

maximum allowed speed when repositioning *moveable test objects* (3.3) while not participating in ongoing test

Note 1 to entry: The *test object* (3.1) is manually driven with the remote-control functionality or automatically driven when outside the test execution phase.

3.15

device ID

unique identifier for each entity in the test setup

Note 1 to entry: The device ID number is used as transmitter ID or receiver ID in every message except when tunnelling data.

3.16

message gating

mechanism to gate messages from a sender to a receiver defined by the transmitter ID and receiver ID in the message header

Note 1 to entry: ~~CC~~*Control-centre* (3.5) gating messages from one entity to another ~~does~~do not alter the transmitter ID in the process of message gating.

4 Abbreviated terms

ASP	Adaptive Synchronization Point
DIDX	Device Interface Description XML
ECEF	Earth-Centred, Earth-Fixed (geographical coordinate system)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System (one constellation of GNSS)
ISE	Infrastructure Elements
NTP	Network Time Protocol
NTRIP	Networked Transport of RTCM via Internet Protocol
OWD	One-Way Delay / End-to-end delay
PGRS	Proving Ground Reference System
PTP	Precision Time Protocol
RPM	Reference Point Marker (physical reference point on the proving ground)
RTK	Real Time Kinematic
SCT	Soft Crash Targets
SOW	Second Of Week (in respect to GPS time)
SV	Subject Vehicle, also known as VUT

TAI	International Atomic Time
TCP	Transmission Control Protocol – Connection oriented communication between a server and client~~.~~
TSV	Traffic Simulation Vehicles
UDP	Used Datagram Protocol - Connectionless communication model~~.~~
UTM	Universal Transverse Mercator (a two-dimensional Cartesian coordinate system for locations on the surface of the Earth~~).~~.)
VUT	Vehicle Under Test
WGS84	World Geodetic System 1984
CC	Control Centre

5 Test scenario illustration

The illustration of a test scenario in Figure 2 is used as an example to explain a possible test scenario with various test objects. The test objects present in the example scenario ~~is~~are categorised in types and sub types in Table 1. The example does not include all possible test objects and scenarios referred to in ~~the~~this document.

To be able to achieve the following scenario, several different mechanisms can be used to control and monitor all different test objects, which will be described later in this document. Some or all test objects can be controlled by a CC but may also be controlled by a safety driver or by an integrated controller. All test objects are always monitored by the CC.

A test scenario is normally described in a story board or segment description.

Table 1 — Test object type categorization example

Test object type	Test object sub type	Illustration
Stationary test objects	Active infrastructure elements (A-ISE)	
	Passive infrastructure elements (P-ISE)	
Moveable test objects	Object controlled/monitored by the CC (TSV/SCT)	
	Subject vehicle (SV/VUT)	

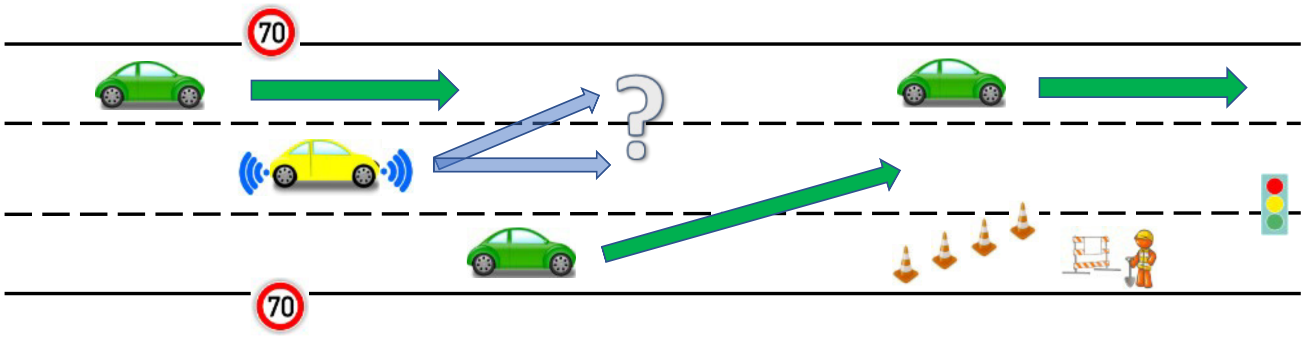


Figure 2 — Example of test scenario

6 General requirements and recommendations

6.1 Function overview

Several techniques and methods used for function and safety testing of autonomous moving test objects are covered by this document and listed below~~.~~:

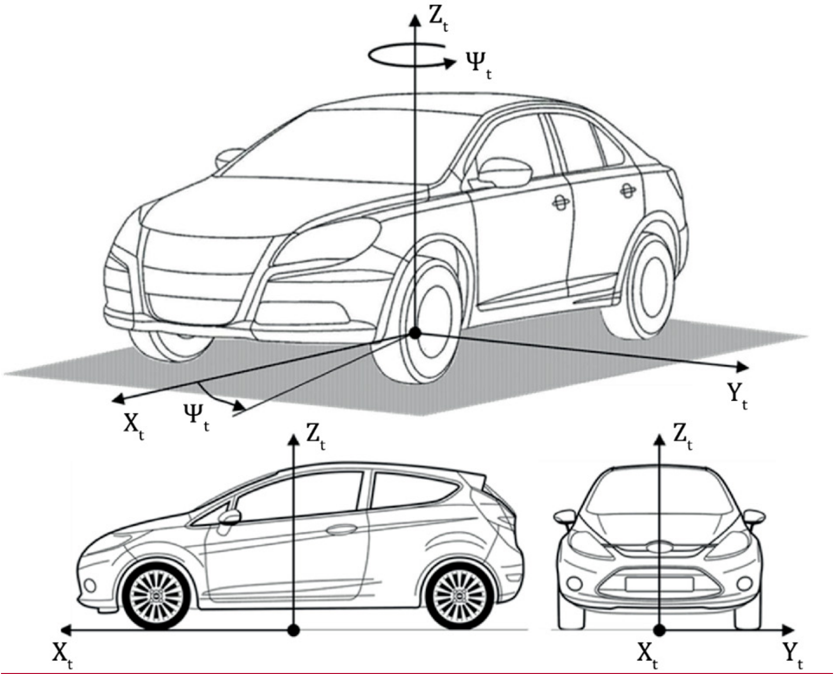
a) ~~Test~~test scenario execution,
b) ~~Static~~static and dynamic trajectory following,
c) ~~Trigger~~trigger and actions,
d) ~~Adaptive~~adaptive synchronization points (master/slave~~)~~),
e) ~~Remote~~remote control driving,
f) ~~Object~~object-to-object communication,
g) ~~Safety~~safety features:
   — ~~Emergency~~emergency stop,
   ~~— Arm/Disarm~~
   — ~~Time~~arm/disarm,
   — time synchronization,
   ~~— Geofencing~~
   — ~~Centralized~~geofencing,
   — centralized control.

6.2 Test object coordinate system

6.2.1 Vehicle

Vehicle coordinate system orientation shall follow ISO 8855. See Figure 3.

If not otherwise stated, the geometrical centre which is the centre of the bounding box of the test object projected on the ground is used as the origin of the coordinate system.



NOTE ψ_t is the rotation about the z_t axis.

Figure 3 — Vehicle reference coordinate system (Source: ISO 19206-3:2021, Figure 2~~[2])~~)

6.2.2 Moveable test objects other than vehicle

6.2.2.1 Bicyclist

Origin is the centre of pedal crankshaft, projected on the ground, see Figure 4 (see also ISO 19206-4:2020, Figure A.1~~[3]).~~).

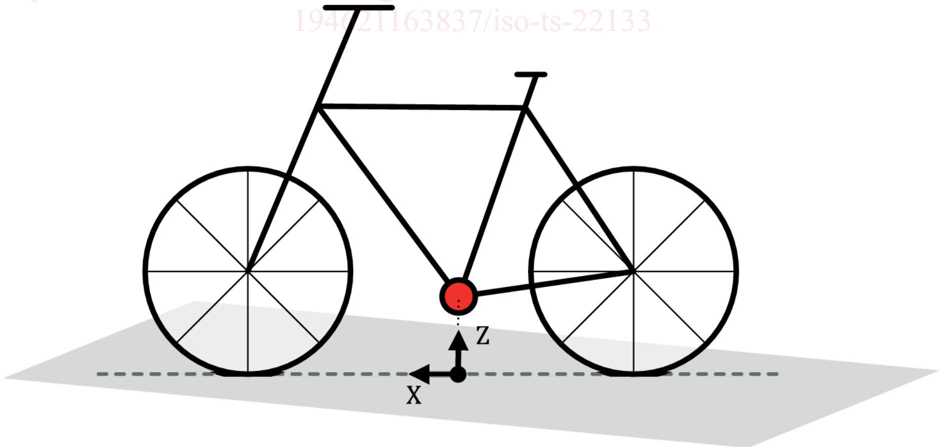


Figure 4 — Bicyclist reference coordinate system

6.2.2.2 Pedestrian

Origin is the centre between the hips, projected on the ground, see Figure 5 (see also ISO 19206-2:2018, Figure A.1~~[1]).~~).