
Intelligent transport systems — Low-speed automated driving (LSAD) systems for predefined routes — Performance requirements, system requirements and performance test procedures

Systèmes de transport intelligents — Systèmes de conduite automatisée à basse vitesse pour des itinéraires prédéfinis (LSAD) — Exigences de performance, exigences du système et procédures de test de performance

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

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 move towards automated driving systems is leading to a shift in the way people, goods and services are transported. One such new mode of transport is low-speed automated driving (LSAD) systems, which operate on predefined routes. LSAD systems will be used for applications like last-mile transportation, transport in commercial areas, business or university campus areas and other low-speed environments.

A vehicle that is driven by the LSAD system (which can include interaction with infrastructure) can potentially have many benefits, like providing safe, convenient and affordable mobility and reducing urban congestion. It can also provide increased mobility for people who are not able to drive. However, with different applications of LSAD systems in the industry worldwide, there is a need to provide guidance for manufacturers, operators, end users and regulators to ensure their safe deployment.

The LSAD system requirements and procedures specified herein are intended to assist manufacturers of the LSAD systems in incorporating minimum safety requirements into their designs and to allow end users, operators and regulators to reference a minimum set of performance requirements in their procurements.

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Intelligent transport systems — Low-speed automated driving (LSAD) systems for predefined routes — Performance requirements, system requirements and performance test procedures

1 Scope

This document specifies:

- requirements for the operational design domain,
- system requirements,
- minimum performance requirements, and
- performance test procedures

for the safe operation of low-speed automated driving (LSAD) systems for operation on predefined routes. LSAD systems are designed to operate at Level 4 automation (see ISO/SAE PAS 22736), within specific operational design domains (ODD).

This document applies to automated driving system-dedicated vehicles (ADS-DVs) and can also be utilized by dual-mode vehicles (see ISO/SAE PAS 22736). This document does not specify sensor technology present in vehicles driven by LSAD systems.

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 19206-2, *Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions — Part 2: Requirements for pedestrian targets*

ISO 19206-3, *Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions — Part 3: Requirements for passenger vehicle 3D targets*

ISO 19206-4, *Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions — Part 4: Requirements for bicyclist targets*

ISO 26262 (all parts), *Road vehicles — Functional safety*

ISO 21448:—¹⁾, *Road vehicles — Safety of the intended functionality*

ISO/SAE PAS 22736:—²⁾, *Taxonomy and definitions for terms related to driving automation systems for on-road motor vehicles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/SAE PAS 22736 and the following apply.

- 1) Under preparation. Stage at the time of publication: ISO/DIS 21448:2021.
- 2) Under preparation. Stage at the time of publication: ISO/SAE PRF PAS 22736:2021.

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

hazardous situation

condition whereby the position, orientation and motion of an obstacle (e.g. pedal cyclists, pedestrians, vehicles, etc.) relative to the position, orientation and motion of the vehicle driven by the LSAD system, can result in an imminent collision

3.2

predefined route

trajectory defined before start of a trip to be traversed by the vehicle driven by the LSAD system, from a point of origin to one (or many) destination(s)

Note 1 to entry: A single trip of a vehicle driven by the LSAD system may have many destinations. A predefined route has a length and curvature but not width.

3.3

minimal risk manoeuvre

MRM

tactical or operational manoeuvre triggered and executed by the LSAD system to achieve minimal risk condition

3.4

trip segment

travel from point of origin to destination or from one destination to another destination in a trip

Note 1 to entry: A trip may comprise multiple trip segments.

3.5

drivable area

manoeuvrable area around the *predefined route* (3.2) where the LSAD system is capable of operating

Note 1 to entry: The width of the drivable area may vary along the predefined route.

3.6

pedal cyclist

human-vehicle combination consisting of a human riding on top of a wheel frame with a steering mechanism, brakes, two pedals for propulsion (optionally with motor assist pedalling) that does not require a licence for use on public roads

3.7

day-time

condition where the ambient illuminance is greater than 2 000 lx

3.8

night-time

condition where the ambient illuminance is less than 1 lx

3.9

standstill

vehicle state when vehicle speed is at 0 m/s

3.10

low-speed automated driving systems

LSAD

automated driving system that has a maximum speed of 8,89 m/s

3.11**low ambient lighting condition**

ambient light between *day-time* (3.7) and *night-time* (3.8)

4 Symbols and abbreviated terms

θ	angle between pedestrian trajectory and vehicle trajectory while in straight section of the evaluation path
ADS-DV	automated driving system-dedicated vehicle
DDT	dynamic driving task
e-stop	emergency stop
LSAD	low-speed automated driving
MaaS	mobility as a service
MRC	minimal risk condition
ODD	operational design domain
R	radius of curvature of trajectory in drivable area
RTI	request to intervene
S_{lat1}	width of drivable area
S_{lat2}	lateral distance between SV and pedestrian starting point
S_{lat3}	lateral distance between SV and target vehicles (TV ₁ and TV ₂)
S_{lat4}	width of reduced drivable area
S_{long}	longitudinal distance of drivable area
S_{long2}	longitudinal distance of evaluation path from situation C
S_{long3}	longitudinal distance between point 1 and point 4
S_{long4}	longitudinal distance between point 1 and point 4 where MRM is triggered
S_{long5}	longitudinal distance between point 4 and end of evaluation path
SV	subject vehicle
$T_{ped_to_Pt2}$	time taken by pedestrian to reach point 2
$T_{pc_to_Pt2}$	time taken by pedal cyclist to reach point 2
TV _(1,2)	target vehicle (1, 2)
V2X	vehicle to - X
V_{LSAD}	velocity for the LSAD system
V_{LSAD_max}	maximum velocity for the LSAD system
V_{pc}	velocity of pedal cyclist

V_{pc_max}	maximum velocity of pedal cyclist
V_{ped}	velocity of pedestrian
V_{ped_max}	maximum velocity of pedestrian
V_{sv_max}	maximum velocity of subject vehicle
VRU	vulnerable road users
DDT	dynamic driving task

5 Example use case for an LSAD system deployment

Vehicles driven by LSAD systems may be used as a part of a larger (MaaS) system. [Figure 1](#) depicts an example system architecture of such a MaaS system. However, the scope of this document is restricted to the LSAD system installed in a vehicle in [Figure 1](#).

As per the example in [Figure 1](#), the LSAD system receives a trip destination from the dispatcher via wireless communication, which in turn receives a destination request from the user (through a web portal or a mobile app). The dispatcher or the control centre processes the destination request and provides a trip/trip segment confirmation to the user and commands the vehicle driven by the LSAD system to proceed. The term "dispatcher" in this document refers to the driverless operation dispatcher (see ISO/SAE PAS 22736).

As there may be more than one predefined route to reach the destination, the selected predefined route may be:

- 1) provided by the dispatcher/control centre;
- 2) selected by the user via a user-interface on a mobile app or on-board the LSAD system equipped vehicle;
- 3) selected by the LSAD system itself.

The LSAD system periodically provides its status (e.g. system health, trip status) to the user and the dispatcher/control server.

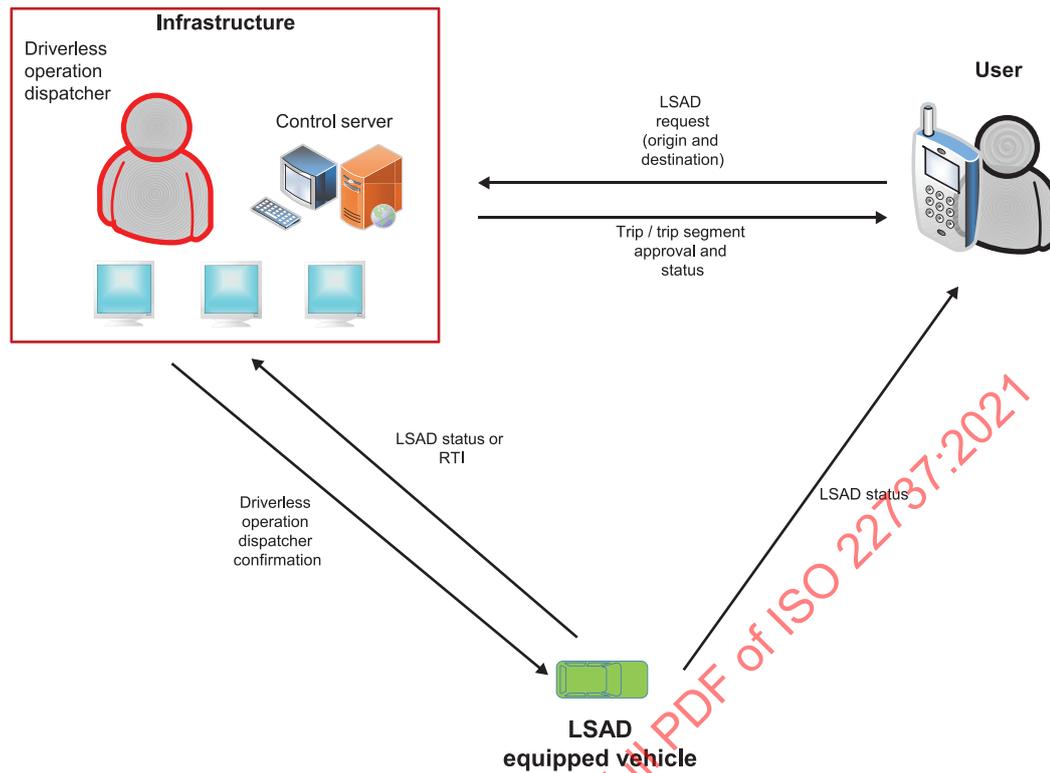
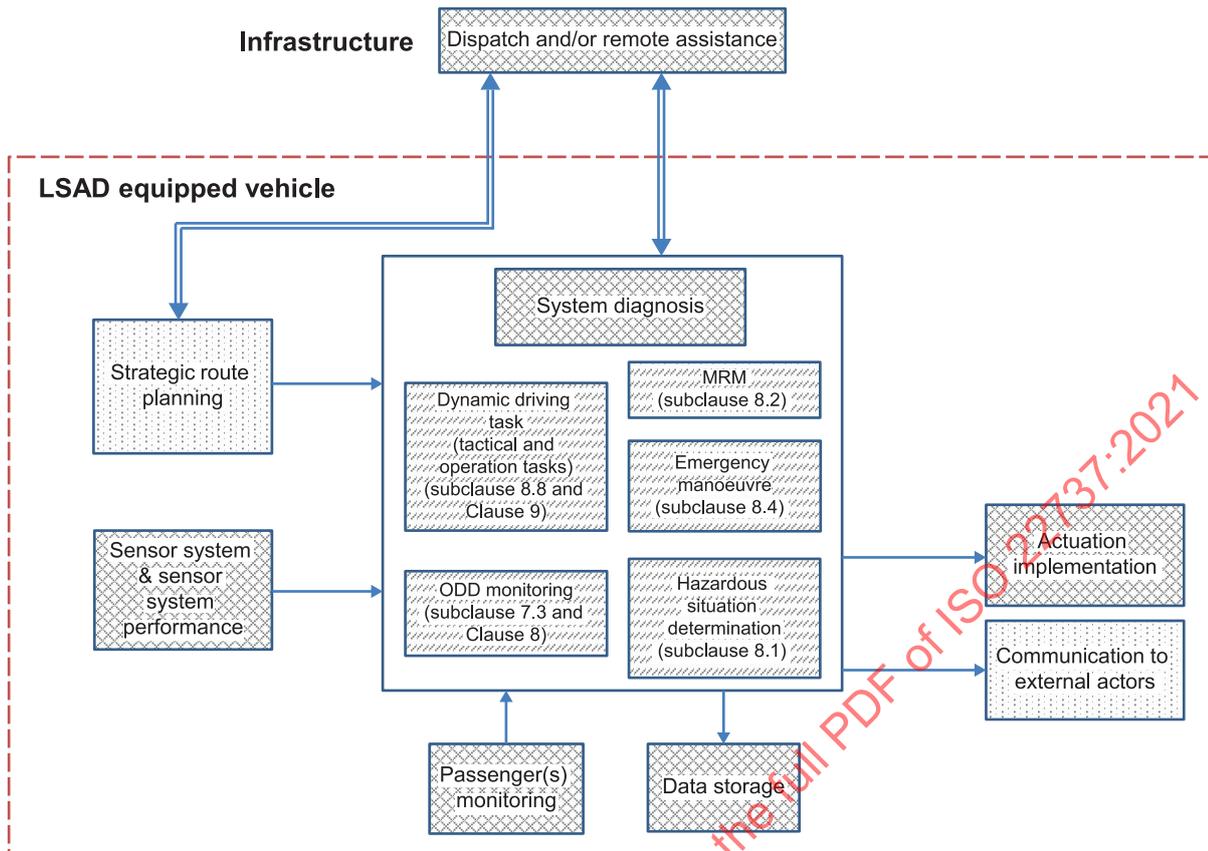


Figure 1 — Example system architecture — LSAD in a MaaS system

6 LSAD system architecture

Figure 2 represents the system architecture of an individual LSAD system. Figure 2 also highlights the components from the LSAD system architecture that are covered within the scope of this document.



- Key**
- functional requirements defined in this document
 - optional features not defined in this document
 - functional requirements not defined in this document

Figure 2 — Example system architecture — Individual LSAD system

7 Basic requirements

7.1 General

The LSAD system shall perform the dynamic driving task (see ISO/SAE PAS 22736). The implementation of the strategic driving tasks (see ISO/SAE PAS 22736) is left to the manufacturer’s discretion. However, the LSAD system shall operate in predefined routes only. The maximum operational speed of an LSAD system engaged vehicle shall be equal to or less than 8,89 m/s or 32 km/h. However, this may be significantly reduced based on special conditions (selected as per the discretion of the driverless operation dispatcher [ISO/SAE PAS 22736]) mentioned in this document, for example time of day, visibility, day of week, rainfall, snow, fog, ice on roads etc.).

The LSAD system shall use sensors in order to enable part of the dynamic driving task. This includes detecting objects, vehicles, pedestrians, buildings, pathways, etc. Appropriate hazard analysis and risk assessment shall be performed for the sensor performance and failures, and other safety critical system elements. The LSAD system development shall be developed according to the ISO 26262 series and ISO 21448.

7.2 Minimum operating capabilities

Subject vehicles driven by the LSAD system shall be capable of performing the following functions:

- a) follow a predefined route to the destination (8.3),
- b) detect a hazardous situation (8.1),
- c) initiate braking and/or steering, to mitigate and/or avoid collision with obstacles (9.1, 9.2),
- d) perform minimal risk manoeuvre (8.2),
- e) inform the dispatcher about the fault state of the LSAD system (e.g. binary flag) (8.4),
- f) provide warnings to road users in case of a hazardous situation.

7.3 Operational design domains (ODDs)

Every LSAD system shall have its ODD defined by the manufacturer. The ODD limitations for an LSAD system shall specify at least the following attributes:

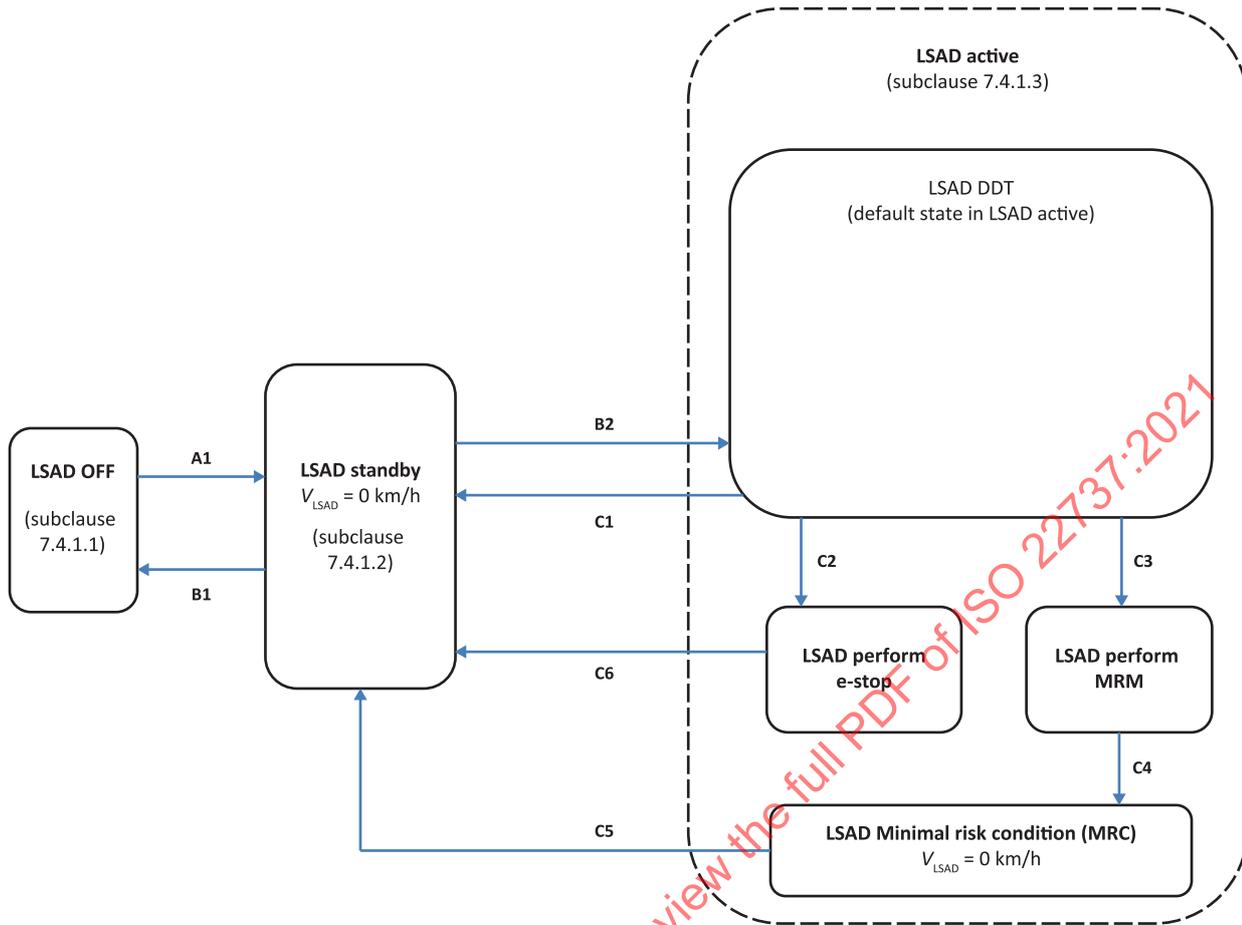
- a) Low speed: the speed of an LSAD system shall be equal to or less than 8,89 m/s or 32 km/h.
- b) Areas of application: for example, either restricted access or dedicated roadways (public or private), or pedestrian/bicycle pathways, or areas from which all or some specific categories of motor vehicles are restricted. Restricted access roadways can be specified by lane markings or speed restriction or physical demarcation. (See Annex D for examples).
- c) Predefined routes: routes defined within the LSAD system before operation of the LSAD system. An LSAD system shall only operate on the predefined routes. Predefined routes shall be defined by relevant stakeholders in conjunction with each other (e.g. local authorities, service providers, manufacturers, etc.). Any deviation from predefined routes shall be confirmed by the dispatcher to not result in a hazardous situation.
- d) Lighting conditions in the area of application.
- e) Weather conditions.
- f) Road conditions.
- g) Presence or absence of VRUs.
- h) Potential presence of static obstacles in the drivable area.
- i) Connectivity requirements.

Either the LSAD systems or the dispatcher should select operating values (for a vehicle driven by the LSAD system) within the boundaries of the predefined values of the ODD attributes for the specified application based on current ODD conditions (e.g. foggy weather conditions, night-time lighting conditions).

EXAMPLE A dispatcher or an LSAD system can decide to restrict the maximum allowable speed on a rainy day to a lower speed as compared to a clear, sunny day.

7.4 LSAD state transition diagram

The LSAD system shall function according to the state transition diagram of Figure 3. Specific implementation, beyond the description in Figure 3 shall be the responsibility of the manufacturer.



Key

- A1 power on and self-test passed
- B1 system failure or power-off dispatcher command or power turned off
- B2 ODD conditions are met and dispatcher has sent engage ADS command and ADS equipped vehicle has data recording capability and has engaged it
- C1 dispatcher disengage command
- C2 passenger or dispatcher initiates emergency stop
- C3 detection of hazardous situation which the LSAD system is unable to handle or DDT performance relevant system failure or loss of safety critical V2X communications or imminent violation of ODD or safe to proceed confirmation authorization not received from dispatcher
- C4 vehicle is in standstill, i.e. 0 m/s
- C5 confirmation to proceed to standby state by dispatcher
- C6 vehicle is in standstill, i.e. 0 m/s, and confirmation to proceed to standby state by dispatcher

Figure 3 — LSAD state transition diagram

7.4.1 LSAD state functional descriptions

7.4.1.1 LSAD off

The LSAD system shall not perform any aspect of the dynamic driving task in the LSAD off state.

7.4.1.2 LSAD standby

In LSAD standby state, the LSAD system shall:

- a) Verify that ODD conditions are satisfied to enable a transition to LSAD active state.
- b) Perform communications with dispatcher.
- c) Remain in standstill.

LSAD standby state may receive an external operating command from the dispatcher selecting the operating values (e.g. nominal or degraded) for the LSAD system when in DDT state.

Note that nominal mode suggests the ideal performance of the vehicle driven by the LSAD system. Degraded mode suggests reduced performance on pre-defined vehicle parameters due to external or the LSAD system's internal conditions.

7.4.1.3 LSAD active

In LSAD active state, the LSAD shall perform the DDT. The LSAD system's maximum operating speed is determined by the dispatcher or by the system itself.

LSAD active state has four sub-states:

- 1) **LSAD DDT sub-state:** This shall be the default sub-state in the LSAD active state. Within the LSAD DDT sub-state, based on the discretion of the LSAD system service providers, LSAD system operating parameters may be dynamically varied. An LSAD system has two basic functions in LSAD DDT sub-state:
 - perform DDT, which includes safely following a predefined route while avoiding a collision with obstacles, and
 - detect the imminent violation of the ODD conditions.
- 2) **LSAD perform e-stop sub-state:** If the passenger or the dispatcher requests an e-stop, in this state the LSAD system shall perform emergency deceleration to bring the vehicle driven by the LSAD system to a standstill and provide state information to the dispatcher and convey the emergency situation externally (e.g. via hazard lights, auditory alert).
- 3) **LSAD perform MRM sub-state:** If any of the triggers for transition C3 are fulfilled, the LSAD system shall perform the minimal risk manoeuvre (MRM) ([subclause 8.2](#)).
- 4) **LSAD MRC sub-state:** In LSAD MRC state, LSAD shall:
 - be in standstill,
 - provide state information to the dispatcher.

In all LSAD active sub-states, the LSAD system shall continuously perform system performance monitoring.

7.4.2 LSAD state transition description:

7.4.2.1 A1

Transition from LSAD off state to LSAD standby state.

Trigger(s):

- a) Power on dispatcher command, and
- b) Power on sequence has been completed and the system has no failures (self-test passed).

7.4.2.2 B1

Transition from LSAD standby state to LSAD off state.

Trigger(s):

- a) Detection of a DDT performance-relevant system failure, or
- b) Power-off dispatcher command or power has been turned off.

7.4.2.3 B2

Transition from LSAD standby state to LSAD active state's default state (LSAD DDT).

Trigger(s):

- a) LSAD system meets its ODD conditions, and
- b) Dispatcher has sent command to transition to LSAD active state (dispatcher engage command), and
- c) Data recorder (see [10.1](#)) has sufficient capacity to store at least an additional safety critical event.

7.4.2.4 C1

Transition from LSAD active state's default state (LSAD DDT) to LSAD standby state.

Trigger(s):

- a) Dispatcher has commanded to disengage LSAD active state (dispatcher disengage command).

7.4.2.5 C2

Transition from LSAD DDT state (LSAD active state's default state) to LSAD perform e-stop state.

Trigger(s):

- a) Passenger or dispatcher initiates an e-stop command.

7.4.2.6 C3

Transition from LSAD DDT state to LSAD Perform MRM state.

Trigger(s):

- a) Detection of a hazardous situation which the LSAD system is unable to resolve, or
- b) Detection of DDT performance relevant system failure, or
- c) Loss of safety critical V2X communications, or
- d) Detection of imminent violation of the ODD conditions by the LSAD system, or
- e) Safe to proceed confirmation authorization not received from the dispatcher (see [7.4.3.1](#)).

7.4.2.7 C4

Transition from LSAD perform MRM state to LSAD MRC state.

Trigger(s):

- a) LSAD vehicle comes to a standstill (i.e. 0 m/s)

7.4.2.8 C5

Transition from LSAD MRC state to LSAD standby state.

Trigger(s):

- a) Dispatcher sends confirmation to proceed to standby state.

7.4.2.9 C6

Transition from LSAD perform e-stop state to LSAD standby state.

Trigger(s):

- a) LSAD vehicle speed is 0 m/s (i.e. LSAD vehicle comes to a standstill), and
- b) Dispatcher sends confirmation to proceed to standby state.

7.4.3 Possible extension of the LSAD state diagram to accommodate dispatcher inputs**7.4.3.1 Safe to proceed confirmation request**

This is a request from LSAD DDT state to dispatcher (external entity) to authorize the vehicle driven by the LSAD system to proceed temporarily outside its drivable area while the LSAD is in LSAD active mode.

It is based on:

- a) Upcoming out of ODD situation (for drivable area) being detected by the LSAD system, or
- b) Blocking of drivable area.

7.4.3.2 Safe to proceed confirmation authorization

This is dispatcher input to the LSAD system while in LSAD active state to confirm that it is safe to proceed.

It is based on:

- a) Whether or not safe to proceed confirmation has been requested by LSAD DDT state.

7.4.3.3 Operating mode command

This is dispatcher input to the LSAD system while in LSAD standby state to select the operating mode (e.g. nominal or degraded) in LSAD DDT state.

7.5 Communication requirements

Depending on the LSAD system implementation, safety critical event data shall be communicated between the vehicle driven by the LSAD system and the dispatcher or control centre. The selection of safety critical data shall be agreed upon by relevant stakeholders (e.g. local authorities, service providers, manufacturers etc.), as per [7.3](#). An example set of communication messages is described in [Annex B](#).

8 Functional requirements

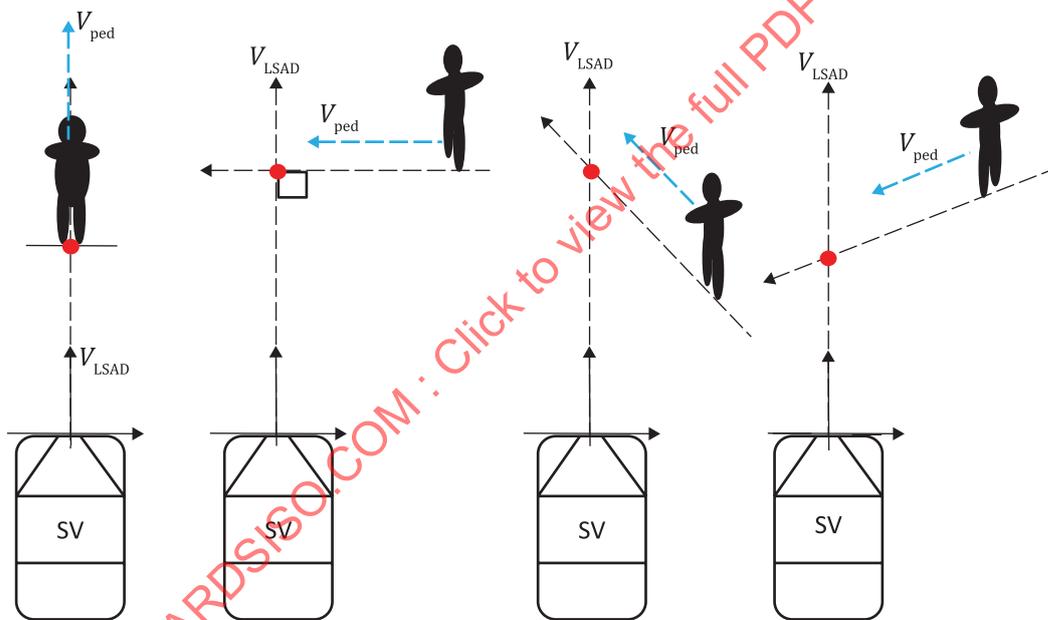
8.1 Determination of hazardous situation

8.1.1 General

In LSAD active state, the LSAD system shall monitor the surrounding environment of the vehicle driven by the LSAD system and shall determine if a hazardous situation exists. A hazardous situation can involve a pedal cyclist, pedestrian (child and adult) or a vehicle and/or stationary and dynamic obstacles. A hazardous situation can be occluded due to other static/dynamic objects. Once the LSAD system has determined the hazardous situation, the system shall act to avoid collision with the obstacle and provide warnings to external road users.

8.1.2 Non-occluded view

As a minimum, the LSAD system shall respond to the hazardous situation involving a pedestrian as shown in [Figure 4](#), where the SV is the vehicle driven by the LSAD system. Typical hazardous situations involving a pedal cyclist are shown in [Figure 5](#), where the SV is the vehicle driven by the LSAD system. [Figure 4](#) and [Figure 5](#) show hazardous situations in which the oncoming object (pedestrian or pedal cyclist) is not occluded.



Key
 SV subject vehicle
 V_{ped} velocity of pedestrian
 V_{LSAD} velocity of LSAD

Figure 4 — LSAD pedestrian hazardous situation

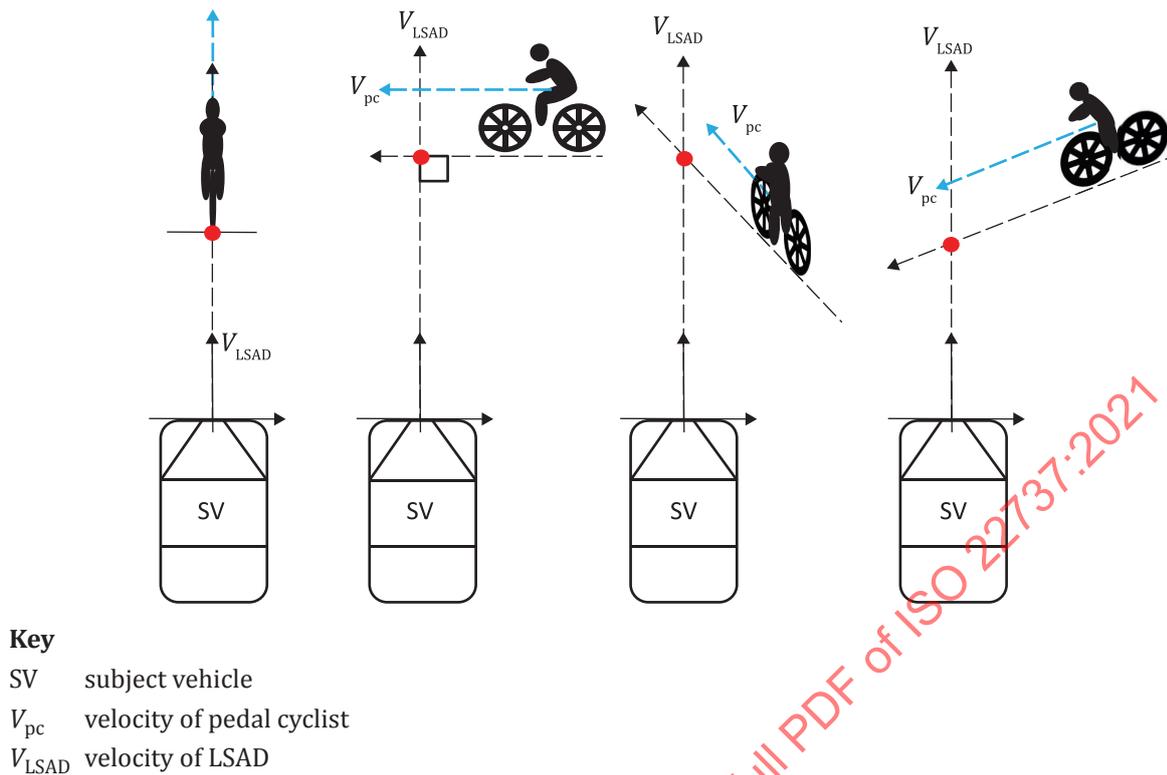
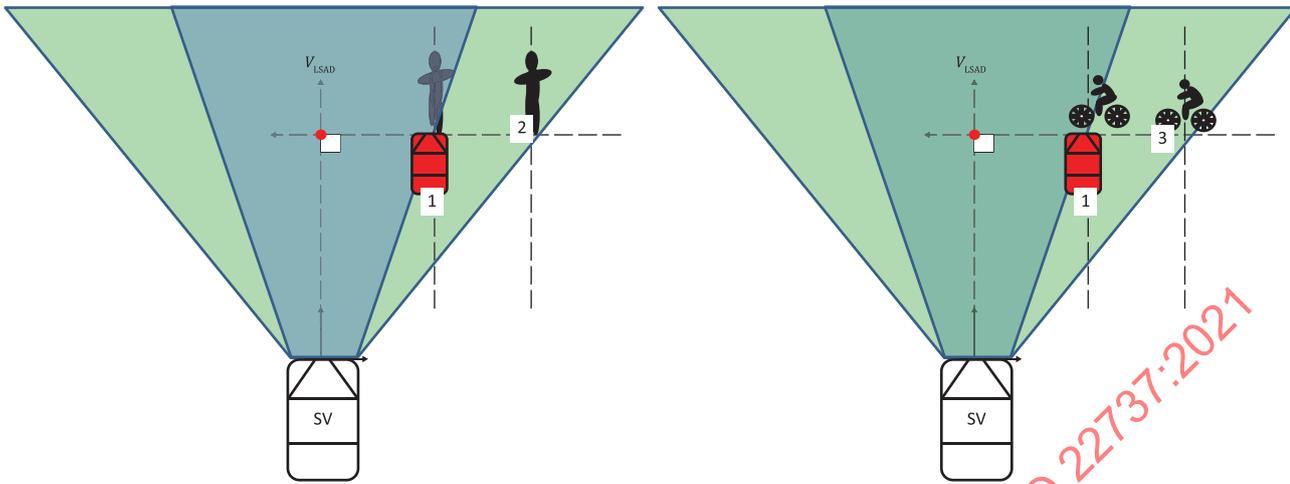


Figure 5 — LSAD pedal cyclist hazardous situation

8.1.3 Occluded view

A typical hazardous situation involving a pedestrian in an occluded situation is shown in [Figure 6 a\)](#), where the SV is the vehicle driven by the LSAD system. A typical hazardous situation involving a pedal cyclist in an occluded situation is shown in [Figure 6 b\)](#), where the SV is the vehicle driven by the LSAD system. In addition, in both the figures two examples of possible detection zones for the vehicle driven by the LSAD system are depicted. The difference between the two detection zones lies in their field of view which may lead to early or late detection of the hazardous situation.



a) Occluded hazardous situation — pedestrian b) Occluded hazardous situation — pedal cyclist

- Key**
- 1 occluding object
 - 2 pedestrian
 - 3 pedal cyclist
 - V_{LSAD} velocity of LSAD

Figure 6 — Occluded hazardous situations — pedestrian and pedal cyclist

8.2 Minimal risk manoeuvre (MRM)

An MRM initiated by the LSAD system shall bring the vehicle to a standstill and may perform steering. When an MRM is initiated by the LSAD system, it shall also provide notification to the occupant(s) and other road users.

A minimal risk manoeuvre (MRM) shall be triggered at least due to the following:

- a) a detection of a hazardous situation which the LSAD system is unable to resolve, or
- b) a DDT performance relevant system failure, or
- c) a safety critical V2X communications loss, or
- d) imminent violation of the ODD conditions by the LSAD system, or
- e) safe to proceed confirmation authorization not received from the dispatcher.

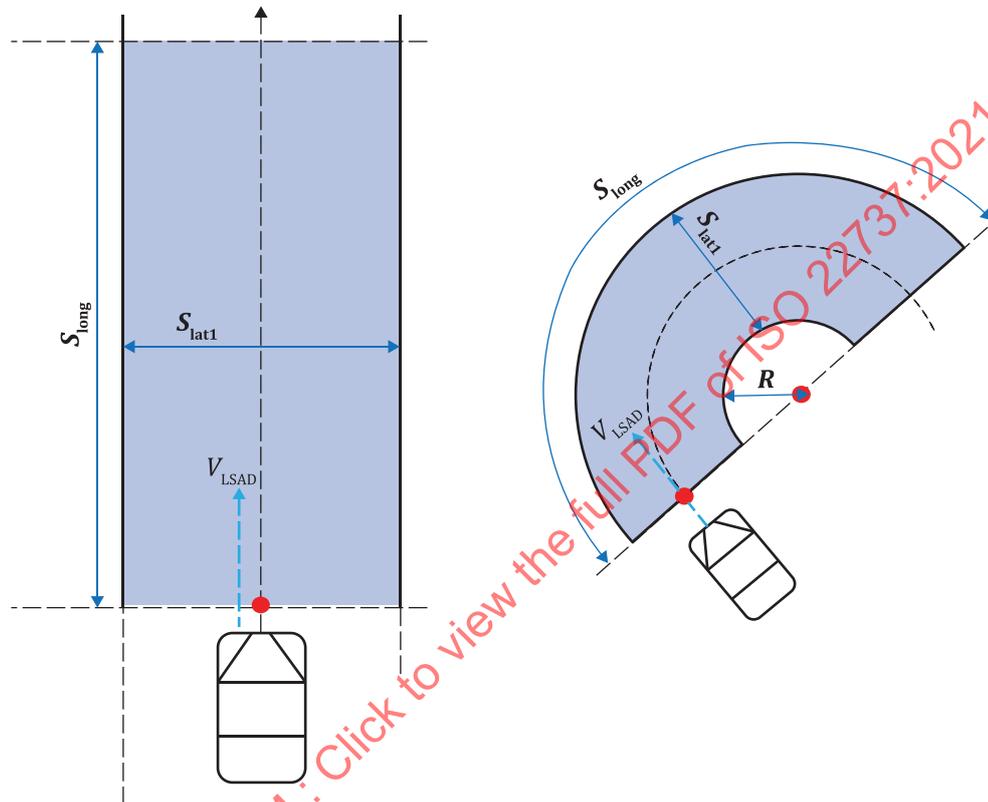
An MRM is initiated by the system, whereas an emergency stop (8.4) is initiated by the passenger or the dispatcher.

In cases where the LSAD system has performed an MRM stop, the system shall communicate the information about its MRC to the dispatcher. The dispatcher shall confirm the safety of the LSAD system to invoke the transition from MRC to LSAD standby state.

NOTE An MRM is different from the degraded mode of the LSAD DDT sub-state by virtue of the fact that at the end of an MRM the vehicle will be at standstill, whereas in the LSAD DDT sub-state the vehicle continues to drive.

8.3 Driving in the drivable area

A vehicle driven by the LSAD system shall always remain within the drivable area defined as part of the predefined route for the system. The drivable area shall always include the route along with the width of the path (for the route), i.e. for defining the drivable area both S_{long} and S_{lat1} (in Figure 7) shall be specified throughout the predefined route by the relevant stakeholder. S_{lat1} may vary along the predefined route. For curved routes, radius of curvature, R , shall also be defined. Parameters S_{lat1} and R may vary along the length of the route.



Key

V_{LSAD}	velocity of LSAD system equipped vehicle (m/s)	S_{lat1}	width of drivable area (m)
S_{long}	longitudinal distance of drivable area (m)	R	radius of curvature of drivable area (m)

Figure 7 — Drivable area

Depending upon the ODD definition by the manufacturer, maximum allowable V_{LSAD} may be different for straight roads and curved roads.

8.4 Emergency stop (e-stop)

An e-stop is the emergency stop function that is activated by a vehicle driven by the LSAD system passengers or dispatcher when they detect an emergency situation such as a fire or if the vehicle is not driving safely.

A passenger-initiated emergency stop shall be appropriately triggered if the passenger presses the emergency stop (e-stop) button present in the vehicle driven by the LSAD system. A passenger may press the e-stop due to occupant illness, undesired behaviour of the LSAD system-equipped vehicle, LSAD system-equipped vehicle becoming incapacitated, etc. The e-stop interface shall be visible, easy to understand and accessible to passengers.

A dispatcher-initiated emergency stop shall be triggered if the dispatcher commands the emergency stop. A dispatcher may command the e-stop due to vehicle driven by the LSAD system becoming

incapacitated, a change in ODD conditions, the detection of a hazardous situation that the LSAD system has not recognized, etc.

In order for the LSAD system to re-engage to active state, a confirmation from the dispatcher shall be required to ensure the system integrity of the LSAD system and the equipped vehicle.

9 Performance requirements for the LSAD system

9.1 Maximum subject vehicle speed (V_{SV_max})

All vehicles driven by the LSAD system shall have an upper limit of 8,89 m/s (32 km/h) for maximum velocity ($V_{LSAD} = V_{SV_max}$).

9.2 Obstacle detection requirements

9.2.1 Maximum pedestrian speed (V_{ped_max})

The maximum pedestrian speed which the vehicle driven by the LSAD system shall be required to detect is 2,22 m/s or 8 km/h. Vehicles driven by an LSAD system may be able to detect pedestrians travelling at higher speeds.

Relevant stakeholders may decide to add additional requirements (e.g. higher target speeds in accordance with the ODD definition).

9.2.2 Maximum pedal cyclist speed (V_{pc_max})

The maximum pedal cyclist speed which the vehicle driven by the LSAD system shall be required to detect is 6,94 m/s (25 km/h). Vehicles driven by LSAD system can be able to detect pedal cyclists travelling at higher speeds.

Relevant stakeholders may decide to add additional requirements (e.g. higher target speeds in accordance with the ODD definition).

9.2.3 LSAD system deceleration

Vehicles driven by the LSAD system shall have a maximum deceleration of 4,9 m/s² for MRM.

If an e-stop (passenger- or dispatcher-initiated) or an MRM is triggered, the LSAD system shall apply a deceleration up to a maximum deceleration of 4,9 m/s², until the vehicle comes to a standstill.

If the vehicle driven by the LSAD system can accommodate standing occupants, it shall have the capability to detect standing occupants and reduce the deceleration if standing occupants are detected.

10 System requirements

10.1 Recording data about a safety-critical event

LSAD systems shall maintain the capability to record vehicle status and parameters throughout its operation for enabling post-hoc analysis. The data recorder shall store data when the following events occur:

- MRM
- e-stop
- collision

- other events as required by the relevant stakeholders (e.g. local authorities, service providers, manufacturers, etc.)

There may be more than one data recorder. The LSAD system shall provide the ability to recover data for at least 30 seconds prior to the safety-critical event and at least until the vehicle is at a standstill or 30 seconds after, whichever is earlier.

If the data recorder does not have capacity to store further events, the vehicle driven by the LSAD system shall remain in LSAD standby state until the data have been preserved according to the requirements of the relevant stakeholders and memory has been freed. An example set of data to be recorded is described in [Annex C](#).

11 Performance test procedures

11.1 General

Test procedures defined in this clause are not intended to be used as exhaustive conformance tests. They are basic validation tests for use by the LSAD system stakeholders (e.g. local authorities, service providers, manufacturers, etc.). If there are any changes in system functionality after the initial test procedure validation, the test procedures shall be re-performed depending upon the criticality of the changes to the system functionality. More extensive tests may be performed, at the discretion of the manufacturer and in consultation with relevant stakeholders (for example using higher target speeds in accordance with the ODD definition), to ensure the LSAD system's conformance to the functional requirements of this document. A test run shall be invalid if the test parameters and tolerances are not met.

Manufacturers shall perform the test procedures relevant to the defined ODD of the LSAD system. For example, if the ODD of a particular LSAD system precludes night-time operation, then it may not be required to perform the night-time test procedures. [Table 1](#) provides an example test matrix guide with respect to ODD parameters defined by the manufacturer.

Table 1 — Example of test matrix guide for test procedure selection depending on the LSAD system ODD parameters

LSAD system ODD parameters specification	Relevant test procedure
VRU (pedestrian) present	Hazardous situation test (pedestrian).
VRU (pedal cyclist) present	Hazardous situation test (pedal cyclist).
Night-time operation	Night-time test conditions (for all test procedures in 11.3 , 11.4 and 11.5).
Day-time operation	Day-time test conditions (for all test procedures in 11.3 , 11.4 and 11.5).
Operational in rain	Environmental conditions shall include rain (for all test procedures in 11.3 , 11.4 and 11.5).

See [Annex A](#) for information on test speeds for hazardous situation tests.

11.2 Environmental parameters

Environmental conditions shall be selected based on the specific ODD for the application. It is recommended to select the ODD attributes (e.g. rainfall, lighting conditions etc.) at their boundary values.

11.3 Hazardous situation

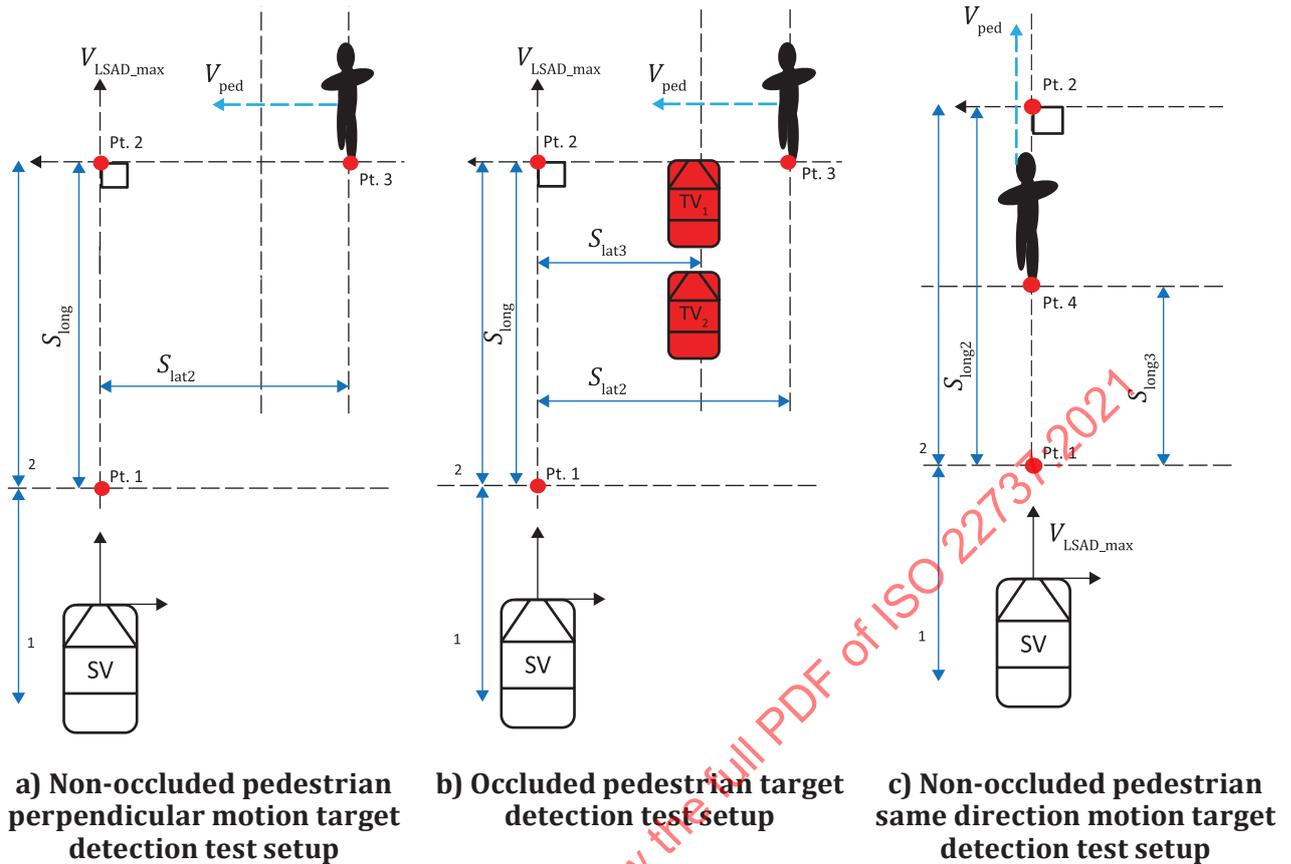
11.3.1 Pedestrian as an obstacle

11.3.1.1 Test setup

[Figure 8](#) depicts the test setup for pedestrian hazardous situation tests. [Figure 8](#) a) depicts a non-occluded pedestrian hazardous situation. [Figure 8](#) b) depicts a pedestrian target occluded by two stationary vehicles. [Figure 8](#) c) depicts a non-occluded pedestrian target moving in the same direction as the SV. Pedestrian test targets used in the test procedures shall be in accordance with ISO 19206-2. Both adult and 7-year old child targets shall be used in the test setup.

The stationary vehicle target in [Figure 8](#) b) shall be in accordance with ISO 19206-3.

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Key

- V_{LSAD_max} max. velocity of LSAD system-equipped vehicle (m/s)
- S_{long} longitudinal distance of the evaluation path (m) for situation A and situation B
- S_{long2} longitudinal distance of evaluation path (m) for situation C
- V_{ped} velocity of pedestrian (m/s)
- S_{lat2} lateral distance between SV and pedestrian starting point (m)
- S_{lat3} lateral distance between SV and target vehicles (TV_1 and TV_2) (m)
- S_{long3} distance between Pt. 1 and Pt. 4 (m)
- Pt.1 beginning of evaluation path
- Pt.2 end of evaluation path
- Pt.3 point by which V_{ped} = specified target speed for situation A and situation B
- Pt.4 point at which V_{ped} = specified target speed for situation C
- SV subject vehicle
- TV_x target vehicle ($x = 1, 2$)
- 1 approach path
- 2 evaluation path

Figure 8 — Pedestrian target (occluded and non-occluded) detection test setup

11.3.1.2 Vehicle parameters

Vehicle speed (V_{LSAD_max}) at point 1 shall be “test speed” $\pm 0,07$ m/s at point 1. “Test speed” shall be the maximum operating speed of the vehicle driven by the LSAD system defined by the manufacturer or other relevant stakeholders.

11.3.1.3 Pedestrian target parameters – Situation A

The speed of the pedestrian target (V_{ped}) shall be $2,2 \pm 0,07$ m/s by the time it reaches point 3. The lateral distance of the pedestrian (at point 3) from the vehicle centreline shall be $4 \pm 0,1$ m (S_{lat2}).

11.3.1.4 Pedestrian and vehicle target parameters – Situation B

The speed of the pedestrian target (V_{ped}) shall be $1,39 \pm 0,07$ m/s by the time it reaches point 3. The lateral distance of the pedestrian (at point 3) from the vehicle centreline shall be $4 \pm 0,1$ m (S_{lat2}).

Pedestrian targets to be used shall include adult and child targets as per ISO 19206-2, for both situation A and situation B test procedures.

Lateral distance between target vehicles [TV_1 and TV_2] centreline and SV centreline shall be $3 \pm 0,1$ m (S_{lat3}). The front edge of TV_1 shall be set 1m before the lateral line on point 2, and the distance between the rear edge of TV_1 and the front edge of TV_2 shall be 1 m.

11.3.1.5 Pedestrian target parameters – Situation C

The speed of the pedestrian target (V_{ped}) shall be $2,2 \pm 0,07$ m/s by the time it reaches point 4. The longitudinal distance of the pedestrian (at point 4) from point 1 shall be 25 ± 1 m (S_{long3}). If $V_{LSAD_max} < V_{ped}$, then V_{ped} shall be lowered to be less than V_{LSAD_max} for the situation C test.

11.3.1.6 Longitudinal start distance

The longitudinal start distance (S_{long}) for the evaluation of the test (in situation A and B) shall be dependent on the top speed of the LSAD system (V_{LSAD_max}). According to the top speed of the vehicle driven by the LSAD system, S_{long} shall be calculated as per [Formula \(1\)](#) and [Formula \(2\)](#):

$$T_{ped_to_pt2} = \frac{S_{lat2}}{V_{ped}} \quad (1)$$

$$S_{long} = V_{LSAD_max} \times T_{ped_to_pt2} + 1m \quad (2)$$

The longitudinal start distance for the evaluation of the test (in situation C) shall be at least 75 ± 1 m (S_{long2}).

11.3.1.7 Environmental parameters

Ambient temperature shall be between 5 °C and 40 °C. Depending on the ODD definition, the test shall be done both in daylight (in excess of 2 000 lux) and in low ambient lighting conditions. Lighting measurements shall be made at the point of collision. Additional environmental conditions may be selected in consultation with relevant stakeholders.

11.3.1.8 Pass criteria

The test procedure shall be repeated 5 times for a 7-year old child target. The test shall be considered as a pass if the vehicle driven by the LSAD system (SV) completely avoids colliding with each of the pedestrian targets and has provided external warning for 5 consecutive runs. For situation C, the test shall be considered as a pass if the vehicle maintains a distance of at least $1 \pm 0,1$ m behind the pedestrian for 5 consecutive runs.

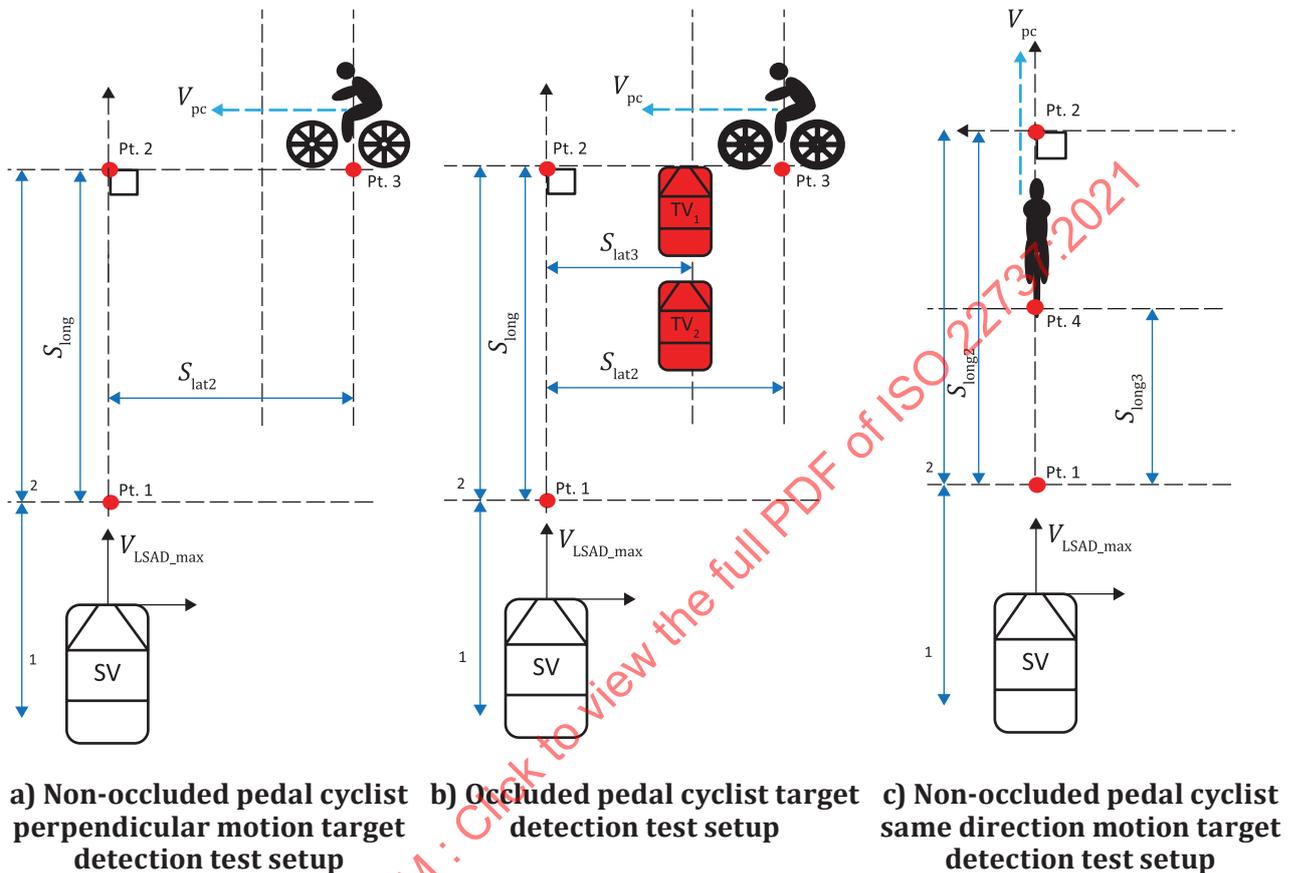
11.3.2 Pedal cyclist as an obstacle

11.3.2.1 Test setup

[Figure 9](#) depicts the test setup for pedal cyclist target hazardous situation test. [Figure 9](#) a) depicts a non-occluded pedal cyclist target. [Figure 9](#) b) depicts a pedal cyclist target occluded by two stationary

vehicles. Figure 9 c) depicts a non-occluded pedal cyclist travelling in the direction of the subject vehicle. Pedal cyclist test targets used for the test procedure shall be in accordance with ISO 19206-4. For the purposes of the test procedures defined in this section, the wheels on the pedal cyclist target shall rotate, pedalling is optional for the test procedures.

The stationary vehicle target shall be in accordance with ISO 19206-3.



Key

- V_{LSAD_max} max velocity of LSAD system equipped vehicle (m/s)
- S_{long} longitudinal distance of the evaluation path (m) for situation A and situation B
- S_{long2} longitudinal distance of the evaluation path (m) for situation C
- V_{pc} velocity of pedal cyclist (m/s)
- S_{lat3} lateral distance between SV and target vehicles (TV_1 and TV_2) (m)
- SV subject vehicle
- S_{long3} distance between point 1 and point 4 (m)
- Pt.1 beginning of evaluation path
- Pt.2 end of evaluation path
- Pt.3 point by which V_{pc} = specified target speed (situation A & situation B)
- Pt.4 point by which V_{pc} = specified target speed (situation C)
- S_{lat2} lateral distance between SV and pedal cyclist starting point (m)
- TV_x target vehicle ($x = 1, 2$)
- 1 approach path
- 2 evaluation path

Figure 9 — Pedal cyclist target (occluded and non-occluded) detection test setup

11.3.2.2 Vehicle parameters

Vehicle speed (V_{LSAD_max}) shall be “test speed” $\pm 0,07$ m/s at point 1. “Test speed” shall be the maximum operating speed of vehicle driven by the LSAD system defined by the manufacturer or other relevant stakeholders.

11.3.2.3 Pedal cyclist target parameters – Situation A

The speed of pedal cyclist target (V_{pc}) shall be $4,16 \pm 0,07$ m/s by the time it reaches point 3.

The lateral distance of the pedal cyclist (at point 3) from the vehicle centreline shall be $4 \pm 0,1$ m (S_{lat2}).

11.3.2.4 Pedal cyclist and Vehicle Target Parameters – Situation B

The speed of pedal cyclist target (V_{pc}) shall be $2,77 \pm 0,07$ m/s by the time it reaches point 3.

The lateral distance of the pedal cyclist (at point 3) from the vehicle centreline shall be $4 \pm 0,1$ m (S_{lat2}).

The lateral distance between target vehicles (TV_1 and TV_2) centreline and SV centreline shall be $3 \pm 0,1$ m (S_{lat3}). The front edge of TV_1 shall be set 1 m before the lateral line on point 2, and the distance between rear edge of TV_1 and front edge of TV_2 shall be 1 m.

11.3.2.5 Pedal cyclist target parameters – Situation C

The speed of pedal cyclist target (V_{pc}) shall be $4,16 \pm 0,07$ m/s by the time it reaches point 4. The longitudinal distance of the pedal cyclist (at point 4) from point 1 shall be 15 ± 1 m (S_{long3}).

If $V_{LSAD_max} < V_{pc}$, then V_{pc} shall be lowered to be less than V_{LSAD_max} for situation C test.

11.3.2.6 Longitudinal start distance, S_{long}

The longitudinal start distance (S_{long}) for the evaluation of the test (in situation A and situation B) shall be dependent on the top speed of the LSAD system (V_{LSAD_max}). According to the top speed of the vehicle driven by the LSAD system, S_{long} shall be calculated as per [Formula \(3\)](#) and [Formula \(4\)](#):

$$T_{pc_to_pt2} = \frac{S_{lat2}}{V_{pc}} \quad (3)$$

$$S_{long} = V_{LSAD_max} \times T_{pc_to_pt2} + 1\text{m} \quad (4)$$

The longitudinal start distance for the evaluation of the test (in situation C) shall be at least 75 ± 1 m (S_{long2}).

11.3.2.7 Environmental parameters

Ambient temperature shall be between 5 °C and 40 °C. Depending on the ODD definition, the test shall be performed both in daylight (in excess of 2 000 lux) and in low ambient lighting conditions. Additional environmental conditions may be selected in consultation with relevant stakeholders.

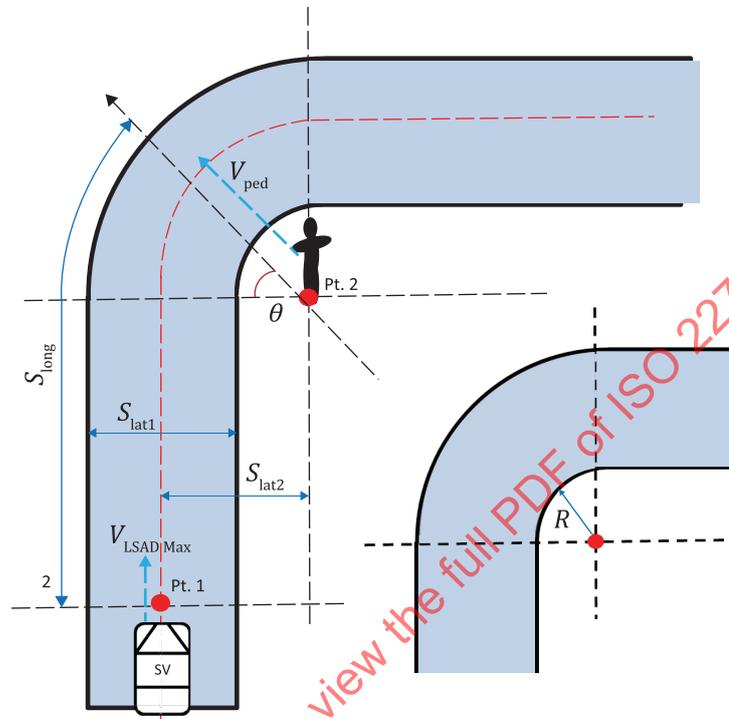
11.3.2.8 Pass criteria

The test procedure shall be repeated 5 times. The test shall be considered as a pass if the vehicle driven by the LSAD system (SV) completely avoids colliding with the pedal cyclist target and shall provide warning for external road users for 5 consecutive runs. For situation C, the test shall be considered as a pass if the vehicle maintains a distance of at least $1 \pm 0,1$ m behind the pedal cyclist for 5 consecutive runs.

11.3.3 Hazardous situation turning around a corner

11.3.3.1 Test setup

Figure 10 depicts the test setup for a hazardous situation test for a turning around a corner. Pedestrian test targets used in the test procedure shall be in accordance with ISO 19206-2.



Key

V_{LSAD_max}	max. velocity of LSAD system equipped vehicle (m/s)
S_{long}	longitudinal distance of the evaluation path (m)
V_{ped}	velocity of pedestrian (m/s)
SV	subject vehicle
R	radius of curvature of the bend
Pt.1	beginning of evaluation path
Pt.2	point by which V_{ped} = specified target speed
S_{lat1}	width of drivable area (m)
S_{lat2}	lateral distance between SV and pedestrian starting point (m)
θ	angle between pedestrian trajectory and vehicle trajectory while in straight section of the evaluation path
2	evaluation path

Figure 10 — Hazardous situation test — Turning around a corner

11.3.3.2 Vehicle parameters

Vehicle speed (V_{LSAD_max}) at point 1 shall be “test speed” $\pm 0,07$ m/s.

11.3.3.3 Pedestrian target parameters

The speed of pedestrian target (V_{ped}) shall be $2,2 \pm 0,07$ m/s by the time it has reached point 2.

Lateral distance of the pedestrian (at point 2) from the vehicle centreline shall be $4 \pm 0,1$ m (S_{lat2}) and α shall be between 45° and 75° . R shall be between $3,05 \pm 0,1$ m and $4,57 \pm 0,1$ m.

11.3.3.4 Longitudinal start distance (S_{long})

The longitudinal start distance (S_{long}) for the evaluation of the test shall be dependent on the top speed of the LSAD system (V_{LSAD_max}). According to the top speed of the vehicle driven by the LSAD system, S_{long} shall be calculated as per [Formula \(5\)](#) and [Formula \(6\)](#):

$$T_{ped_to_pt2} = \frac{R}{V_{ped}} \quad (5)$$

$$S_{long} = V_{LSAD_max} \times T_{ped_to_pt2} + 1\text{m} \quad (6)$$

11.3.3.5 Lateral detection evaluation zone (S_{lat1})

The width of the evaluation zone (S_{lat1}) shall be $4,5 \pm 0,1$ m.

11.3.3.6 Environmental parameters

Ambient temperature shall be between 5°C and 40°C . Depending on the ODD definition, the test shall be performed both in daylight (in excess of 2 000 lux) and in low ambient lighting conditions.

Additional environmental conditions may be selected in consultation with relevant stakeholders.

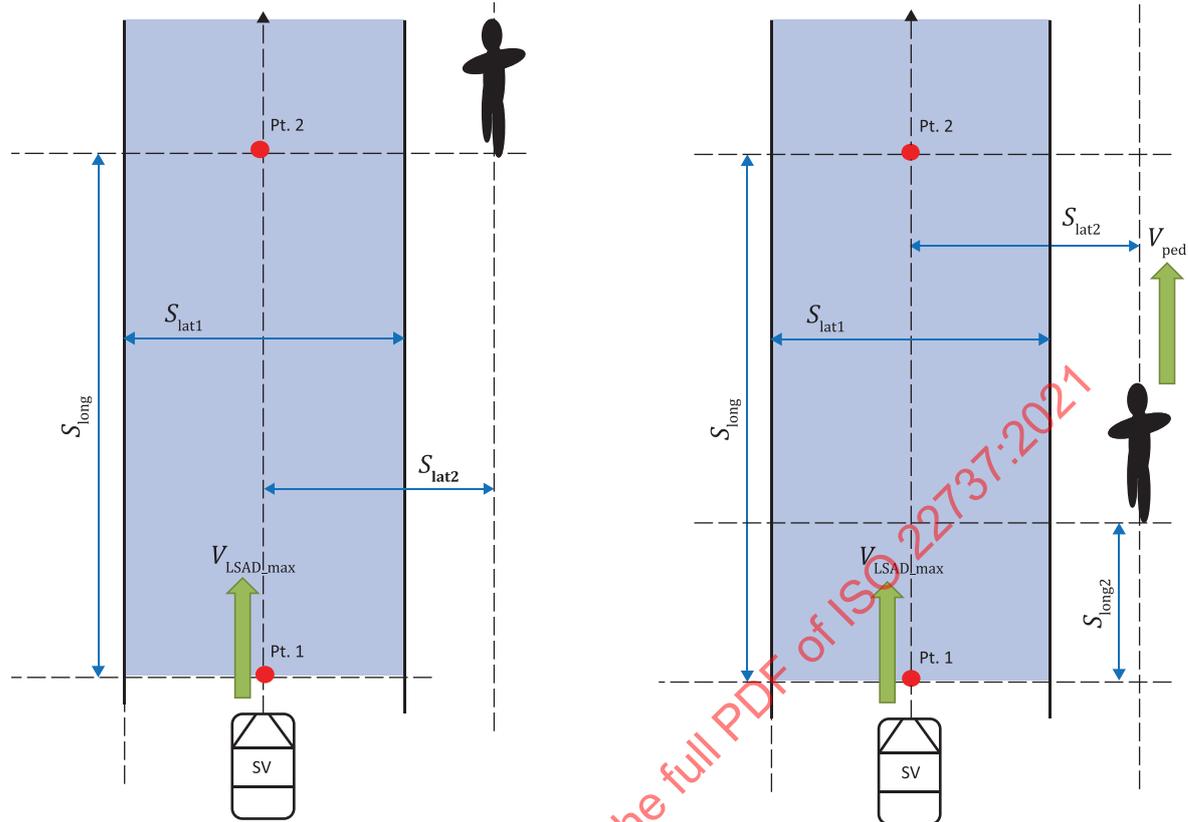
11.3.3.7 Pass criteria

The test procedure shall be repeated 5 times. The test shall be considered as a pass if the vehicle driven by the LSAD system (SV) completely avoids colliding with the pedestrian target and provides external warning for 5 consecutive runs. External warning may be visual or audible or both.

11.3.4 False positive tests

11.3.4.1 Test setup

[Figure 11](#) depicts the test setup for false positive test for hazardous situations. [Figure 11](#) a) depicts a static pedestrian target. [Figure 11](#) b) depicts a moving (in direction of vehicle driven by the LSAD system) pedestrian target. Pedestrian test targets used in the test procedure shall be in accordance with ISO 19206-2.



a) False positive test setup (static pedestrian target) b) False positive test setup (moving pedestrian target)

Key

- V_{LSAD_max} max. velocity of the LSAD system equipped vehicle (m/s)
- S_{long} longitudinal distance of the evaluation path (m)
- V_{ped} velocity of pedestrian (m/s)
- SV subject vehicle
- S_{long2} longitudinal distance between SV at point 1 and pedestrian starting point (test B) (m)
- Pt.1 beginning of evaluation path
- Pt.2 end of evaluation path
- S_{lat1} width of drivable area (m)
- S_{lat2} lateral distance between SV and pedestrian (m)

Figure 11 — Test setup for false positive test for hazardous situations

11.3.4.2 Vehicle parameters

The vehicle speed (V_{LSAD_max}) at point 1 shall be “test speed” $\pm 0,07$ m/s. “Test speed” shall be the maximum operating speed of vehicle driven by the LSAD system defined by the manufacturer or other relevant stakeholders

11.3.4.3 Pedestrian target parameters – Situation A, Figure 12 a)

The pedestrian target shall be static at $3 \pm 0,1$ m from vehicle centreline (S_{lat2}).

11.3.4.4 Pedestrian target parameters – Situation B, Figure 12 b)

The speed of pedestrian target (V_{ped}) shall be $2,2 \pm 0,07$ m/s parallel to the SV direction of travel.

The starting position of the pedestrian target shall be 3 ± 01 m from vehicle centreline (S_{lat2}), and $5 \pm 0,1$ m from Pt. 1 in the longitudinal direction (S_{long2}).

11.3.4.5 Longitudinal distance (S_{long})

The longitudinal distance (S_{long}) shall be 30 ± 1 m.

11.3.4.6 Environmental parameters

Ambient temperature shall be between $5\text{ }^{\circ}\text{C}$ and $40\text{ }^{\circ}\text{C}$. Depending on the ODD definition, the test shall be performed both in daylight (in excess of 2 000 lux) and in low ambient lighting conditions.

Additional environmental conditions may be selected in consultation with relevant stakeholders.

11.3.4.7 Pass criteria

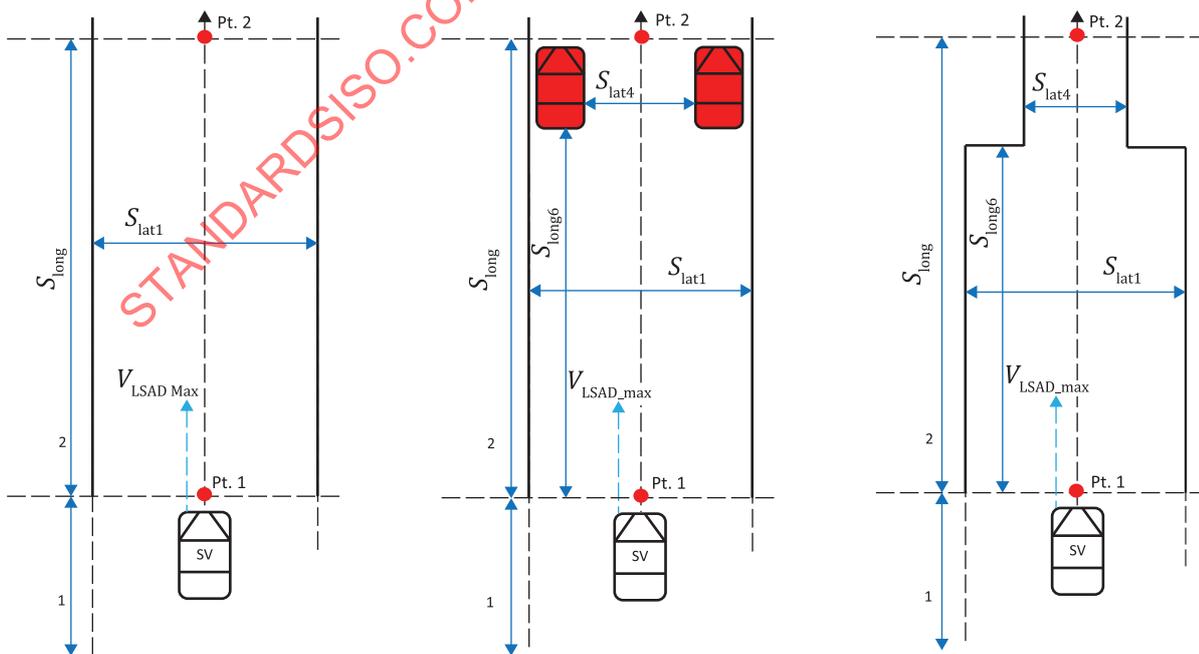
The test procedure shall be repeated 5 times. The test shall be considered as a pass if the vehicle driven by the LSAD system (SV) completely continues driving from point 1 and point 2 and it passes the pedestrian without coming to a standstill for 5 consecutive runs.

11.4 Drivable area test

11.4.1 Test setup

This test is defined to test that the vehicle driven by the LSAD system always remains within the driveable area defined as part of the predefined route for the system. Figure 12 depicts the test setup for the drivable area test. Figure 12 a) depicts an unblocked drivable area. Figure 12 b) depicts a blocked drivable area. Figure 12 c) depicts a drivable area becoming narrow.

The stationary vehicle target shall be in accordance with ISO 19206-3.



a) Drivable area (unblocked) test setup

b) Drivable area (blocked) test setup

c) Drivable area (shrinking area) test setup

Key

$V_{\text{LSAD_max}}$	max. velocity of the LSAD system equipped vehicle (m/s)
SV	subject vehicle
S_{long}	longitudinal distance of the evaluation path (m)
S_{long6}	longitudinal distance point 1 and rear-end of obstacle (test B) / beginning of reduced drivable area section (test C) (m)
Pt.1	beginning of evaluation path
Pt.2	end of evaluation path
S_{lat1}	width of drivable area (m)
S_{lat4}	width of reduced drivable area (m)
1	approach path
2	evaluation path

Figure 12 — Test setup for the drivable area test

In both blocked and unblocked test setups, the vehicle shall be tested at its maximum allowable speed (equal to or less than 8,89 m/s or 32 km/h) as decided by the relevant stakeholders. The vehicle shall start in an approach path in such a way that at Pt. 1 in the [Figure 12](#) the vehicle has achieved its maximum allowable speed. Point 1 is depicted by the start of the evaluation path and is not necessarily at the lateral mid-point of the evaluation path.

In the blocked drivable area test, stationary vehicles will be placed (as determined by the testing organizations or local government agencies) in the evaluation path.

11.4.2 Vehicle parameters

Vehicle speed ($V_{\text{LSAD_max}}$) at point 1 shall be “test speed” $\pm 0,07$ m/s. “Test speed” shall be the maximum operating speed of vehicle driven by the LSAD system defined by the manufacturer or other relevant stakeholders.

11.4.3 Evaluation path parameters

The length of the evaluation path (S_{long}) shall be 100 ± 1 m.

The width of the evaluation path (S_{lat1}) shall be three times the width of SV or 6,5 (whichever is larger) $\pm 0,1$ m. S_{long6} shall be more than 50 ± 1 m.

The width of the narrowed evaluation path or blocked evaluation path (S_{lat4}) shall be decided in consultation with the LSAD system stakeholders for the specified predefined route and shall be up to a maximum of twice the width of the LSAD equipped vehicle.

11.4.4 Environmental parameters

The ambient temperature shall be between 5 °C and 40 °C. Depending on the ODD definition, the test shall be performed both in daylight (in excess of 2 000 lux) and in low ambient lighting conditions.

Additional environmental conditions may be selected in consultation with relevant stakeholders.

11.4.5 Pass criteria for unblocked drivable area

The test procedure shall be repeated 5 times. The test shall be considered as a pass if the vehicle driven by the LSAD system (SV) always crosses the evaluation path while remaining within the lateral bounds of the evaluation path for all 5 runs.

11.4.6 Pass criteria for blocked drivable area

The test procedure shall be repeated 5 times. The test shall be considered as a pass if the vehicle driven by the LSAD system (SV) always crosses the evaluation path while remaining within the lateral bounds of the evaluation path for all 5 consecutive runs.

If the unblocked drivable area between the stationary cars (S_{lat4}) is less than the safe width for SV operation for manoeuvring around the stationary cars, the SV shall come to a stop within the evaluation path.

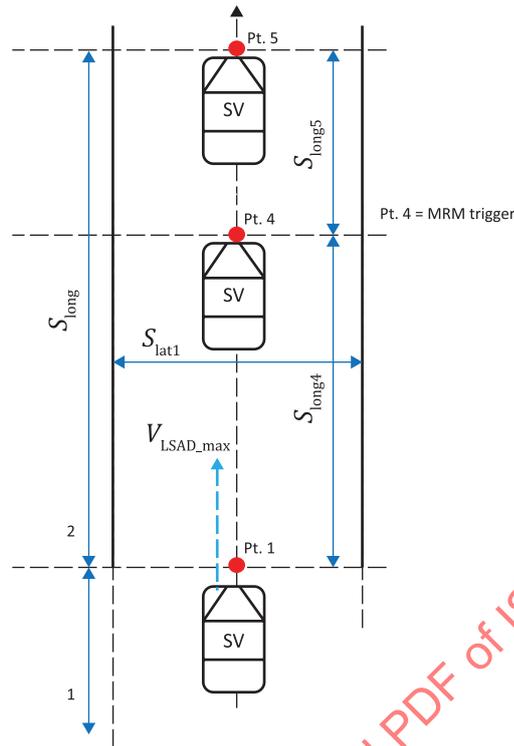
11.5 Minimal risk manoeuvre (MRM) test

11.5.1 Test setup

This test is defined to test the activation and the performance of the minimal risk manoeuvre of the vehicle driven by the LSAD system. [Figure 13](#) depicts the MRM test setup. The vehicle shall be tested at its maximum allowable speed (equal to or less than 8,89 m/s or 32 km/h) as decided by the relevant stakeholder. The vehicle shall start in an approach path in such a way that at point 1 in [Figure 13](#) the vehicle has achieved its maximum allowable speed. Point 1 is depicted by the start of the evaluation path and is not necessarily at the lateral mid-point of the evaluation path.

At point 4, MRM trigger condition shall be generated. The LSAD system shall apply deceleration up to a maximum value of 4,905 m/s² from point 2 onwards and bring the vehicle to standstill. The LSAD system shall also inform the dispatcher that an MRM has been initiated and MRC has been attained.

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Key

V_{LSAD_max}	max. velocity of the LSAD system equipped vehicle (m/s)
SV	subject vehicle
S_{long}	longitudinal distance of the evaluation path (m)
S_{long4}	longitudinal distance between Pt. 1 and Pt.4 where MRM is triggered (m)
S_{long5}	longitudinal distance between Pt.4 and end of evaluation path (m)
Pt.1	beginning of evaluation path
Pt.4	point where MRM is triggered along the evaluation path
Pt.5	end of evaluation path
S_{lat1}	width of drivable area (m)
1	approach path
2	evaluation path

Figure 13 — Minimal risk manoeuvre test setup

11.5.2 Vehicle parameters

The vehicle speed (V_{LSAD_max}) shall be “test speed” $\pm 0,07$ m/s at point 1. “Test speed” shall be the maximum operating speed of vehicle driven by the LSAD system defined by the manufacturer or other relevant stakeholders.

11.5.3 Evaluation path parameters

The length of the evaluation path (S_{long1}) shall be 100 m. The distance between point 1 and point 4, i.e. S_{long4} , shall be a maximum of 75 ± 2 m.

11.5.4 Environmental parameters

The ambient temperature shall be between 5 °C and 40 °C.

Additional environmental conditions may be selected in consultation with relevant stakeholders.

11.5.5 MRM trigger

In order to trigger MRM, out of ODD condition (e.g. geo fence, weather changes) or a deliberate sensor failure situation (via fault injection) may be created. In either of the cases, the manufacturer shall define the mechanism to trigger MRM.

11.5.6 Pass criteria

The test procedure shall be repeated 5 times. The test shall be considered as a pass if (for all 5 consecutive runs) the SV starts decelerating at point 4 and comes to standstill at or before point 5. The SV may also perform evasive steering manoeuvre(s). Additionally, for all 5 consecutive test runs, the SV shall also inform the dispatcher that MRM has been initiated and MRC has been achieved, and shall also provide notification to occupants(s) and other road users (for example using the hazard lights).

Additional conditions may be selected in consultation with local government and testing organizations.

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Annex A (informative)

Test speeds for hazardous situation tests

[Table A.1](#) and [Table A.2](#) provide details of the S_{long} distance for various speeds of the LSAD system. [Table A.1](#) refers to pedestrian obstacles.

Table A.1 — S_{long} values for pedestrian occluded hazardous situation test

$V_{\text{LSAD_max}}$ km/h	$V_{\text{LSAD_max}}$ m/s	S_{long} (Situation A) m	S_{long} (Situation B) m
32	8,89	17	26,6
31	8,61	16,5	25,8
30	8,33	16	25
29	8,05	15,5	24,2
28	7,78	15	23,4
27	7,5	14,5	22,6
26	7,22	14	21,8
25	6,94	13,5	21
24	6,67	13	20,2
23	6,39	12,5	19,4
22	6,11	12	18,6
21	5,83	11,5	17,8
20	5,55	11	17
19	5,28	10,5	16,2
18	5	10	15,4
17	4,72	9,5	14,6
16	4,44	9	13,8
15	4,17	8,5	13
14	3,89	8	12,2
13	3,61	7,5	11,4
12	3,33	7	10,6
11	3,05	6,5	9,8
10	2,78	6	9
9	2,5	5,5	8,2
8	2,22	5	7,4
7	1,94	4,5	6,6
6	1,67	4	5,8
5	1,39	3,5	5
4	1,11	3	4,2
3	0,83	2,5	3,4
2	0,56	2	2,6
1	0,28	1,5	1,8
0	0	1	1

Table A.2 refers to pedal cyclist obstacles.

Table A.2 — S_{long} values for pedestrian occluded hazardous situation test

V_{LSAD_max} km/h	V_{LSAD_max} m/s	S_{long} (Situation A) m	S_{long} (Situation B) m
32	8,89	9,53	13,8
31	8,61	9,27	13,4
30	8,33	9,00	13
29	8,05	8,73	12,6
28	7,78	8,47	12,2
27	7,5	8,20	11,8
26	7,22	7,93	11,4
25	6,94	7,67	11
24	6,67	7,40	10,6
23	6,39	7,13	10,2
22	6,11	6,87	9,8
21	5,83	6,60	9,4
20	5,55	6,33	9
19	5,28	6,07	8,6
18	5	5,80	8,2
17	4,72	5,53	7,8
16	4,44	5,27	7,4
15	4,17	5,00	7
14	3,89	4,73	6,6
13	3,61	4,47	6,2
12	3,33	4,20	5,8
11	3,05	3,93	5,4
10	2,78	3,67	5
9	2,5	3,40	4,6
8	2,22	3,13	4,2
7	1,94	2,87	3,8
6	1,67	2,60	3,4
5	1,39	2,33	3
4	1,11	2,07	2,6
3	0,83	1,80	2,2
2	0,56	1,53	1,8
1	0,28	1,27	1,4
0	0	1,00	1

Annex B (informative)

Example LSAD communication messages

[Table B.1](#) shows an example of V2I data communication messages (message set).

Table B.1 — Example for LSAD communication messages

Data	Description	Transmit (T)/ Receive (R)		Minimum Frequency
		Vehicle driven by the LSAD system	Dispatcher	
Vehicle ID	Vehicle unique identifier (at any point in time).	T	R	1 Hz
LSAD system state	LSAD off/standby/active (DDT, MRC, e-stop, MRM).	T	R	1 Hz
Dispatcher authentication	Trip/trip segment approval by dispatcher to confirm status of the LSAD system.	R	T	At start of trip/trip segment or when the LSAD system has applied e-stop.
LSAD system maximum operating speed	Selection of top speed ODD parameter based on the dispatcher's or system's evaluation of the LSAD system's ODD and other external factors (e.g. weather, scheduled construction etc.).	R	T	At start of trip/trip segment or when the LSAD system has applied e-stop.
LSAD system speed		T	R	1 Hz
Vehicle driven by the LSAD system heading		T	R	1 Hz
LSAD system position		T	R	1 Hz

Annex C (informative)

Example LSAD system data recorder

[Table C.1](#) provides suggestions on some of the LSAD system parameters that may be recorded by the LSAD system data recorder, along with suggestions on the sampling rate.

Table C.1 — LSAD system data recorder details

Data variable	Minimum sampling rate
Vehicle speed	10 Hz
Wheel speed	10 Hz
Steering angle	10 Hz
Brake status/brake torque	10 Hz
Component error states	10 Hz
LSAD system health status data to supervisor	10 Hz
Vehicle yaw rate	10 Hz
Vehicle acceleration (longitudinal and lateral)	10 Hz
Heading angle from north	10 Hz
Vehicle position any collisions or incidents	10 Hz
Any intervention by the supervisor	10 Hz
Allowable top speed	1 Hz