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Road vehicles — Partial driving automation — Technical characteristics of conditional hands-free driving systems

Véhicules routiers — Automatisation partielle de la conduite — Caractéristiques techniques des systèmes de conduite mains-libres conditionnels

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Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Functionality	3
4.1 Overall system context.....	3
4.2 General requirements.....	5
4.3 State: L2 hands-free.....	6
4.3.1 Control loop.....	6
4.3.2 Possibility for the driver to deactivate, overrule and override the L2 hands-free state.....	6
4.3.3 ODD monitoring.....	7
4.3.4 Driver monitoring.....	7
4.3.5 Driver information and warning.....	7
4.4 Transitions.....	8
4.4.1 Enter "L2 hands-free state" from "manual-driving mode", "L1-driving mode" or "PADS active-driving mode".....	8
4.4.2 Leaving "L2 hands-free state" due to drivers' intervention.....	8
4.4.3 Leaving "L2 hands-free state" due to system intervention.....	8
4.4.4 Leaving "L2 hands-free state" due to risk-mitigation.....	9
5 Technical characteristics of "L2 hands-free subsystems"	9
5.1 Driver-monitoring system.....	9
5.2 Driver information and warning system.....	10
5.3 ODD-monitoring system.....	10
5.4 Risk-mitigation system.....	11
Annex A (informative) Driver information and warning system	12
Bibliography	14

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.

Introduction

This document can be used as a system level standard by other standards, which extend the combination of ACC according to ISO 15622 and PADS according to ISO 21717 with additional requirements motivated by costumer use-cases and by safety to a more detailed standard for a higher level of functionality which will include the hands-free use case in certain conditions.

The main functionality of a "L2 hands-free system" is to control and limit the vehicle behaviour for longitudinal and lateral control, as it is described in ISO 15622 and ISO 21717, with respect to the performance, the intended ODD and the driver's capabilities. Together with an appropriate driver monitoring, which is typically realized with a driver monitoring camera and in addition a hands-on/off detection regarding to the steering wheel, it is possible for a system to operate while the driver can take the hands away from the steering without losing the ability and the responsibility to control the DDT.

This document contains the basic control strategy, basic driver interface elements and a minimum set of requirements for a L2 hands-free system. This document is applicable for, but not limited to, passenger cars. It is not applicable to automated driving systems of Level 3 according to ISO/SAE PAS 22736 or higher.

While a lane change functionality is not specified in this document, it is explicitly considered.

Regional regulation, e.g. UN/ECE R79, can limit the applicability of parts of this document.

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Road vehicles — Partial driving automation — Technical characteristics of conditional hands-free driving systems

1 Scope

This document provides technical characteristics of partial driving automation system according to ISO/SAE PAS 22736 and associated control strategies enabling hands-free driving.

These technical characteristics, together with an appropriate operational design domain enable the proper usage of such partial driving automation systems which is supervised by drivers.

This document does not address performance limits, verification and validation of such systems.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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/>

3.1

ODD

operational design domain

operating conditions under which the driving automation system is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics

[SOURCE: ISO/SAE PAS 22736:2021, 3.21, modified —The notes to entry and examples have been removed.]

3.2

EOR

eyes-on request

request by the L2 hands-free system to the driver to monitor the traffic situation

3.3

HOW

hands-on warning

warning by the L2 hands-free system to the driver to *direct control* (3.12) the vehicle, at least by lateral steering control of the vehicle

Note 1 to entry: An HOW could be represented by a yellow warning signal accompanied by an acoustic warning.

3.4

HOA

hands-on alert

alert by the L2 hands-free system to the driver to *direct control* (3.12) the vehicle immediately, at least by lateral steering control of the vehicle

Note 1 to entry: A HOA could be represented by a red warning signal accompanied by an acoustic warning.

3.5

DMS

driver-monitoring system

system that detects the presence of a driver, assesses the driver's attention to the traffic and assesses hands-on/off detection on steering wheel

Note 1 to entry: One part of a driver-monitoring system is typically a *driver-monitoring camera* (3.6) and/or other suitable means, e.g. capacitive hands-on/off detection.

3.6

DMC

driver-monitoring camera

camera as part of the *driver-monitoring system* (3.5) which can determine the driver's attention on the traffic

3.7

driver information and warning system

system that informs the driver about the system status and warns the driver when actions are required by the driver

EXAMPLE *Eyes-on request* (3.2), *hands-on warning* (3.3).

3.8

overrule

action by the driver to *direct control* (3.12) of lateral and/or longitudinal motion of the vehicle which deactivates the L2 hands-free system

Note 1 to entry: Overrule is a possibility to deactivate the L2 hands-free system.

3.9

override

direct control (3.12) of lateral and/or longitudinal motion of the vehicle within a defined threshold without deactivation of the L2 hands-free system

3.10

hands-free

system condition under which the driver is permitted to remove his hands from the steering wheel

Note 1 to entry: Part of the system condition is that the vehicle is in a specified *operational design domain* (3.1), the driver monitors the traffic situation and system behaviour while the system monitors the driver.

3.11

hands-on

condition of the driver to hold the steering wheel

Note 1 to entry: During "L2 hands-on driving mode", the driver directly controls the vehicle either with or without support by a "L2 hands-free system" or a "L2 hands-on system".

3.12 direct control

control of the vehicle by the driver by holding or moving the steering wheel or using brake or driving pedal

Note 1 to entry: Within this document the acceleration is always positive and the negative acceleration is called deceleration.

3.13 DDT

dynamic driving task
control and execution of longitudinal and lateral movements of the vehicle

3.14 mode

behaviour of the driver in interaction with the system which depends on system states

EXAMPLE In an L2 hands-on driving mode the driver's hands are on the steering wheel, while the system can either be in L2 hands-on state or in L2 hands-free state with the corresponding technical requirements.

Note 1 to entry: The mode may differ from the *state* (3.15) of the system.

3.15 state

execution of implemented requirements depending on system and environmental conditions

4 Functionality

4.1 Overall system context

This document focus on requirements of the "L2 hands-free state" with the corresponding transitions as shown in Figure 1. The other states beside "lateral only" are briefly described only for completeness in this clause and those are defined in ISO 15622 and ISO 21717.

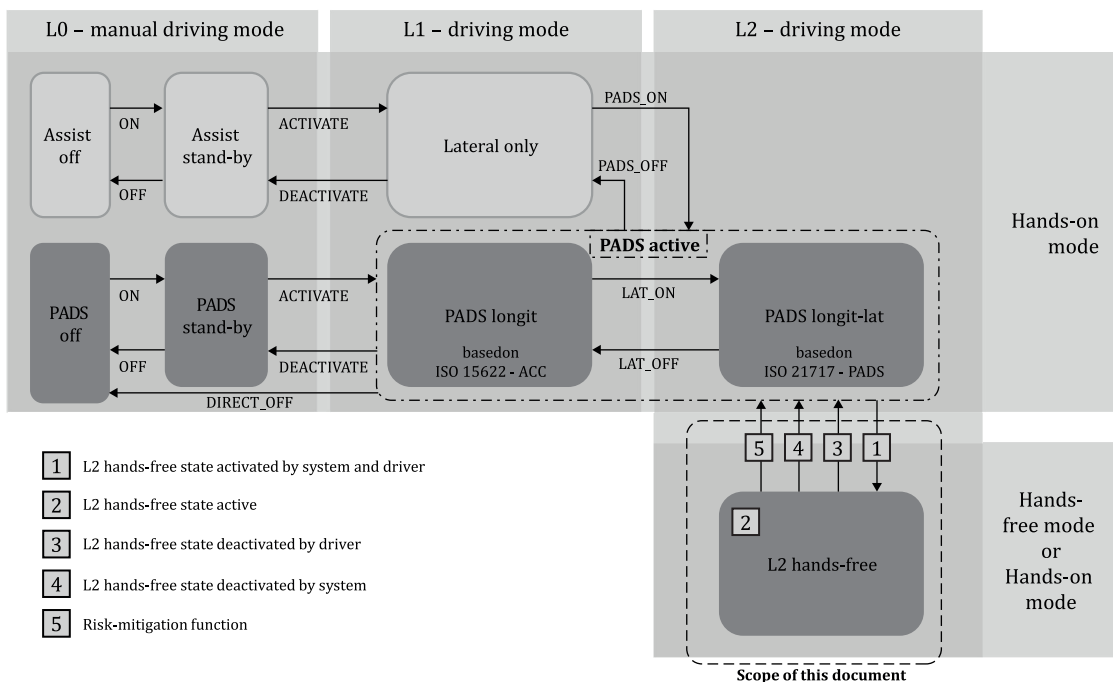


Figure 1 — L2 hands-free system modes, states and transitions in interaction with ACC (ISO 15622), PADS (ISO 21717) and lateral only

In this document the overall functionality of an "L2 hands-free system" is represented by an overall system-state-diagram with states and transitions. Therefore, it is possible to describe an L2 hands-free system with function modes from a customer perspective and with states and transition from a technical point of view. Functionality-like features or subfeatures can be distributed via several or other states.

Transitions will describe the trigger conditions which are needed to leave or to enter a state.

State "PADS off" (ISO 21717:2018, 6.1.1):

- in the state "PADS off" there is no action performed;
- the "ON" transition from state "PADS off" to state "PADS stand-by" can be performed by the driver or automatically, e.g. after the ignition is switched on.

State "PADS stand-by" (ISO 21717:2018, 6.1.2):

- in the state "PADS stand-by" the system is ready to be activated while the driver is performing the DDT manually;
- the transition "ACTIVATE" from "PADS stand-by" to "PADS active" can be initiated by the driver. The transition "ACTIVATE" could lead to "PADS longitudinal" or to "PADS longitudinal lateral" state as a part of the "L2 hands-on driving mode". A possible transition to "lateral only" is not described in any ISO standard yet;
- a transition to activate "L2 hands-free state" could be initiated automatically or by the driver when the conditions for the option for "L2 hands-free driving mode" are fulfilled.;
- the transition "OFF" from "PADS stand-by" to "PADS off" can be performed by the driver or automatically, e.g. after the ignition is switched off or a system failure has occurred.

State "lateral only":

- in "lateral only" the system does not perform accelerating or decelerating actions. This state is not described in any ISO standards, it is typically not used in context of this document;
- if the driver initiated all of the selected activation criteria for long-lateral, the system shall perform the transition lateral state to PADS longitudinal-lateral state;
- if the driver initiated all of the selected activation criteria for long-lateral, the system can perform the transition lateral state to PADS longitudinal-lateral state.

State "PADS active" - (L2 hands-on mode) (ISO 21717:2018, 6.1.3):

- in both substates, "longitudinal-lateral" and "longitudinal", of the "PADS active" state the system provides speed and distance control in accordance with ISO 15622. Therefore, longitudinal control is always active in "PADS active" state as long as the driver does not intervene;
- in both substates, "longitudinal-lateral" and "longitudinal", of the "PADS active" state the system evaluates the conditions for lateral control;
- depending on the substates, "longitudinal-lateral" and "longitudinal", the system within "PADS active" evaluates the activation criteria for lateral control or lat-long control which are typically the related ODD, speed, lane boundaries of the lane and/or relative distance to forward vehicles and the drivers vehicle control;
- under certain driving conditions (ODD, driver, vehicle, monitoring systems active) it is possible to take the hands off from steering wheel and switch to "hands-free" state which is described in more detail in [Clause 4](#);
- "PADS active" in both substates could be left to "PADS-off" or "PADS stand by" by "inactive" or "direct-off" due to the driver's action, for example, brake, or automatically for instance after a system failure has occurred.

State "PADS active" with "longitudinal" state as a substate (L2-hands-on-mode) (ISO 21717:2018, 6.1.4):

- in "longitudinal state" (ACC) the system performs longitudinal control with or without vehicle in front from standstill to a defined vehicle maximum speed;
- if all criteria for lateral control are met the system can perform the transition "LAT_ON" to PADS longitudinal-lateral state, driver initiated or automatically.

State "PADS active" with longitudinal-lateral state as a substate (L2 hands-on mode) (ISO 21717:2018, 6.1.5):

- in PADS longitudinal-lateral state the system is performing steering actions to influence the lateral movement of the subject vehicle with the intention to keep the vehicle within the lane while longitudinal control is already active as described before;
- in PADS longitudinal-lateral state the system evaluates the deactivation criteria for lateral control. If certain deactivation criteria for lateral control is fulfilled the system shall perform the transition "LAT_OFF" to PADS "longitudinal state".

State "L2 hands-free state active":

- in "L2 hands-free state active" state the system performs as described in 4.3. This includes the basic functionality for the control-loop, the possibility for driver intervention and the subsystems for "driver monitoring", "ODD monitoring", "driver information and warning";
- the conditions, which need to be fulfilled to reach or leave "L2 hands-free state", will be described in the subclauses:
 - 4.4.1 transition: "manual-driving mode" or "L1-driving mode" or "PADS active-driving mode" to "L2 hands-free state";
 - 4.4.2 transition: leaving "L2 hands-free state" due to drivers' intervention;
 - 4.4.3 transition: leaving "L2 hands-free state" due to system intervention;
 - 4.4.4 transition: leaving "L2 hands-free state" due to risk-mitigation.

4.2 General requirements

The following requirements are applicable for "L2 hands-free system":

- a) to ensure that the driver is supervising the vehicle and can perform the DDT, a DMS shall monitor the driver's presence and attentiveness;
- b) the intended ODD, for example, motorway, shall be defined based on the performance of the vehicle dynamics control and drivers' capabilities in L2 hands-free driving mode:
 - active-safety functions can support L2 hands-free driving mode, e.g. pedestrian detection;
 - the selection of the intended ODD depends typically on street curvature, driving speed, driver's capabilities and the implemented system performance to control vehicle by the driver also in case of failures or unwanted performance.
- c) the driver-monitoring system shall be active within the "L2 hands-free driving state";
- d) the ODD-monitoring system shall be active within the "L2 hands-free driving state";
- e) the driver information and warning system shall inform the driver about the driving mode and if necessary, shall request eyes on road, warn or alert the driver to take direct control;

NOTE Reasons for information, warning or alerts are: