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Intelligent transport systems — Partially-automated parking systems (PAPS) — Performance requirements and test procedures

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Foreword

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

This second edition cancels and replaces the first edition (ISO 20900:2019), which has been technically revised.

The main changes are as follows:

— the concept of an "area where partially-automated parking systems (PAPS) control is permitted" within parking scenarios has been removed;

— the concept of a "narrow situation" within parking scenarios has been introduced.

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Introduction

Partially-automated parking systems (PAPS) perform parking manoeuvres controlling both longitudinal and lateral movement of the vehicle to mitigate the driver's burden. Information about the intended parking space should be available prior to starting the system operation, via on-board sensors and potentially via external infrastructural information sources, in order to determine the strategic path to follow.

The system consists of driver command input device(s) and non-contact sensors for acquiring external information. In addition, the system involves the automatic control of propulsion, brake, transmission and steering, through which the vehicle is manoeuvred into an intended relative position and is made to stop within certain tolerances without the driver's direct manipulations.

A human-machine interface (HMI) provides system information to the driver. The system function is initiated by a driver command. The system monitors the vicinity of the vehicle to detect and avoid hazards. The vehicle behaviour and safety conditions are supervised by the driver.

The driver is able to cancel/halt the system operation at any time necessary.

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Intelligent transport systems — Partially-automated parking systems (PAPS) — Performance requirements and test procedures

1 Scope

This document addresses light vehicles,[1] for example passenger cars, pick-up trucks, light vans and sport utility vehicles (motorcycles excluded), equipped with partially-automated parking systems (PAPS).

This document establishes minimum functionality requirements that the driver can expect and that are to be taken into account by the manufacturer.

There are two possible types of PAPS configuration.

— Type 1: the system is supervised by the conventional driver located in the driver's seat.

— Type 2: the system is supervised by the remote driver (present within or outside the vehicle), who is not necessarily located in the driver's seat. The vehicle remains in the line of sight of the remote driver.

This document addresses minimum requirements and conditions for safety, system performance and function, including human-machine interface (HMI) information content and a description of system operating states, for both types of system.

The requirements include the driver, who supervises the safety throughout the system manoeuvres.

System test requirements are also addressed, including test criteria, method and conditions.

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
partially-automated parking system
PAPS
system capable of measuring the dimensions of a *parking space* (3.2)/*parking slot* (3.3)/*garage* (3.4), calculating an applicable trajectory, performing lateral and longitudinal (longitudinal in both directions) control of the vehicle while manoeuvring into the space/slot/garage and providing necessary instructions to the driver

3.2
parking space
area which exists between two bordering vehicles and is available for parking

3.3
parking slot
allotted place which is delineated by lines or markings and is available for parking

3.4
garage
parking space (3.2) of adequate size for a single vehicle enclosed with walls or another structure

3.5
parking manoeuvre
operation to move a vehicle to a *parking space* (3.2)/*parking slot* (3.3)/*garage* (3.4)

3.6
leaving manoeuvre
operation to move a vehicle out from a *space* (3.2)/*parking slot* (3.3)/*garage* (3.4)

3.7
conventional driver
driver who is seated in the driver's seat and is capable of the supervision of the safe operation of the vehicle

3.8
remote driver
driver who operates the *partially-automated parking system (PAPS)* (3.1) using a remote control device

Note 1 to entry: The remote driver may be seated in the vehicle.

3.9
automated parking manoeuvre
automated lateral and longitudinal motion control of the vehicle by the *partially-automated parking system (PAPS)* (3.1) during the parking manoeuvre while the driver supervises

3.10
automated leaving manoeuvre
automated lateral and longitudinal motion control of the vehicle by the *partially-automated parking system (PAPS)* (3.1) during the leaving manoeuvre while the driver supervises

3.11
system activation
action of transitioning the system operation from a system ready state to an active state

3.12
test object
object with a specific material, geometry and surface for testing the monitoring range

3.13
bordering vehicle
vehicle that delimits the *parking space* (3.2)

3.14
PAPS vehicle
vehicle which is equipped with a *partially-automated parking system (PAPS)* (3.1)

4 Definition of PAPS types and requirements

4.1 PAPS types

Within PAPSs, the driver operates the vehicle until the parking location is determined.

Following this, until the parking operation is completed, the system performs all operations necessary to park the vehicle such as steering, acceleration, braking, transmission shifting and applying the parking brake.

The following two types of PAPS are defined in this document based on the scenarios in which the system is supervised by an on-board conventional driver or by a remote driver who is not necessarily located in the driver's seat.

4.2 Basic system functionality

4.2.1 Type 1 — System supervised by a conventional driver located in the driver's seat

4.2.1.1 General

— The system shall be supervised by a conventional driver seated in the car.

— The conventional driver shall request automated parking manoeuvres.

— The system searches for parking spaces/slots/garages.

— The search may be initiated automatically or by a conventional driver.

— In both cases, the system shall inform the conventional driver that it has identified a possible parking space/slot/garage.

— If multiple possible parking spaces/slots/garages are identified, the system shall present the candidates and the conventional driver may select one of the candidates.

— In the case where the conventional driver does not select any of the options from the multiple parking spaces/slots/garages identified by the PAPS, the search may continue.

With its automatic control of propulsion, brake, transmission and steering, the system shall move the vehicle, park the vehicle in the target parking space/slot/garage within the specified location accuracy limits, and finally release control.

4.2.1.2 System reactions for Type 1

System reactions corresponding to conventional driver intervention are specified in Table 1.

Table 1 — System reactions corresponding to conventional driver intervention

Conventional driver intervention	Corresponding system reactions
Main switch OFF	The system shall cancel the parking manoeuvre and inform the conventional driver. It should then stop the vehicle.
Shift transmission into park	
Acceleration	The system should cancel the parking manoeuvre. If the parking manoeuvre is cancelled, the system shall inform conventional driver of the cancellation.
Other shift operations	The system shall stop the vehicle and inform the conventional driver.[b]
Steering[a]	

[a] The minimum torque to override the system applied by the conventional driver to the steering wheel shall be defined by the vehicle manufacturer. A typical value could be approximately 5 Nm.

[b] In this case, the system shall immediately stop vehicle movement and provide the conventional driver with information which indicates both suspension of the system control and action for the conventional driver to take. After driver compliance, depending on the concept of the vehicle manufacturer or the driver's selection, the system can either re-start the automatic control or terminate it.

Table 1 *(continued)*

Conventional driver intervention	Corresponding system reactions
Braking	When the amount of braking by a conventional driver exceeds the amount of braking generated by the system, the system operates according to the amount of braking applied by the conventional driver.
[a] The minimum torque to override the system applied by the conventional driver to the steering wheel shall be defined by the vehicle manufacturer. A typical value could be approximately 5 Nm. [b] In this case, the system shall immediately stop vehicle movement and provide the conventional driver with information which indicates both suspension of the system control and action for the conventional driver to take. After driver compliance, depending on the concept of the vehicle manufacturer or the driver's selection, the system can either re-start the automatic control or terminate it.	

4.2.2 Type 2 — System supervised by a remote driver

4.2.2.1 General

There are two main scenarios: entering a parking space/slot/garage and leaving a garage/perpendicular parking space/slot.

4.2.2.2 Entering a parking space/slot/garage

The system searches for parking spaces/slots/garages. The search may be initiated by the driver. The system should inform the driver that it has identified one or more possible parking spaces/slots/garages. The system may also be activated after the driver parks the car straight (e.g. 1 m) in front of the garage/perpendicular parking slot/space.

If multiple possible parking spaces/slots/garages are identified, the system should present candidates. The system proposes a parking space/slot/garage, but the driver shall be able to choose the intended parking space/slot/garage from the candidates. The proposed parking space/slot/garage may be used if the driver does not make a selection. The driver transfers the control method to the remote supervision device while the vehicle is stopped. The remote driver then activates the parking manoeuvre using the remote supervision device. Only while the remote driver is using the remote supervision device to continuously give authorization for the vehicle to move, shall the system automatically operate and park the vehicle in the target parking space/slot/garage within the specified location accuracy limits. The vehicle is stopped when the final parking position is reached or when the remote driver deactivates the system using the remote supervision device.

4.2.2.3 Leaving a garage/perpendicular parking space/slot

The system shall start the leaving manoeuvre when it receives and confirms a leaving manoeuvre request from the remote driver. Only while the remote driver is using the remote supervision device to continuously give authorization for the vehicle to move, shall the system automatically operate and move the vehicle from the parking space/slot/garage within the specified location accuracy limits. The vehicle is stopped when the specified position is reached or when the remote driver deactivates the system using the remote supervision device.

4.2.2.4 System reactions for Type 2

System reactions corresponding to remote driver intervention and system failure are specified in Tables 2 and 3.

Table 2 — System reactions corresponding to remote driver intervention

Remote driver intervention	Corresponding system reactions
Main switch OFF (if available on remote device)	The system shall stop the vehicle and cancel automatic control of the system.[a]
Ignition OFF	
A door or trunk of the vehicle opens while the remote driver is giving the command to move by the remote supervision device.	The system shall stop the vehicle.[b] When the condition is cleared, the system may continue the parking manoeuvre.

[a] In this case, the system shall immediately stop vehicle movement and provide the remote driver with information which indicates cancellation of the system control.

[b] In this case, the system shall immediately stop vehicle movement and provide the remote driver with information which indicates suspension of the system control. After driver compliance, depending on the concept of the vehicle manufacturer or the driver's selection, the system can either re-start the automatic control or terminate it.

Table 3 — System reactions corresponding to system failure

System failure	Corresponding system reactions
The distance between the remote driver and the vehicle exceeds a threshold defined by the system designer.	The system shall stop the vehicle.[a] When the condition is cleared, the system may continue the parking/leaving manoeuvre.
The communication between the remote device and the system is interrupted or data is corrupted.	

[a] In this case, the system shall immediately stop vehicle movement and provide the remote driver with information which indicates suspension of the system control. After driver compliance, depending on the concept of the vehicle manufacturer or the driver's selection, the system can either re-start the automatic control or terminate it.

4.3 General requirements

4.3.1 Maximum speed during operation

The system shall only operate up to 10 km/h (+2 km/h tolerance).

4.3.2 PAPS termination conditions

PAPS shall abort the automated parking/leaving manoeuvres if there is a system failure detected by the PAPS.

The system shall cancel automated control and provide information to the driver upon detecting malfunctions.

4.3.3 User's manual

The vehicle user's manual (owner's manual) should include an advisory note that clearly indicates how to use the system. It should also include a description of abort or pause criteria, the driver's responsibility and the limitations of the system.

The manual shall particularly emphasize the responsibility of the driver for safety while the system is operating. This includes identifying obstructions and other possible hazards that can potentially not be detected by the PAPS. Particularly in case of garage/perpendicular spaces/slots, the driver shall ensure the parking space/slot/garage is of sufficient depth.

5 Functional and performance requirements for PAPS

5.1 Supported parking types

5.1.1 Parking types

PAPS shall support one or more parking types of the following:

a) parallel parking space;

b) parallel parking slot;

c) perpendicular parking space;

d) perpendicular parking slot;

e) garage parking space.

5.1.2 Parallel parking space

As a minimum requirement, the parking manoeuvre shall be performed with a parallel parking space limited by either one or both of the following:

— two bordering vehicles;

— (optionally) curb as a lateral reference.

The system should be able to detect a reference curb, as described in Figure 9.

For this parking type, the bordering vehicles should be properly parallel parked. The standard parking space width, *W*, is defined as the length of the PAPS vehicle plus Δ*y*. The space depth, *D*, is defined as the width of the PAPS vehicle plus 0,2 m, without side view mirrors. Two parking scenarios are considered, either with or without a reference curb. In a situation with a reference curb, the vehicles are parked with a fixed distance parallel to them. In a situation without a reference curb, the virtual connecting line between the outer borders (without side view mirrors) of the two bordering parked vehicles projected onto the ground is the lateral reference line.

The parking space is defined by its width, *W*, and its depth, *D* (as shown in Figure 1). *W* is the distance between the two bordering vehicles. The depth, *D*, is the distance between the lateral reference line and the width of the PAPS vehicle plus 0,2 m, without side view mirrors.

For a PAPS vehicle with a length between 4 m and 6 m, Δ*y* = the length of the PAPS vehicle multiplied by 0,25.

For small vehicles (length ≤4 m), the value of Δ*y* (measured in m) is calculated as 4 × 0,25 = 1,0.

For large vehicles (length ≥6 m), the value of Δ*y* (measured in m) is calculated as 6 × 0,25 = 1,5.

The PAPS-controlled vehicle shall be capable of performing a PAPS manoeuvre not only on broad roads without limiting boundaries on the opposite side of the parking space/slot, but also in narrow situations with a minimum width of $S \geq 4{,}5$ m (see dimension *S* in Figure 1). Parking in narrow situations shall be at least possible for vehicles with a length up to 5,5 m and when the lateral distance between the PAPS-controlled vehicle and parked vehicles at the beginning of the PAPS manoeuvre is in a feasible range (see test specification in 6.5).

It is also important to inform users of how the system performs the parking manoeuvre and its performance limit. The description of how the system works and possible interference with surrounding objects shall be stated in the user's manual, at least.