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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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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).

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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*.

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.

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

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.

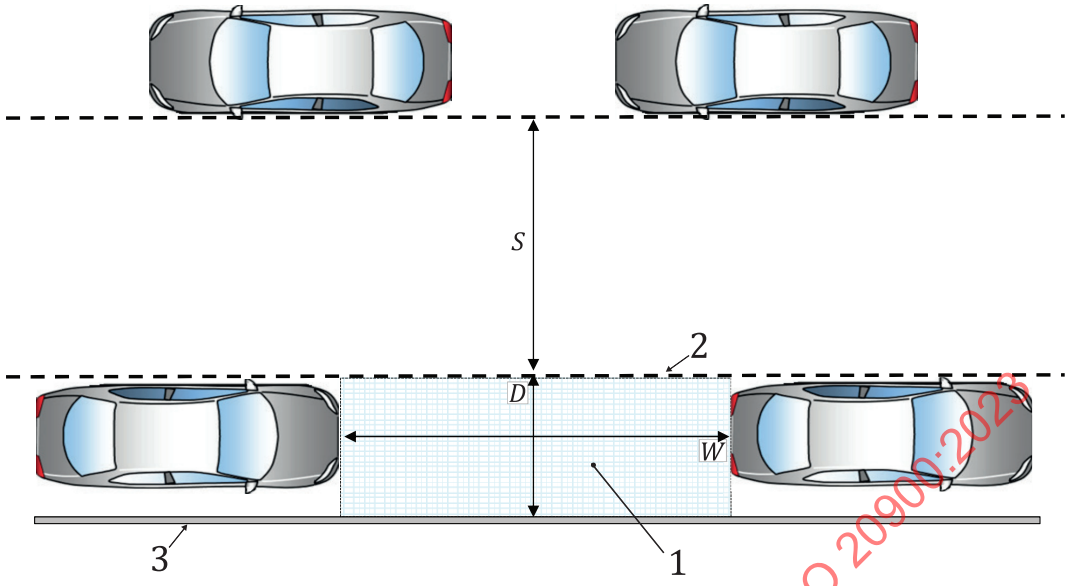
For a PAPS vehicle with a length between 4 m and 6 m, Δ*y* = the length of the PAPS vehicle multiplied by 0,25.

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.



Key

1 target parking area
2 lateral reference line
3 (optional) curb
W space width = length of PAPS vehicle + Δ*y*
D space depth = width of PAPS vehicle + 0,2 m without side view mirrors
S available width for manoeuvring in a narrow situation = 4,5 m

Figure 1 — Geometry of a parallel parking space

5.1.3 Parallel parking slot

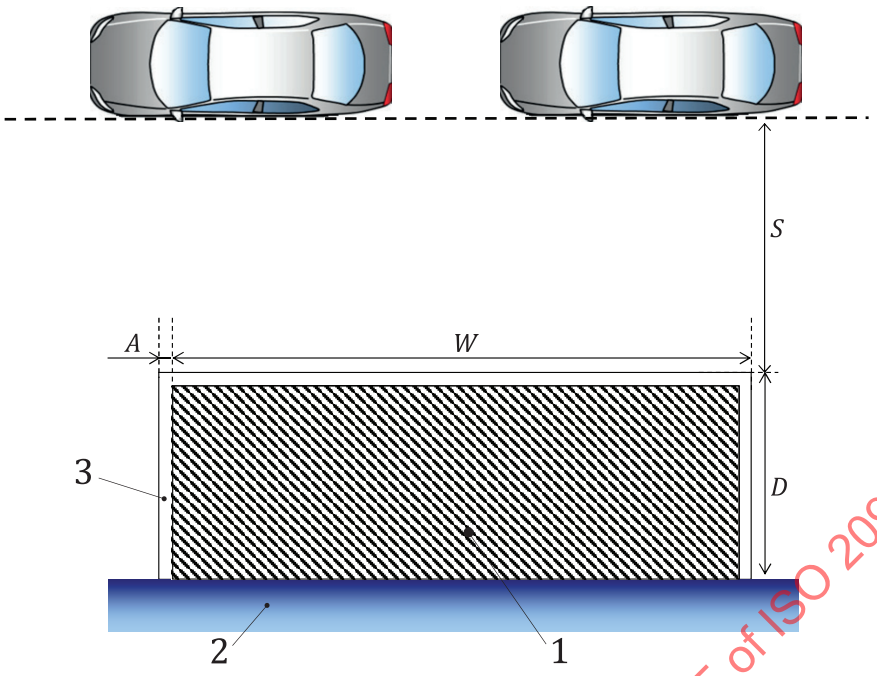
As a minimum requirement, the parking manoeuvre shall be performed with a parking slot limited by the following:

— contrastive markings on the ground surface.

The contrastive markings should have a minimum contrast ratio of five. Recommended design and size of the markings are shown in Figure 2.

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 $S \geq 4{,}5$ m (see dimension *S* in Figure 2). 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.



Key

1	target parking area	3	parking slot line
2	the edge of road		
W	width of the parking slot (=7,0 m)	*D*	depth of parking slot (=2,5 m)
A	width of parking slot line (=0,15 m)	*S*	available width for manoeuvring in a narrow situation = 4,5 m

Figure 2 — Geometry of parallel parking slot

5.1.4 Perpendicular parking space

As a minimum requirement, the parking/leaving manoeuvre shall be performed with a parking space limited by the following:

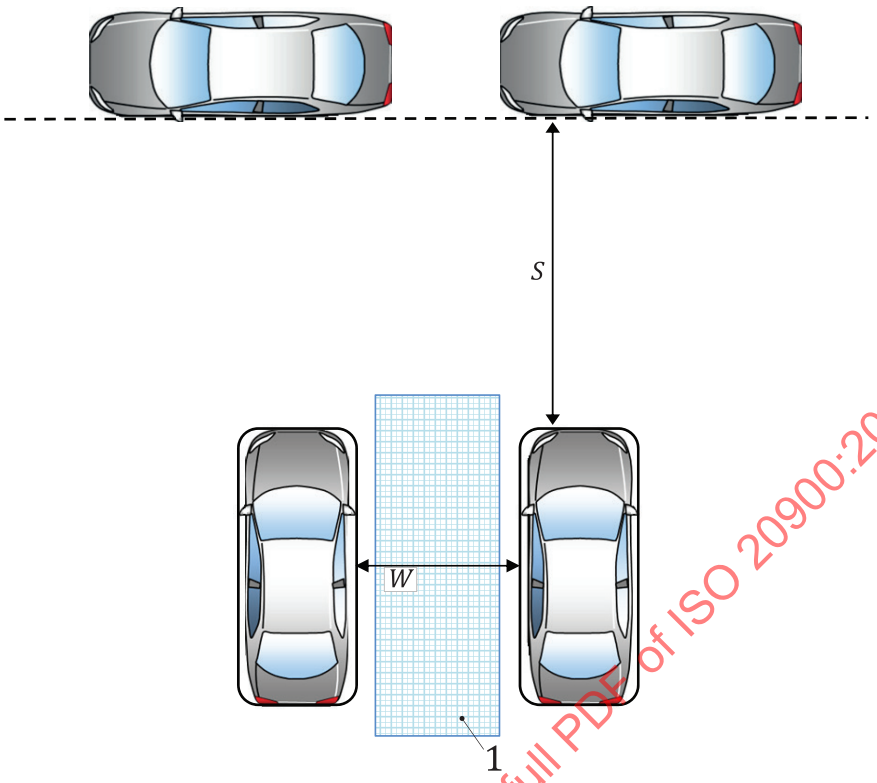
— two bordering vehicles.

For this parking type, the bordering vehicles should be properly perpendicularly parked. The standard parking space width, *W*, is defined as the width of the PAPS vehicle including side view mirrors plus Δx (1,2 m) as shown in Figure 3.

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 $S \geq 7$ m (see dimension *S* in Figure 3). 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/leaving 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.

The details of the target parking area are shown in Figure 17.



Key

1 target parking area

W space width = width of PAPS vehicle + *Δx* (= 1,2 m)

S available width for manoeuvring in a narrow situation = 7 m

Figure 3 — Geometry of perpendicular parking space

5.1.5 Perpendicular parking slot

As a minimum requirement, the parking/leaving manoeuvre shall be performed with a perpendicular parking slot limited by the following:

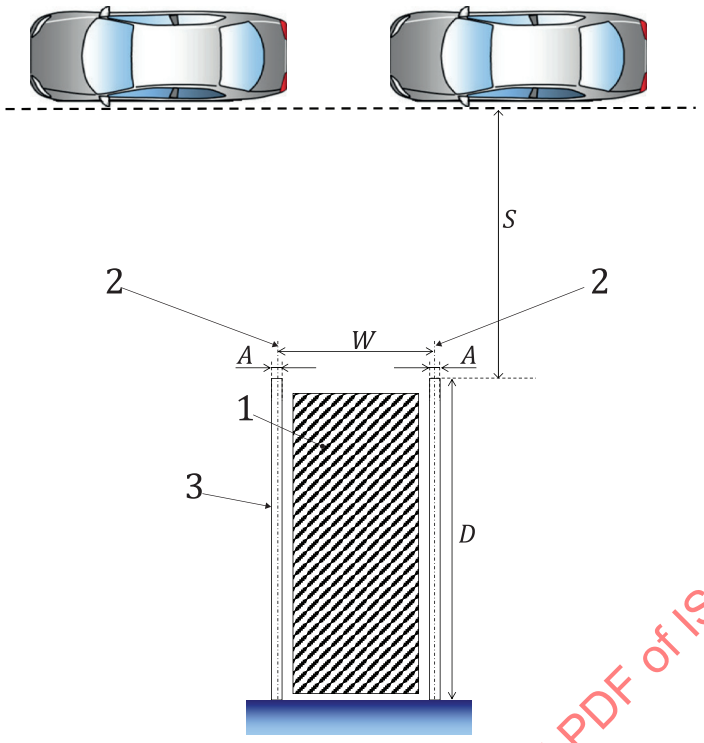
— contrastive markings on the ground surface.

The contrastive markings should have a minimum contrast ratio of 5 (five). Recommended figure and size of the markings are shown in Figure 4.

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 width $S \geq 7$ m (see dimension *S* in Figure 4). 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/leaving 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.

The details of the target parking area are shown in Figure 18.



Key

1 target parking area

2 centre of the slot line

3 slot line

W width of the parking slot opening (=2,5 m)[a]

D depth of parking slot (=6,0 m)[b]

A width of parking slot line (=0,15 m)

S available width for manoeuvring in a narrow situation = 7 m

a For large cars whose width exceeds 1,9 m without side view mirrors, *W* can be extended.

The target *W* for such cars should be "vehicle width (without side view mirrors) plus 0,6 m" (0,3 m margin for each side).

b For large cars whose length exceeds 5,0 m, *D* can be extended. The target *D* for such cars should be "vehicle length plus 1,0 m".

The minimum requirement for the surface of a parking slot is a flat paved surface.

Figure 4 — Geometry of perpendicular parking slot

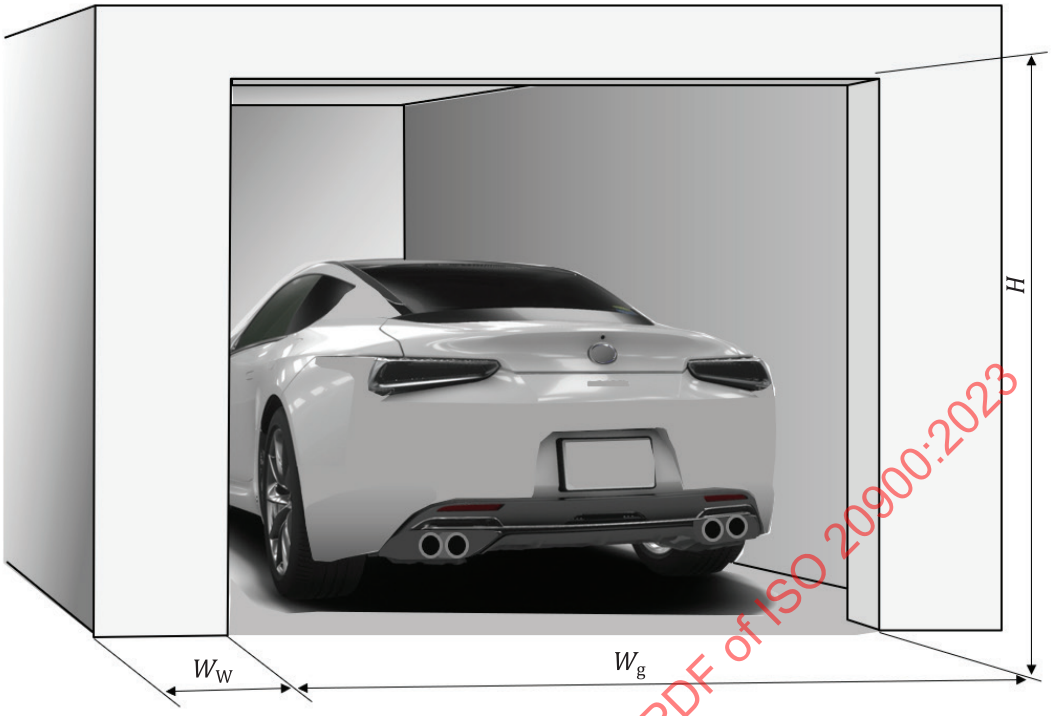
5.1.6 Garage parking space

As a minimum requirement, the parking/leaving manoeuvre shall be performed with a common garage limited by the following:

— garage gate;

— garage front, side and back walls.

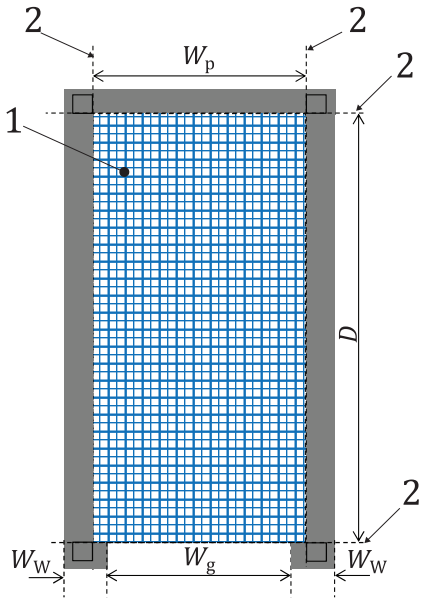
The garage parking space is defined by its gate width, W_g, its park width, W_p, and its depth, *D*, as shown in Figures 5 and 6.



Key

W_g garage gate width = width of PAPS vehicle (including side view mirrors) + 0,8 m
W_w width of garage front wall[a] = 1,0 m
H garage height (> height of PAPS vehicle)
[a] There needs to be a sufficient contrast between the wall and opening of the garage.

Figure 5 — Geometry of garage gate



Key

1 target parking area

2 inside line of the garage

W_g garage gate width = width of PAPS vehicle (including door mirrors) + 0,8 m

W_p garage park width ($W_g \leq W_p \leq W_g + 2 \times W_w$)

W_w width of garage front wall[a] = 1,0 m

D garage depth = length of PAPS vehicle + 1,0 m

[a] There needs to be a sufficient contrast between the wall and opening of the garage.

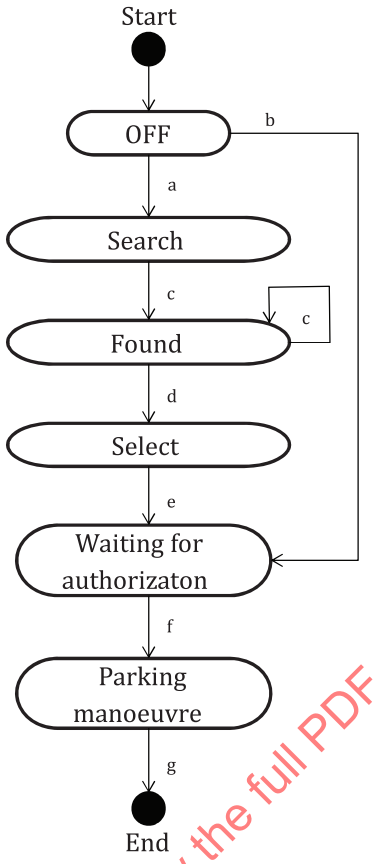
Figure 6 — Geometry of garage top view

5.2 Operating states and user interface

5.2.1 Parking manoeuvre

5.2.1.1 Sequence of operating states

Figure 7 shows an example sequence of operating states for the case of a parking manoeuvre, the corresponding information presented to the driver in each operating state, and actions required of the driver.



Key

a Driver action (e.g. main switch ON) or system action (e.g. 0 < speed ≤ threshold).

b In case the system is activated after the driver parks the vehicle in front of a garage/ perpendicular parking space/slot.

c System detects a parking space/slot/garage.

d Original equipment manufacturer (OEM) specific (e.g. driver stops the vehicle).

e Driver or system selects the target parking space/slot/garage.

f Driver authorization (e.g. by pressing a button).

g Parking manoeuvre complete or cancel.

Figure 7 — PAPS diagram of operating states in parking manoeuvre

Advancement to the next state is only possible when the driver has completed the specified action.

Upon system activation, the system moves from the "OFF" state to the "Search" state, starts searching the environment for parking spaces/slots/garages, evaluates the objects detected and generates appropriate feedback to the driver.

The system may switch its operating state between "Search", "Found", "Select" and "Waiting for authorization". If the operating state is "Waiting for authorization" and the driver gives authorization to the PAPS, the state transits to "Parking manoeuvre" and performs an automated parking manoeuvre.

5.2.1.2 OFF state

The system starts from the OFF state.

The system shall inform the driver that the system is ready for use.

If the system is not available due to a failure or other causes, the driver shall be informed of such a system condition.

When manufacturer-specified conditions are satisfied (for example, when the driver presses a button or the vehicle speed goes below the threshold), the system transitions to the search state.

If the system is activated after the driver parks the vehicle in front of a garage/perpendicular parking space/slot, the system may transition to the waiting for authorization state.

5.2.1.3 Search state

The system shall search for possible parking spaces/slots/garages. When the system finds a space/slot/garage or obtains such information, the system transitions to the found state.

5.2.1.4 Found state

This is the state in which the system has detected one or more possible parking spaces/slots/garages.

The system shall inform the driver of one or more parking spaces/slots/garages detected as a result of the search.

When manufacturer-specified conditions are satisfied (for example, when the driver has stopped the vehicle), the system transitions to the select state.

For Type 2 systems, the driver may get out of the vehicle at this point and use the remote supervision device for further parking operation. If the width of the parking space/slot/garage is very narrow, the system may inform the driver that the driver should get out of the vehicle.

5.2.1.5 Select state

When the system has detected only one space/slot/garage, the system selects it.

When the system has detected two or more spaces/slots/garages, depending on the manufacturer design specifications, the driver or the system may select one of them.

For Type 2 systems, the driver may get out of the vehicle at this point and use the remote supervision device for further parking operation. If the width of the parking space/slot/garage is very narrow, the system may inform the driver that the driver should get out of the vehicle.

5.2.1.6 Waiting for authorization state

This is the state in which the system is waiting for authorization from the driver for automated manoeuvre.

For Type 2 systems, the driver may get out of the vehicle at this point and use the remote supervision device for further parking operations. If the width of the parking space/slot/garage is very narrow, the system may inform the driver that the driver should get out of the vehicle.

When manufacturer-specified conditions are satisfied (for example, when the driver presses a button), and the driver gives authorization to the system to move the vehicle, the system transitions to the parking manoeuvre state.

5.2.1.7 Parking manoeuvre state

When the authorization from the driver to start system control is received, the system shall control propulsion, brake, transmission and steering to move the vehicle into the selected parking space/slot/garage.

For Type 1 systems, the conventional driver shall indicate the intention to continue system control to the system.

For Type 2 systems, the remote driver shall continuously indicate the intention to continue system control to the system. As an example, the system should possess the functionality for continued control when the remote driver continually presses the command switch, and the system pauses control when the remote driver releases the switch.

While the system is controlling the vehicle movement, collisions with objects in the surrounding area should be avoided. When the system detects any obstacles, it should inform the driver of the possibility of collision. Intervention or action by the driver to avoid a collision overrides system operations at any time. If the obstacle is removed, the PAPS may continue the manoeuvre as soon as the driver gives authorization.

When the vehicle reaches the final target position, the system shall stop the vehicle, keep the PAPS vehicle stationary, and simultaneously inform the driver of completion of the control.

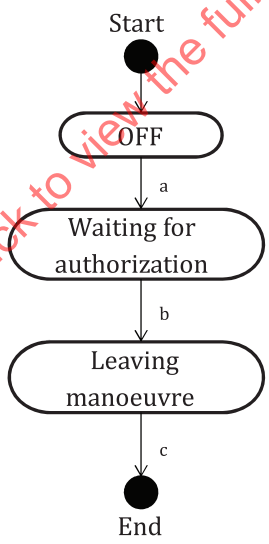
For Type 1 systems, the system shall transition to the OFF state after completion of parking.

For Type 2 systems, when control is completed, with the remote driver's confirmation of completion, the system shall transition to the OFF state. Engine OFF or door lock command may be executed.

5.2.2 Leaving manoeuvre for Type 2

5.2.2.1 Sequence of operating states

Figure 8 shows an example sequence of operating states for the case of a leaving manoeuvre.



Key

a Remote driver action (e.g. main switch ON).

b Remote driver authorization (e.g. by pressing a button).

c Leaving manoeuvre complete or cancel.

Figure 8 — PAPS diagram of operating states in leaving manoeuvre

Advancement to the next state is only possible when the driver has completed the described activity.

Upon system activation, the system transitions from the "OFF" state to the "Waiting for authorization" state, and the system waits for the remote driver's authorization.

Then, the remote driver gives authorization to the system, the system state transits to "Leaving manoeuvre" and the system performs an automated leaving manoeuvre.

5.2.2.2 OFF state

The system starts from the OFF state.

The system shall inform the remote driver that the system is ready for use.

If the system is not available due to a failure or other causes, the remote driver shall be informed of such a system condition.

When the command of the remote driver to start the engine is received and confirmed via a remote device, the PAPS Type 2 system may offer an automated leaving manoeuvre function to the remote driver.

5.2.2.3 Waiting for authorization state

This is the state in which the system is waiting for authorization from the remote driver for an automated manoeuvre.

The system needs to be able to move the vehicle from the parked position without a collision to a position where the remote driver can enter the vehicle. If it is possible for the system to perform the manoeuvre both forward and backward, the remote driver needs to select the direction.

When manufacturer-specified conditions are satisfied (for example, when the driver presses a button), if the remote driver gives authorization to the system to move the vehicle, the system transitions to the leaving manoeuvre state.

5.2.2.4 Leaving manoeuvre state

When the authorization from the remote driver to start system control is received, the system shall control propulsion, brake, transmission, and steering, to move the vehicle to the desired direction.

The vehicle speed shall be 1 m/s or less.

When the system is in this state, the remote driver shall continuously indicate to the system the intention to continue system control. As an example, the system should possess the functionality for continued control by the system when the remote driver continually presses the command switch and the system pauses control when the remote driver releases the switch.

While the system is controlling the vehicle movement, collisions with objects in the surrounding area should be avoided. When the system detects any obstacles, it should inform the remote driver of the possibility of collision. If the obstacle is removed, the PAPS may continue the manoeuvre as soon as the remote driver gives authorization.

When the vehicle reaches the final target position, the system shall stop the vehicle, keep the PAPS vehicle stationary, and simultaneously inform the remote driver of completion of the control.

As an alternative to this scenario, it shall always be possible for the system to return to the vehicle's starting position if the remote driver gives this command via a remote device.

When control is completed, with the remote driver's confirmation of completion, the system shall transition to the OFF state.

5.3 Information strategy

5.3.1 General

The system shall inform the driver of the operating state defined by the manufacturer.

The system shall provide the driver with instructions required for the parking/leaving manoeuvre defined by the manufacturer.

The system shall provide information to the driver upon releasing automatic control, either when the automated parking/leaving manoeuvre is finished successfully or when it is aborted.

The method used to provide information/warning may be auditory, visual, haptic or a combination of these.

5.3.2 Information in "Search state"

It is the responsibility of the vehicle manufacturer to define what kind of information is provided from the PAPS to the driver in the space/slot/garage search state.

5.3.3 Information during "Found state" until "Waiting for authorization state"

The driver shall be informed about suitable spaces/slots/garages found by the PAPS.

It is the responsibility of the vehicle manufacturer to define what kind of information is provided to the driver when a suitable space/slot/garage is found before the automated parking manoeuvre is entered.

5.3.4 Information in "Waiting for authorization state"

It is the responsibility of the vehicle manufacturer to define actions the driver has to perform to enable the automatic control of the PAPS.

The driver is required to ensure that the intended parking space/slot/garage is suitable for the PAPS vehicle.

5.3.5 Information during "Parking/Leaving manoeuvre state"

The driver shall be informed when all prerequisites to start parking/leaving manoeuvring are fulfilled and the PAPS switches to the automated parking/leaving manoeuvre.

When the vehicle is in the automated parking/leaving manoeuvre state the following information or warning needs to be provided to the driver:

— the system shall give information to the driver upon releasing the automatic control;

— if the PAPS detects a malfunction, the driver shall be informed.

The driver shall be informed when the PAPS has finished the parking/leaving manoeuvre and stops control of the vehicle.

6 Performance test requirements

6.1 General

In this clause, the minimum requirements for performance testing (environmental conditions, pass/fail criteria, etc.) are specified.

6.2 Environmental conditions

— The wind speed shall not exceed 5,4 m/s (wind force 3) during testing.

— Temperature shall be between 5 °C to 30 °C.

— Non-precipitating conditions (not raining, sleeting, snowing, etc.).

— Testing shall be conducted on a flat, dry, uniform, and (asphalt or concrete) paved surface.

— Walls, auxiliary test equipment and other non-test objects (clutter) shall be removed from the test area in order to eliminate interference caused by their reflections (sonic and/or electromagnetic).

— The minimum illuminance shall be 100 lx.

The performance test may be conducted under ambient conditions different from those specified above. However, if the system fails, the test shall be repeated under the above specified conditions to prove conformance.

6.3 Test object

6.3.1 Bordering vehicle

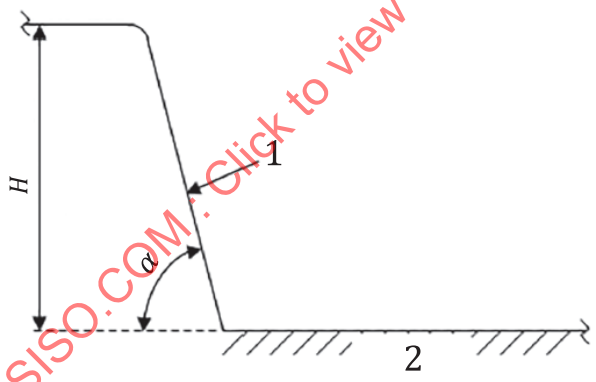
Any light vehicles which are selected by the tester may be used.

6.3.2 Limiting objects

Any feasible objects may be used to bound the width of the area for the PAPS operation on the opposite side of the road from the parking space (e.g. one continuous object like a wall or a row of objects, like vehicles, boxes or poles). The minimum distance between the used objects shall not exceed 1 m. All used objects shall have height of at least 1 m to ensure reliable object detection. The object shall have a closed surface. For example, a mesh fence is not suitable as a reliable detection cannot be ensured.

6.3.3 Reference curb

The shape of the reference curb that shall be used for testing is shown in Figure 9.



Key

1 curb outward side
2 road
H height of curbstone, m (H = 0,08 – 0,12)
α angle of curbstone, ° (α = 80 – 90)

Figure 9 — Definition of reference curb

6.3.4 Slot lines

The minimum luminance contrast ratio between the parking slot lines and road surface needed for recognition should be 5. The definition of the luminance contrast is as shown in Formula (1):

$$C_{l(\mathrm{sl})} = (l_{\mathrm{sl}} - l_{\mathrm{rs}}) / l_{\mathrm{rs}} \quad (1)$$

where

$C_{l(\mathrm{sl})}$ is the parking slot line luminance contrast;

l_{sl} is the slot line luminance;

l_{rs} is the road surface luminance.

6.4 Test criteria

As specified in 5.1, a PAPS supports one or more of the following parking types:

a) parallel parking space;

b) parallel parking slot;

c) perpendicular parking space;

d) perpendicular parking slot;

e) garage parking space.

Performance testing as specified in 6.5 shall be performed according to the supported parking types, following the environmental conditions specified in 6.2, and using the test object specified in 6.3.

For the parking test of Type 1 or Type 2, parking shall be performed using PAPS. When the parking is correctly completed, satisfying all pass criteria, the test is passed successfully.

For the leaving manoeuvre test for Type 2, the test shall be performed immediately after the parking manoeuvre test is completed, from the position at which the vehicle was parked.

An automated parking manoeuvre by the system shall be completed within 180 s from the time at which the system started the manoeuvre.

An automated leaving manoeuvre by the system shall be completed within 180 s from the time at which the system started the manoeuvre.

Parking/leaving manoeuvre tests shall be performed 10 times, each with the same conditions. 9 times out of 10 shall be successful.

For a PAPS which detects a parking space or slot, vehicle conditions at the time of detection (moving or stopped, location, moving speed, etc.) shall be in accordance with the requirements specified by the manufacturer.

6.5 Performance test

6.5.1 Parallel parking space

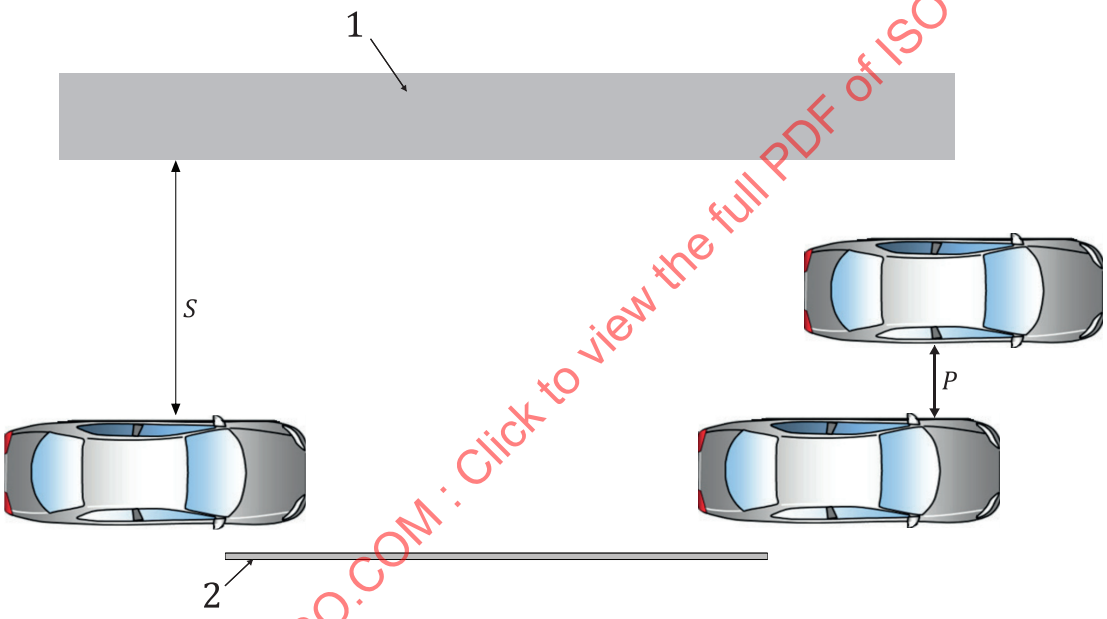
6.5.1.1 General

This subclause describes the performance test procedures and pass criteria for a PAPS which supports parallel parking space as specified in 5.1.2.

6.5.1.2 Test procedure for parking manoeuvre

The location of the test object shall be as shown in Figure 1.

For vehicles with a length up to 5,5 m, the parallel parking space as described in 5.1.2 is limited by an area of limiting objects as defined in 6.3.2 in order to create a narrow situation. The lateral distance, *P*, of the PAPS-controlled vehicle to the parked vehicles shall be 1 m ± 0,2 m at the beginning of the PAPS manoeuvre, as shown in Figure 10.



Key

1 area of limiting objects
2 curb (optional)
P lateral distance at beginning of PAPS manoeuvre, 1 m ± 0,2 m (vehicle to vehicle without mirrors)
S lateral distance to limiting objects = 4,5 m

Figure 10 — Test scenario for parallel parking slot

The distance D_r, D_f (distance rear, front) and the angle, α, shall be measured after reaching the end position at each trial.

In situations with a curb, D_f, D_r is measured from the front wheel and the rear wheel to the curb (see Figure 11). α is the angle between the vehicle and the curb (see Figure 13).

In situations without a curb, D_r, D_f is measured from the front wheel and the rear wheel to the connecting line between the two bordering parked vehicles (see Figure 12). α is the angle between the vehicle and the connecting line between the two bordering parked vehicles (see Figure 14).

The target distance D_r, D_f (to the curb or to the connecting line) may be PAPS internal parameters depending on the vehicle manufacturer's choice. Exact values are not defined in this document, but valid ranges are given.

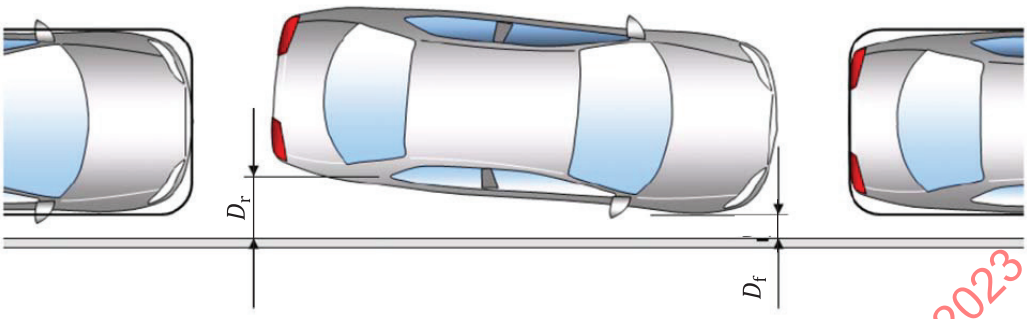


Figure 11 — Definition of D_r and D_f: distance from vehicle rear/front to curb

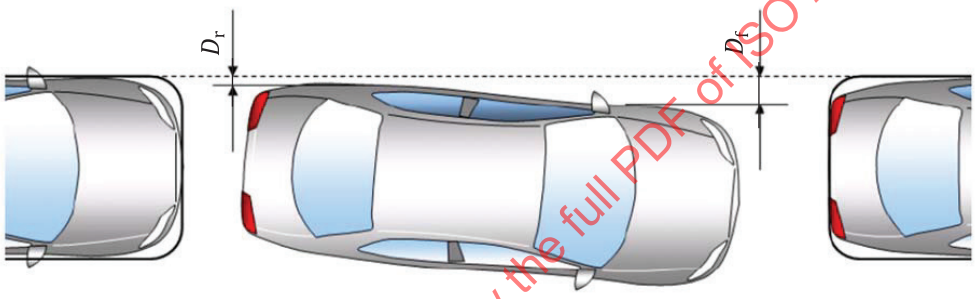
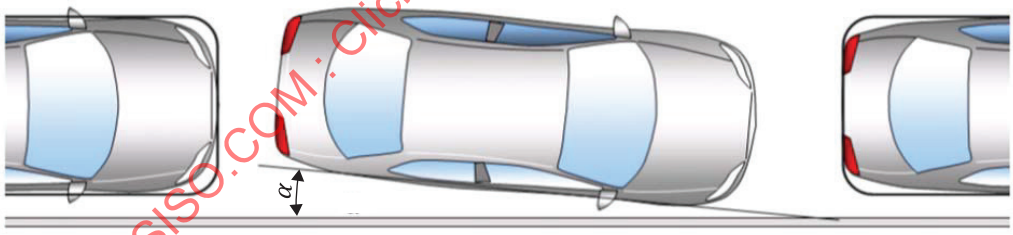
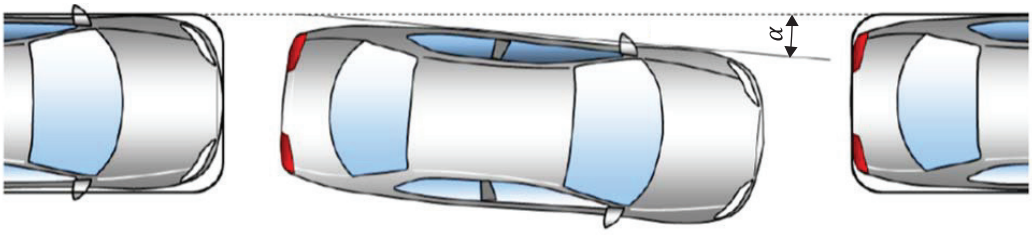


Figure 12 — Definition of D_r and D_f: distance from vehicle rear/front to vehicle connecting line



NOTE The angle is positive in this example.

Figure 13 — Definition of α: orientation of vehicle to the curb



NOTE The angle is positive in this example.

Figure 14 — Definition of α: orientation of vehicle to vehicle connecting line

6.5.1.3 Pass criteria for parking manoeuvre

a) Requirements for the angle (Figures 13 and 14) are as follows.

   1) The mean angle α to the curb or vehicle connecting line shall be in the range $-3° \leq \alpha \leq 3°$.

   2) The standard deviation of α based on the successful tests shall be not more than 1,5°.

b) Requirements for the distance from the referenced line are as follows.

   1) The mean distance D_r, D_f from the curb shall be in the range of 0,05 m to 0,3 m (Figure 11), or the mean distance D_r, D_f from the vehicle connecting line shall be in the range determined by the vehicle manufacturer (Figure 12).

   2) The standard deviation of D_r, D_f shall not be more than 0,1 m based on the successful tests.

6.5.2 Parallel parking slots

6.5.2.1 General

This subclause describes performance test procedures and pass criteria for PAPSs which support parallel parking slots as specified in 5.1.3.

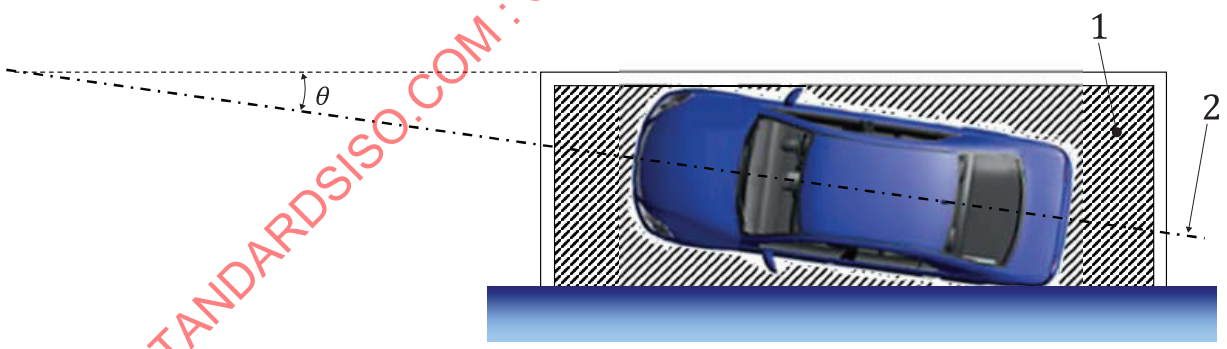
6.5.2.2 Test procedure for parking manoeuvre

The location of the test object shall be as shown in Figure 2.

At the end position, the outline of the PAPS vehicle projected on the ground without side view mirrors shall be measured.

The inclination angle, θ, relative to the road edge shall be measured after reaching the end position at each trial.

The definition of a border line of a parallel parking slot is shown in Figure 15.



Key

1 target parking area

2 centreline of the PAPS vehicle

Figure 15 — Definition of border line of parallel parking slot

6.5.2.3 Pass criteria for parking manoeuvre

— The PAPS vehicle shall be positioned within the target area (Figure 15).

— The mean angle θ shall be in the range $-3° \leq \theta \leq 3°$ (Figure 15).

— The standard deviation of θ based on the successful tests shall be not more than 1,5° (Figure 15).