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Intelligent transport systems — Assisted parking system (APS) — Performance requirements and test procedures

Systèmes intelligents de transport — Système de stationnement assisté (APS) — Exigences de performance et modes opératoires d'essai

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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).

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For an explanation on 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 the following URL: 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 16787:2016), of which it constitutes a minor revision.

The main changes compared to the previous edition are as follows:

— some editorial errors have been corrected, such as the term, “must”, replaced with the term, “shall”;

— the figures and keys have been updated for clarity.

Introduction

Assisted parking system (APS) consists of non-contact sensors and steering control which assist the driver in parking the vehicle. The assistance starts with searching a suitable parking area, getting information on the area around the vehicle (environmental map), calculating the trajectory and finishes with the lateral control of the vehicle. APS also assists the driver in recognizing obstacles while manoeuvring into the parking slot.

Intelligent transport systems — Assisted parking system (APS) — Performance requirements and test procedures

1 Scope

This document covers the assisted parking system (APS) for light-duty vehicles, e.g. passenger cars, pick-up trucks, light vans and sport utility vehicles (motorcycles excluded) equipped with such APS. This document establishes minimum functionality requirements that the driver can expect of the system, such as the detection of suitable parking spaces, calculation of trajectories and lateral control of the vehicle. Information on the presence of relevant obstacles in the driving path of the vehicle can also be included in the functionality of such systems. This document also sets minimum requirements for failure indication as well as performance test procedures. It includes rules for the general information strategy, but does not restrict the kind of information or display system.

APS is intended to provide automated parking assistance functionality to the driver. The APS searches the environment adjacent to the vehicle for suitable parking areas between other parked vehicles or markings on the road such as painted lines, evaluates the required information to calculate parking trajectories and sends steering commands to an electronic interface of the steering system for lateral control of the vehicle during the parking manoeuvre.

The basic APS function is to assist the driver with lateral control of the vehicle during parking manoeuvres. As an optional extension, APS can also offer limited longitudinal control of the vehicle movement, e.g. braking assistance while manoeuvring into the parking slot.

This document contains requirements for the lateral control capability of APS. It does not address longitudinal control.

During the parking manoeuvre, the driver can take over the control of the vehicle movement at any time and is also fully responsible for the parking manoeuvre.

APS uses object-detection devices for detection and ranging in order to search the environment for suitable parking areas. Such devices can be sensors with distance information or vision-based systems. In addition, sensors or counters, as well as relevant data available on the vehicle network (e.g. CAN), may be used to calculate the position of the vehicle relative to the parking area.

APS is an extension of systems which inform the driver about obstacles in parking manoeuvres (e.g. ISO 17386 and ISO 22840).

This document does not include assisted parking systems, reversing aids and obstacle-detection devices for use on heavy commercial vehicles or on vehicles with trailers.

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 terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp/

3.1
assisted parking system
APS
system capable of measuring the dimensions of a parking slot, calculating an applicable trajectory, performing lateral control of the vehicle while manoeuvring into the slot and giving needed instructions to the driver

3.2
slot search mode
operation mode in which the *APS* (3.1) searches the environment for suitable parking slots

3.3
assisted parking mode
automated lateral control (i.e. steering) of the vehicle by the *APS* (3.1) during the parking manoeuvre while the driver has control of the vehicle speed and driving direction

3.4
system activation
action of transitioning the system operation from a quiescent mode to an active one

3.5
driver assistance request
unique interaction between driver and user interface which is required to enable the *APS* (3.1) before each active parking manoeuvre

3.6
audible information and warning
acoustical signal (e.g. pulses, speech) which is used to present relevant information to the driver

3.7
visual information and warning
optical signal (e.g. a telltale or display) which is used to present relevant information to the driver

3.8
sensor system
component or set of components which detects objects in the monitoring range

3.9
test object
object with a specific material, geometry and surface for testing the monitoring range

3.10
searching range
minimum area in which *APS* (3.1) is able to search the environment for suitable parking slots

3.11
APS exit condition
condition after *system activation* (3.4) which causes the *APS* (3.1) to abort the manoeuvring support

3.12
APS end condition
assisted parking manoeuvre is finished and *APS* (3.1) gives the full control of the vehicle back to the drive

3.13
bordering vehicle
vehicle that limits the parking slot to the rear or the front

3.14
APS vehicle
vehicle which is equipped with *APS* (3.1)

3.15
V_{search_max}
requirement up to which maximum speed *APS* (3.1) shall be able to search the environment for suitable parking slots

3.16
parking slot defining line(s)
painted lines on the ground surface in a bright colour to identify the boundary of a defined parking slot

4 Definition of APS type and common requirements

4.1 Basic system functionality

The APS recognizes a parking slot where the vehicle can be parked, determines the target parking position and calculates the parking trajectory.

The APS guides the vehicle to the target parking position by automatically controlling the steering during a parking manoeuvre. Upon completion of control, the vehicle's position relative to the target parking position shall fulfil a certain accuracy requirement.

4.2 APS types

This document addresses the practical systems available in the market because the driver's parking behaviour and urban parking conditions are unique issues for each country or district. Two APS type definitions according to the system's target parking slot follow:

a) APS type 1: the APS whose target slot is the space between two vehicles;

b) APS type 2: the APS whose target slot is defined by markings such as painted lines.

For both types, parallel and perpendicular slots are possible.

4.3 Common requirements

4.3.1 Maximum speed during operation

It is recommended to limit the speed range during assisted parking and abort the assisted parking mode for safety when the driver exceeds this limit. The recommended range for the speed limit is (Forward: 10 km/h; Reverse: 7 km/h to 12 km/h). However, this speed limit shall conform to local regulatory requirements such as internal law, technical guidelines.

4.3.2 APS exit conditions

APS shall abort the assisted parking mode if one or more of the following conditions apply.

— The driver operates the steering to take over the control. Minimum torque to the steering wheel shall be defined by OEM. Typical value could be approximately 5 Nm.

— There is a system internal failure detected by the APS.

— The vehicle exceeds the speed limit for the assisted parking mode, as specified in 4.3.1.

The system shall cancel automatic steering control and give both audible and visual information to the driver upon detecting malfunctions.

4.3.3 Advisory note

The APS, as described in this document, is intended to detect suitable parking slots and steer the vehicle during the parking manoeuvre. It is recommended that the vehicle operator's handbook

(owner's manual) includes an advisory note that clearly indicates how to use the system and includes a description of abort criteria, the driver's responsibility and the limitations of the system.

It shall particularly remind the driver of his responsibility for safety while manoeuvring into the parking slot. This includes taking care of obstructions and other possible hazards that may not be detected by the APS. Especially in case of perpendicular parking slots, the driver shall ensure that the depth of the parking slot is sufficient. If there is an unsafe condition detected by the system, the driver shall be advised not to start the manoeuvre or to immediately take over the control of the vehicle movement.

The APS shall also assist the driver in recognizing obstacles while manoeuvring into the parking slot. Examples of such systems are described by MALSO (ISO 17386), ERBA (ISO 22840) International Standards or rear viewing camera systems.

5 Functional and performance requirements of APS type 1

5.1 Basic system functionality

5.1.1 General

APS type 1 shall support either parallel or perpendicular or both types of parking slots.

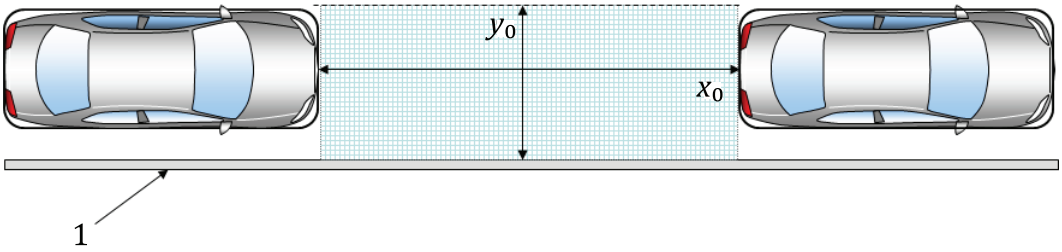
5.1.2 Parking slot type 1 parallel

The parking manoeuvre shall be performed with a parking slot limited by two vehicles of similar model as the APS vehicle and an optional kerb as a lateral reference. It is recommended that the system is able to detect a reference kerb, as described in Figure 9.

For this document, it is recommended that the bordering vehicles are aligned in the same direction and parallel to each other. The document parking slot length, x_0, is defined as the length of the APS vehicle plus Δx_p and the slot depth, y_0, is defined as the width of the APS vehicle plus 0,2 m. For the test parking scene, two situations are considered, either with or without a reference kerb. In the case with a reference kerb, the vehicles are parked with a fixed distance parallel to it. In a situation without kerb, the virtual connecting line between the outer borders of the parked vehicles projected onto the ground is the lateral reference line.

The parking slot is defined by its length, x_0, and its depth, y_0 (as shown in Figure 1). x_0 is the distance between the two reference vehicles. The depth, y_0, is the distance between the outer border line of the reference vehicle and the kerb.

For APS vehicle length between 4 m and 6 m, Δx_p = length of APS vehicle multiplied by 0,25. For small vehicles, (≤4 m): Δx_p = 4 m × 0,25 = 1,0 m and for large vehicles, (≥6 m) Δx_p = 6 m × 0,25 = 1,5 m.



Key

1	kerb
x_0	slot length = length of APS vehicle + Δx_p
y_0	slot depth = width of APS vehicle + 0,2 m
	parking slot

Figure 1 — Geometry of a parking slot type 1 parallel

5.1.3 Parking slot type 1 perpendicular

As a minimum requirement, the parking manoeuvre shall be performed with a parking slot limited by two vehicles of a similar model as the APS vehicle. Compliance with this document may also be proven using vehicles of different types.

For this document, it is recommended that the bordering vehicles are aligned in the same direction as the APS vehicle in its target position and parallel to each other. The parking slot width, x_0, is defined as the width of the APS vehicle plus Δx_l and the slot depth, y_0, is defined as the length of the APS vehicle. Δx_l = 1,2 m. See Figure 2.

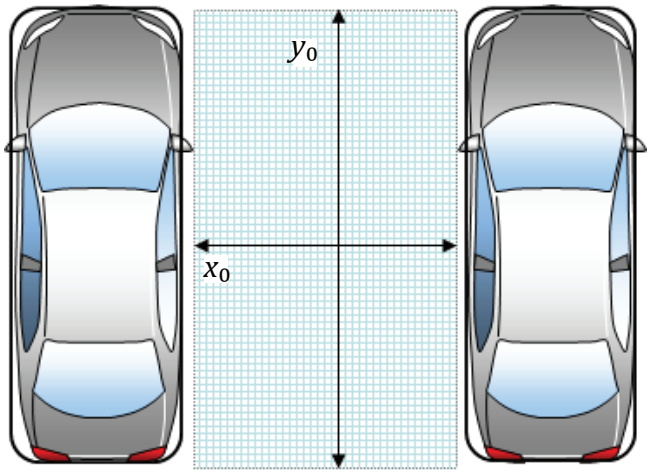


Figure 2 — Geometry of parking slot type 1 perpendicular

5.1.4 APS operation sequence

For APS type 1, see Figure 3.

5.1.5 Basic operation procedure of APS

For APS type 1, see Figure 3.

5.1.6 Quiescent mode

APS type 1: If activation conditions are not fulfilled, the APS shall not perform any action.

5.1.7 Slot search

APS type 1: Below a certain speed, V_{search_max}, and if activation conditions are fulfilled, the APS starts to search the environment for suitable parking slots. The system shall be able to search and park in the direction of both the driver and the passenger side. Depending on the system design, the driver may be able to choose the types of supported parking slots during slot search (for example, perpendicular only, parallel or perpendicular, driver side only, driver and passenger side, etc.). Due to physical limitations of the sensing system, there may be obstructions within the parking slot that are not detected by the APS, but may interfere with parking in the detected slot. Furthermore, in case of perpendicular parking slots, the obstacle detection systems may not cover the whole parking space depth.

5.1.8 Slot found

APS type 1: The system shall inform the driver about potentially suitable parking slots found. The driver needs to check the parking slot for obstructions before proceeding with the next step.

5.1.9 Target parking slot recognition

APS type 1: The APS informs the driver when the vehicle arrives at the position where parking assist is possible.

5.1.10 Assisted parking mode

When the driver decides to park into the suitable parking slot and stops the vehicle, the APS shall assist the driver with advice and by actuating the steering during the parking manoeuvre. The ability of the system to support the parking manoeuvre will depend on the actual starting position of the APS vehicle relative to the parking slot. The limitations of the permissible starting positions shall be described in the owner's manual of the vehicle.

The actuation of the steering shall not start before the vehicle stands still.

The driver shall be able to finish the parking manoeuvre by taking over lateral control of the APS vehicle at any time. In this case, the APS shall terminate the automated actuation of the steering immediately.

5.1.11 End of assisted parking mode

The driver shall be informed when the parking manoeuvre is finished or aborted.

5.1.12 APS diagram of operating modes (APS type 1)

Figure 3 shows an example sequence of operating modes, the corresponding information presented to the driver in each operating mode and also, which activity is required by the driver.

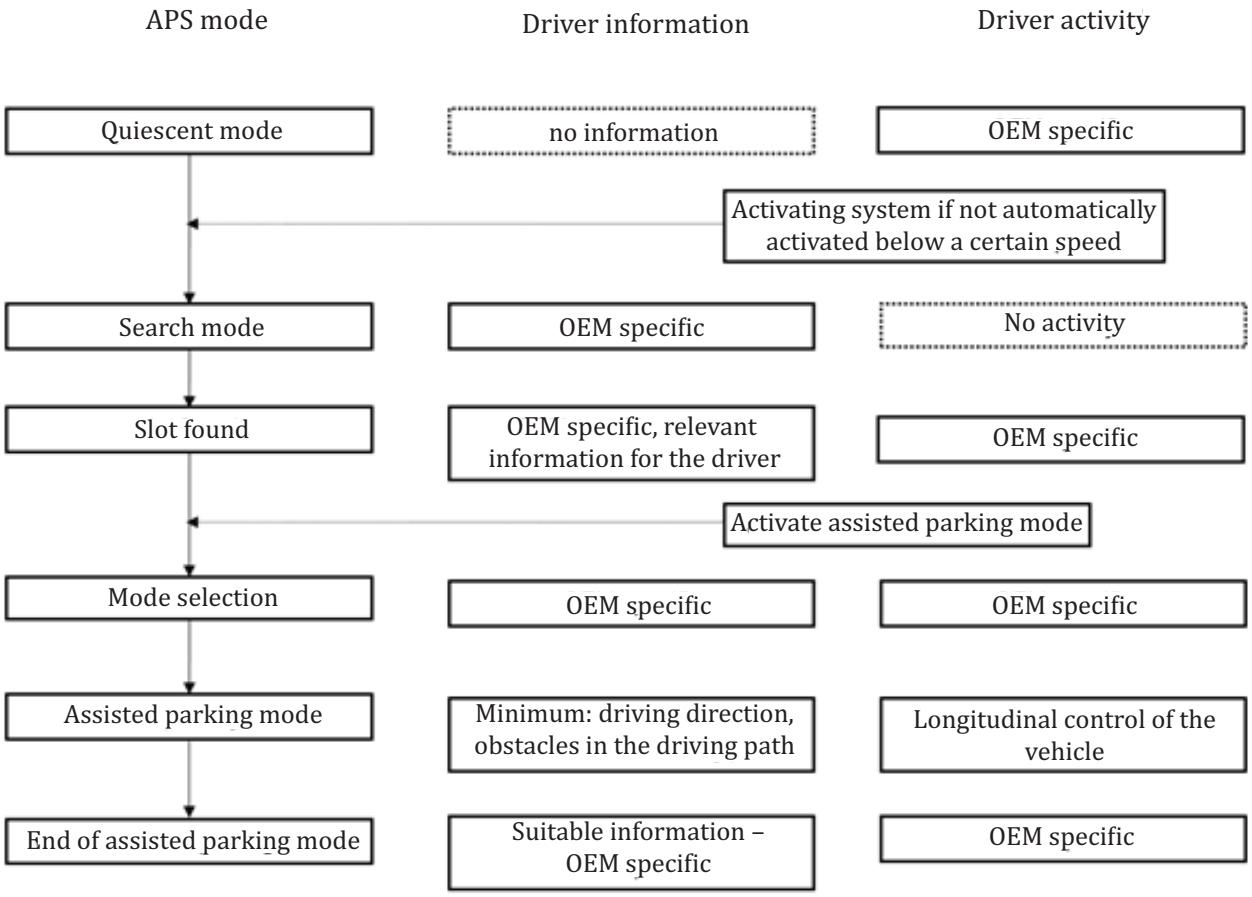


Figure 3 — APS diagram of operating modes (APS type 1)

Advancement to the next mode is only possible if the driver has completed the described activity.

Upon system activation, the system leaves the quiescent mode, starts searching the environment for parking slots, evaluates the objects detected and generates appropriate feedback to assist the driver.

While the system is active, it may switch its operating mode between “search mode”, “slot found”, “mode selection” and “assisted parking mode” depending on the situation and driver activity.

5.2 Driver interface and information strategy

5.2.1 General information presentation

The system may inform the driver on the current operating mode (e.g. slot search, slot found, assisted parking mode, error mode) and shall provide instructions to the driver which are required for the parking manoeuvre. As a minimum requirement, the system shall give audible information to the driver upon releasing the automatic steering, either when the assisted parking manoeuvre is finished successfully or when it is aborted.

A warning may be issued before the steering wheel starts automatic rotation.

5.2.2 Information in the slot search mode

It is in the responsibility of the vehicle manufacturer to define which kind of information the APS provides to the driver in the slot search mode.

5.2.3 Information during "slot found" until "start of assisted parking"

The driver shall be informed about suitable slots found by the APS.

It is the responsibility of the vehicle manufacturer to define which kind of information is provided to the driver when a suitable slot is found before the assisted parking mode is entered.

5.2.4 Driver request

It is the responsibility of the vehicle manufacturer to define which kind of activities the driver has to do to enable the lateral control of the APS.

The driver may need to confirm the selection of the target parking slot, for example, if more than one possible parking slots are available.

5.2.5 Information during assisted parking

The driver shall be informed when all prerequisites to start manoeuvring into the parking slot are fulfilled and APS switches to the assisted parking mode.

When the vehicle is in the assisted parking mode, the following information or warnings need to be provided to the driver.

— The system shall give audible information to the driver upon releasing the automatic steering.

— In case that the APS detects a malfunction (see 4.3.2), the driver shall be informed.

The APS may provide additional information to the driver in the assisted parking mode, such as gear shift instructions or driving speed recommendations.

5.2.6 Information at "end of assisted parking"

The driver shall be informed when APS has finished the parking manoeuvre and stops lateral control of the vehicle (the steering is released upon leaving the assisted parking mode).

5.3 Minimum performance requirements

5.3.1 Performance requirements during slot search mode

When the system is in slot search mode, the minimum system requirements in Table 1 shall be fulfilled.

Table 1 — Minimum requirement for slot search mode

	Type 1 parallel	Type 1 perpendicular
Supported vehicle speed, V_{search}	≤30 km/h	≤20 km/h
Supported lateral clearing distance to parked vehicles	0,5 m to 1,5 m	0,5 m to 1,5 m
Driving path	Straight	Straight
Maximum angle between APS vehicle and connecting line of the bordering vehicles	5°	5°

5.3.2 Performance requirements during assisted parking mode

5.3.2.1 General

APS Type 1: The supported maximum speed during some portion of the parking manoeuvre shall be at least 5 km/h. It is recommended to limit the speed range during

assisted parking and abort the assisted parking mode when the vehicle exceeds this limit. The recommended range for the speed limit is Forward: 10 km/h; Reverse: 12 km/h. The vehicle shall follow a trajectory avoiding collisions with objects detected by APS.

5.3.2.2 Performance requirements for the end position APS Type 1 parallel

For the two standard parking situations described in this subclause, the requirements for the end position reached by the APS vehicle at the end of the assisted parking manoeuvre consider the distance, D_f, D_r, of the front and rear wheel of the vehicle to the kerb and the orientation, α, to kerb (situation with kerb) or the distance, D_f, D_r, and the orientation, α, to the connecting line between the two parked vehicles.

NOTE The target distance, D_r, D_f (distance rear and front), to the kerb or to the connecting line can be an APS internal parameter depending on the vehicle manufacturer's choice and the current situation. An exact value cannot be defined in this document, but a valid range can be given.

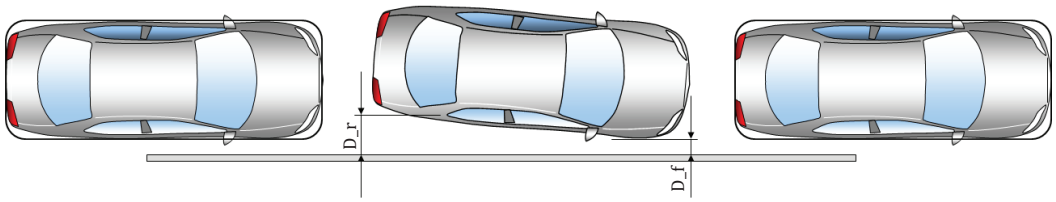


Figure 4 — Definition of D_r and D_f: distance vehicle rear/front to kerb

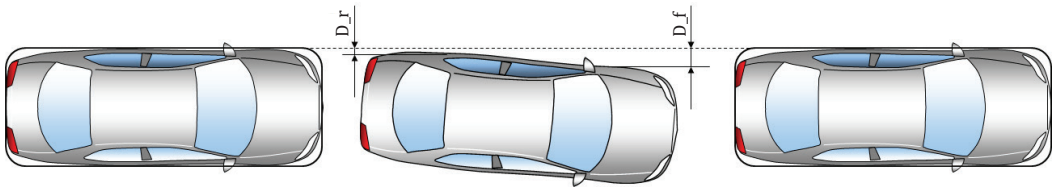
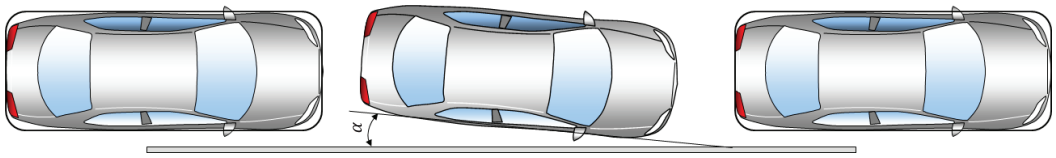
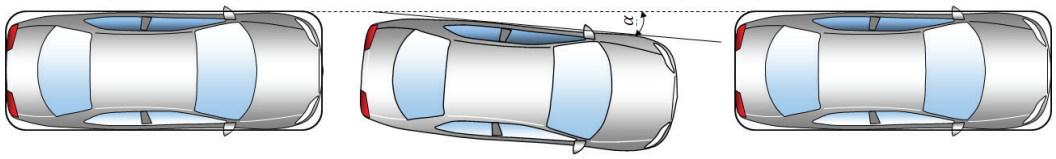


Figure 5 — Definition of D_r and D_f: distance vehicle rear/front to vehicle-connecting line



NOTE The angle is positive in this example.

Figure 6 — Definition of α: orientation of vehicle to the kerb



NOTE The angle is positive in this example.

Figure 7 — Definition of α: orientation of vehicle to vehicle-connecting line

a) Requirements for the angle

— The angle, α, to the kerb or vehicle-connecting line shall be in the range of −3° to +3°, where 0° is the target value (see Figures 6 and 7).

b) Requirements for the distance from the referenced line

— The distances, D_r, D_f, from the kerb shall be in the range of 0,05 m to 0,3 m (see Figure 4) or D_r, D_f from the vehicle-connecting line shall be determined by the vehicle manufacturer and depends on the actual width of the APS vehicle (see Figure 5).

5.3.2.3 Performance requirements for the end position APS Type 1 perpendicular

For the standard parking situations described in this subclause, the requirements for the end position reached by the APS vehicle at the end of the assisted parking manoeuvre is described by a target area. The target area is limited by four lines (see Figure 8). L_1 is parallel to the right flank of the left bordering vehicle at a distance of 0,3 m and L_3 is parallel to the left flank of the right bordering vehicle at a distance of 0,3 m. L_2 and L_4 are parallel to the front/rear edges of the bordering vehicles at a distance of 0,4 m. As the system does not control the longitudinal movement of the APS vehicle, the driver shall stop the vehicle when the system indicates that the assisted parking mode is finished and the target area is reached.

At the end position, the outline of the APS vehicle projected on the ground without regard of the side view mirrors shall be completely within the target area.

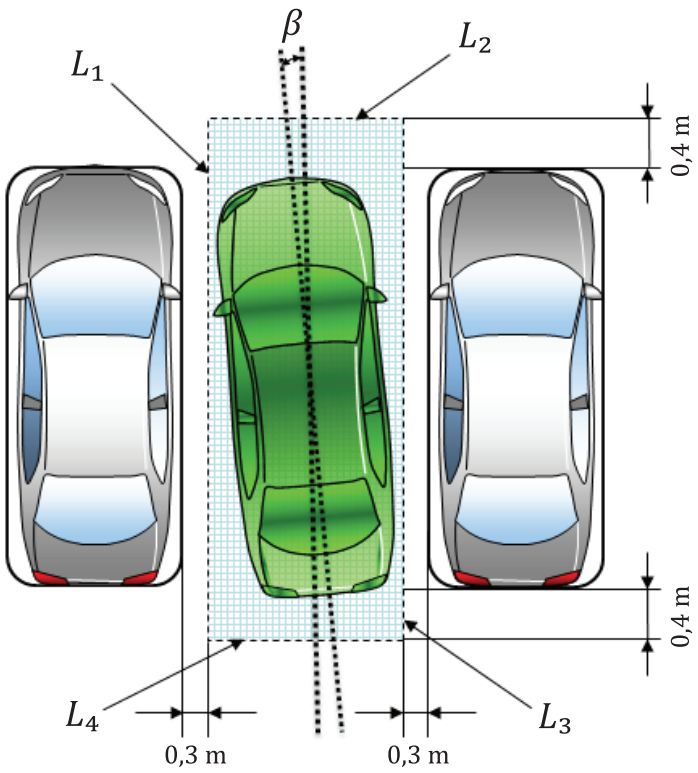


Figure 8 — Definition of β: orientation of vehicle inside the targeted area

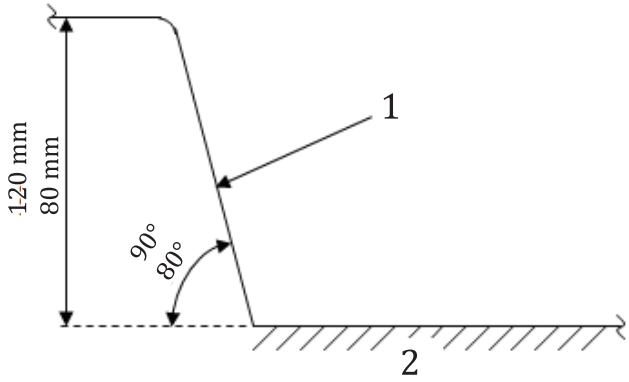
Requirement for all situations: the angle, β, shall be in the range of −3° to +3°, where 0° is the target value.

5.4 Performance test requirements (APS type 1)

5.4.1 Test objects

The test object should represent real world situations and therefore, it is recommended to park between two vehicles of the same type as the test vehicle.

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



Key

1 kerb outward side

2 road

Figure 9 — Definition of reference kerb

5.4.2 Ambient conditions — General

The wind speed shall not exceed 5,4 m/s (wind force 3) during testing. The temperature shall be 5 °C to 30 °C and there shall be non-precipitating conditions (i.e. not raining, sleeting, snowing, etc.). Testing shall be conducted on a flat, dry surface. Walls, auxiliary test equipment and other non-test objects (clutter) shall be removed from the test area in order to eliminate the interference caused by their reflections (sonic and/or electromagnetic).

If ambient conditions differ from the specified conditions above, compliance with this document may be tested nonetheless. If the system fails, however, the test shall be repeated under the specified conditions above to prove compliance.

5.4.3 Test criteria

For this document, only the performance of the system regarding assisted parking is considered. Tests, as described in ISO 17386 and ISO 22840, are not in the scope of this document.

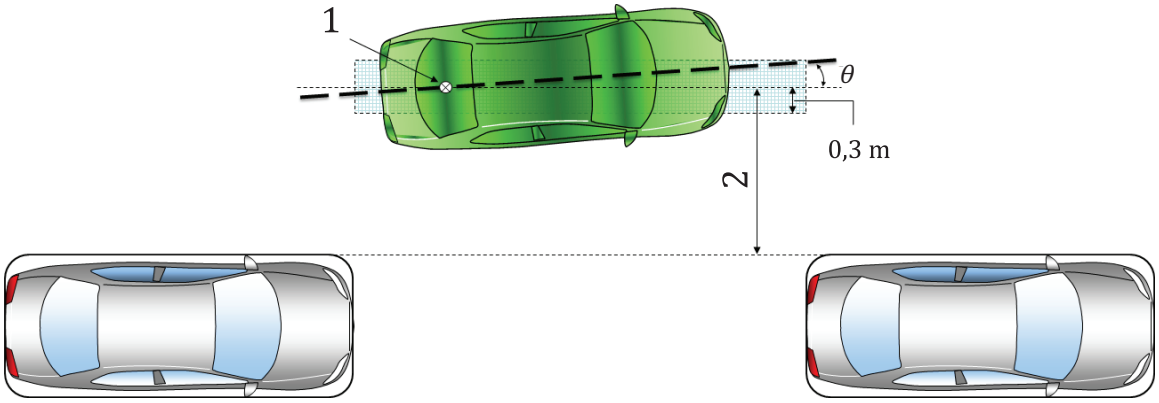
The main test criterion for APS is the end position of the vehicle in the parking slot.

5.4.4 Slot search tests

Tests need to be performed with one defined vehicle speed, one lateral clearing distance and angles to parked vehicles (see Table 2) according to the ranges specified in 5.3.1. Ten test trials shall be performed. A parking slot has to be detected at least nine times.

Table 2 — Conditions for slot search test

	Type 1 parallel	Type 1 perpendicular
Vehicle speed	27,5 km/h ± 2,5 km/h	17,5 km/h ± 2,5 km/h
Lateral clearing distance, d_{lcd}	1,20 m ± 0,30 m	1,00 m ± 0,30 m
Driving path during slot search test	Straight	Straight
Angle between APS vehicle and connecting line of the bordering vehicles during slot search test, θ	4° ± 1°	0° ± 1°



Key

1 reference point

2 d_{lcd} + 1/2 of vehicle width

Figure 10 — Illustration on how to perform slot search test with a lateral clearing distance, d_{lcd}, and angle, θ, shown for type 1 parallel

Reference point = middle of rear axle has to be inside the area shown in Figure 10.

5.4.5 Test of supported speed during assisted parking

Between the start of the manoeuvre and driving into the parking slot, a minimum speed peak of 5,0 km/h +0, –1,0 km/h shall be applied.

5.4.6 End position tests

To test the end position of the APS vehicle, 10 test trials shall be conducted in sequence with the same parking slot. Out of the 10 trials, nine have to be successful. A successful trial includes the complete sequence of APS modes (starting from slot search mode).

The distance, D_f, D_r, and the angle, α, shall be measured after reaching the end position at each trial. In case of situations with a kerb, the distance, D_f, D_r, shall be measured from the front wheel to the kerb and from the rear wheel to the kerb.

APS type 1 parallel

a) Requirements for the angle

— The mean angle, α, to the kerb or vehicle-connecting line shall be in the range of –3° to +3°.

— The standard deviation of α shall not be more than 1,5°.

b) Requirements for the distance from the referenced line

— The mean distance, D_r, D_f, from the kerb shall be in the range of 0,05 m to 0,3 m or mean distance, D_r, D_f, from the vehicle-connecting line shall be in the range determined by the vehicle manufacturer.

The target distance may be chosen in this range by the vehicle manufacturer.

— The standard deviation of D_r, D_f shall not be more than 0,1 m.

APS type 1 perpendicular

Requirements

— The APS vehicle shall be positioned completely within the target area.

— The mean angle, β, shall be in the range −3° to +3°.

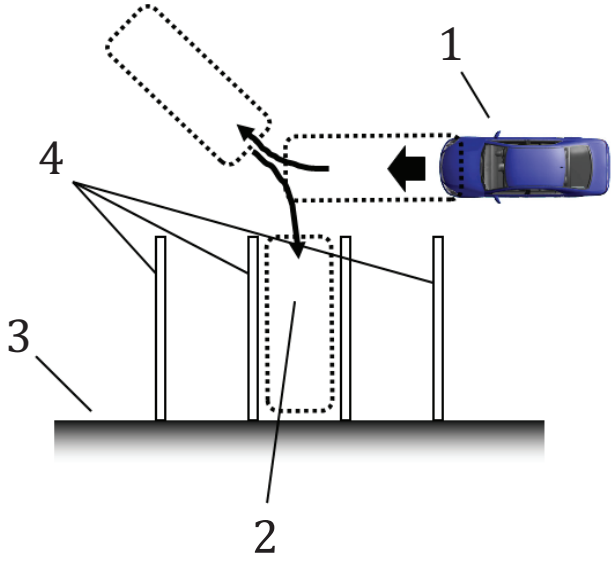
— The standard deviation of β shall not be more than 1,5°.

6 Functional and performance requirements APS type 2

6.1 Basic system functionality

6.1.1 Basic function

APS locates the parking slot where the vehicle can park by recognizing the marker(s), such as painted lines on the ground, to determine the target parking slot and calculates a guide route. See Figure 11.



Key

1 APS vehicle
2 target parking slot
3 side of the road, kerb, etc.
4 parking slot lines

Figure 11 — Example of perpendicular parking operation

The APS guides the vehicle to the target parking slot by automatically controlling the steering during a parking manoeuvre. Upon completion of control, the vehicle's position in the target parking slot shall fulfil certain accuracy.

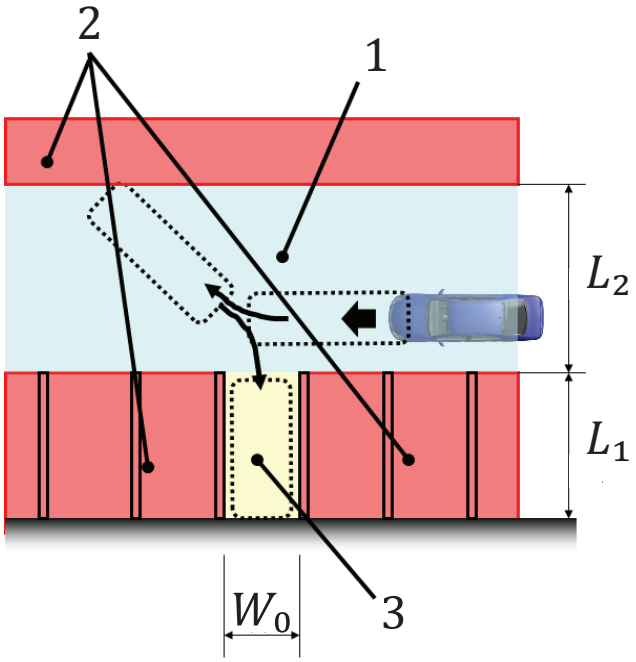
This document defines only the area where the APS control is permitted, the target parking slot and the areas of restricted passage shown in Figures 12 and 13, without addressing methods for sensing or route guidance or limiting the number of "back and forth" (as in a three-point turn) used in a turn during parking.

The basic APS function is to assist the driver with lateral control of the vehicle during parking manoeuvres. However, there is a possibility that the scope of automatic control may be expanded in the future.

6.1.2 Geometric requirements

The vehicle should not enter the areas of restricted passage during vehicle control.

Figures 12 and 13 show the guideline of the surrounding condition, which needs to be considered in the system design. The APS-controlled vehicle is required to stay within the area where APS control is permitted as indicated in the figures. It is also important to let users know how the system assists the parking manoeuvre and its performance limit. The description of how the system works and possible interference with surrounding objects shall at least be stated in the owner's manual.



Key

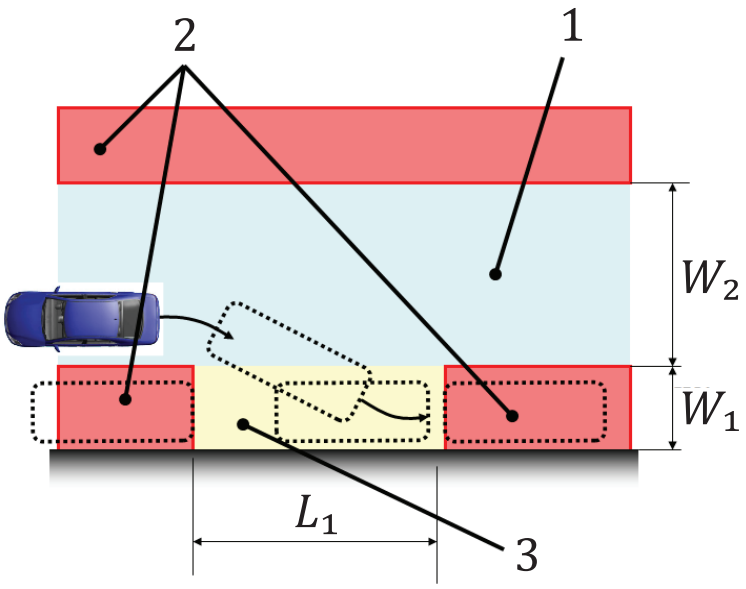
1 areas where APS control is permitted
2 areas of restricted passage
3 target parking slot
W_0 2,5 m
L_1 6,0 m
L_2 7,0 m

NOTE 1 For large cars whose width exceeds 1,9 m, W_0 and L_1 can be extended.

NOTE 2 The target, W_0, for such cars is "vehicle width + 0,6 m" (0,3 m margin for each side).

NOTE 3 The target, L_1, for such cars is "vehicle length + 1,0 m" (0,5 m margin for each end).

Figure 12 — APS required control range for perpendicular parking



Key

1 area where APS control is permitted
2 areas of restricted passage
3 target parking slot
L_1 L_v × 1,4 m
W_1 2,5 m
W_2 4,5 m or more

NOTE L_v is the vehicle length.

Figure 13 — APS required control range for parallel parking

6.1.3 APS diagram of operating modes (APS type 2)

Figure 14 shows an example sequence of operating modes and the corresponding information presented to the driver in each operating mode. Also, the driver's activities required to advance the mode and during each mode are described.

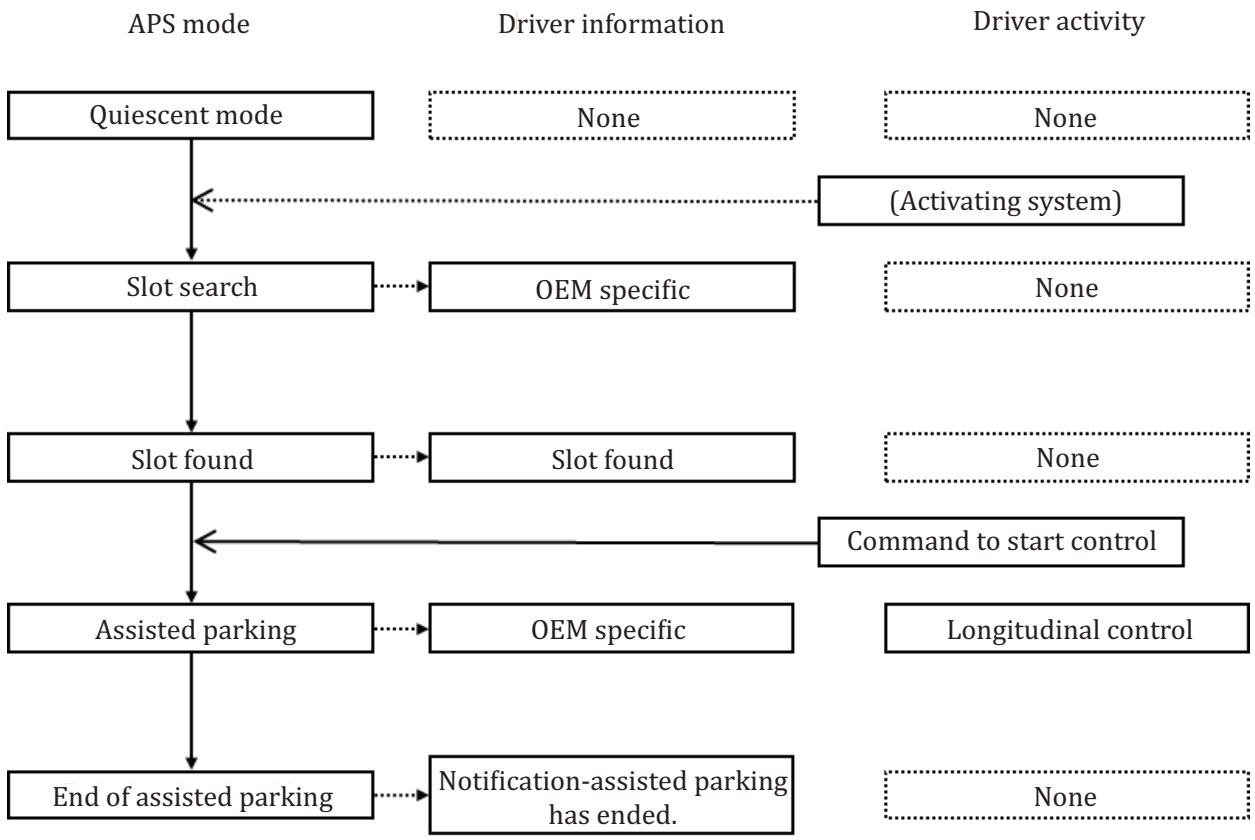


Figure 14 — APS diagram of operating modes (APS type2)

"Activating system" may be automatic. Information at "slot found" should include the position of the parking slot to be chosen by the driver.

6.2 Driver interface and information strategy

6.2.1 Operation procedure

The timing definition of the "starting APS operation" is when the driver commands the system to start manoeuvring the vehicle towards the targeted parking slot detected by the sensor(s). The vehicle manufacturer should define the requirement for the function of searching the target parking slot because it depends on the system design such as number, position and performance of the on-board sensor device(s).

For example, the driver needs to move the vehicle manually to the place from where the on-board sensor can capture the target parking slot in case only a single sensor is equipped on the rear end. However, employing extra sensors on the side and front of the vehicle enables the system to start operation earlier by having wider sensing area.

This document defines the requirements for minimally configured system.

6.2.2 Basic operation procedure of APS

The driver launches the system after he/she has brought the vehicle to the place where APS control can be started as instructed by the owner's manual or such.

The APS informs the driver the target parking position through user interface such as displays.

APS starts manoeuvring the vehicle toward the targeted parking slot triggered by the driver's input such as changing the gear position or depressing the command switch.

The APS should provide the driver essential instructions and necessary warning at an appropriate timing.

The APS shall inform the driver of the end of the APS operation.

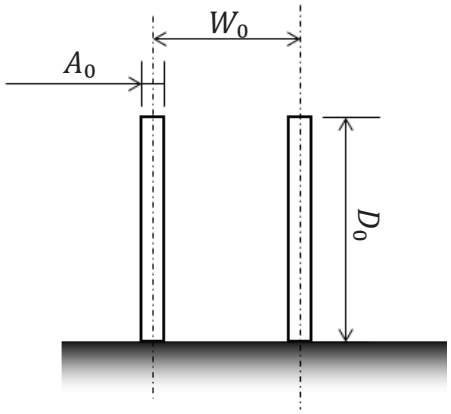
An example of typical operation procedure is described in Annex A.

6.3 Minimum performance requirements

6.3.1 Defined parking slot

6.3.1.1 Perpendicular parking

The minimum requirement items for a standard parking slot defined by painted lines and targeted by the system are shown in Figure 15.



Key

W_0 width of the parking slot opening (= 2,5 m)

D_0 depth of parking slot (= 6,0 m)

A_0 width of parking slot line (= 0,15 m)

NOTE 1 For large cars whose width exceeds 1,9 m, W_0 can be extended.

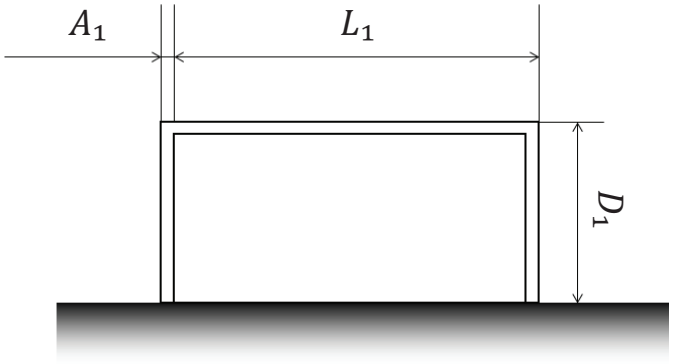
NOTE 2 The target, W_0, for such cars is "vehicle width + 0,6 m" (0,3 m margin for each side).

NOTE 3 The minimum requirement for the surface of a parking slot is a flat paved surface.

Figure 15 — Geometry of a defined perpendicular parking slot

6.3.1.2 Parallel parking

The minimum requirement items for a standard parallel parking slot defined by painted lines and targeted by the system are shown in Figure 16.



Key

L_1 length of the parking slot (= 7,0 m)

D_1 depth of parking slot (= 2,5 m)

A_1 width of parking slot line (= 0,15 m)

Figure 16 — Geometry of a defined parallel parking slot

6.3.2 Target slot recognition

Upon arrival at the parking assist starting position, the system shall recognize the target parking slot and notify the driver of the results. The method of notification is not addressed in this document.

The minimum illumination requirement for recognition of a parking slot should be 100 lx or less (assuming that indoor parking lots will be used).

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

$$\text{Parking slot line luminance contrast} = (L_{sl} - L_{rs})/L_{rs} \quad (1)$$

where

L_{sl} is the slot line luminance;

L_{rs} is the road surface luminance.

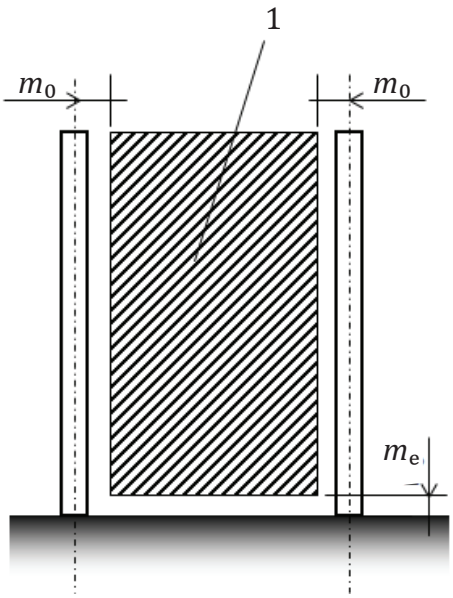
6.3.3 Maximum speed during operation

See 4.3.1.

6.3.4 Performance requirements for the end position

6.3.4.1 Perpendicular parking

APS leads the vehicle to the target parking slot. The vehicle shall stay within the parking slot defined by painted lines when it has completed the assistance. Vehicle manufacturer may define the tolerance requirements according to their targeted system performance. System performance is defined as the inclination angle, θ, relative to the parking slot lines and the "deviations" when the parking assist parking is completed. See Figures 17 and 18.



Key

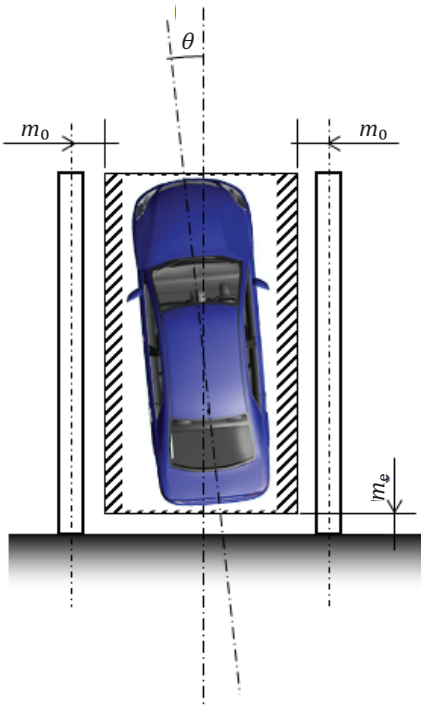
1 target parking area

m_0 0,1 m

m_e 0,1 m

Figure 17 — Definition of target area for end position of APS type 2 perpendicular

APS vehicle shall be placed within the target parking area defined by Figure 17. Maximum tolerance of angular alignment to the parking slot is defined in Figure 18.



Key

m_0 0,1 m

m_e 0,1 m

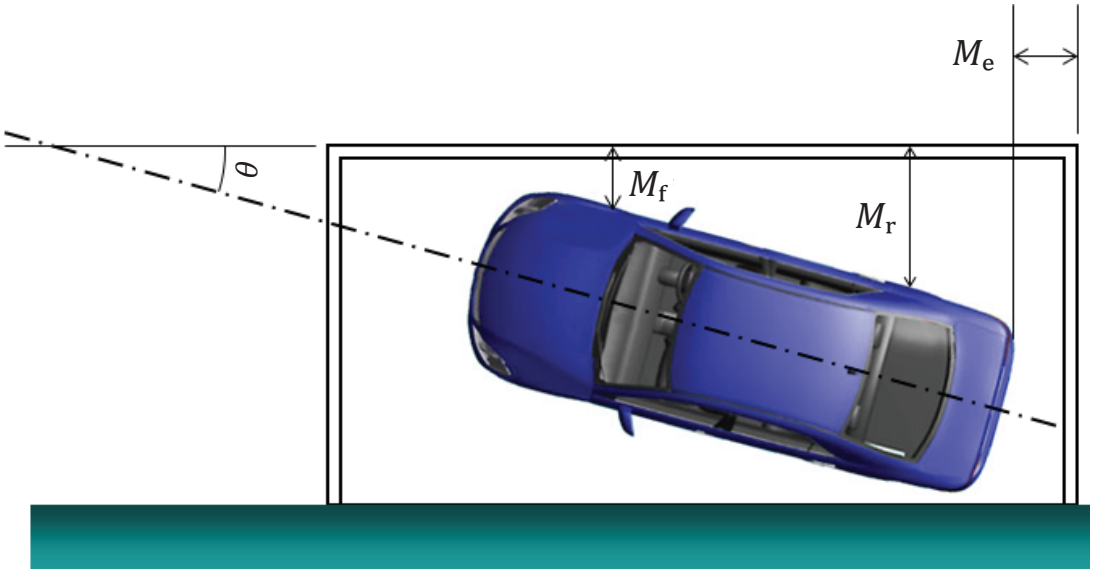
NOTE $-3{,}0° \leq \theta \leq 3{,}0°$.

Figure 18 — Definition of border-line of APS type 2 perpendicular

6.3.4.2 Parallel parking

System performance is defined as the angle, θ, relative to the road edge and the "margins" when the parking assist parking is completed (see Figure 19).

Margins, M_f and M_r, are the shortest distances from the points of outermost tire contact with the ground to the outer edge of the parking slot line. M_e is the shortest distance between the rearmost body and outer edge of the line.



NOTE
$-3{,}0° \leq \theta \leq 3{,}0°$
$M_f > 0$ m
$M_r > 0$ m
$M_e > 0$ m

Figure 19 — Definition of border line of APS type 2 parallel

6.4 Performance test requirements

6.4.1 Performance test conditions

The illumination for the target parking slot should be 100 lx or more.

The brightness contrast ratio between the painted lines and the surface should be 5:1 or more.

6.4.2 Parking slot recognition test

6.4.2.1 General

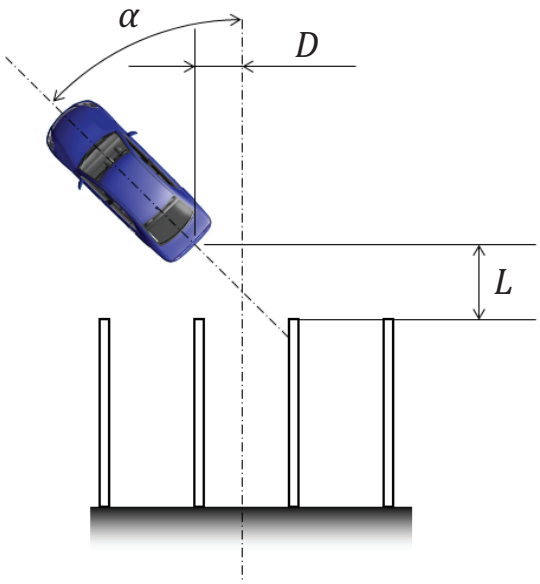
Parking slots should be on a flat, uniform and (asphalt or concrete) paved surface.

The typical test parking slot dimensions are defined in Figure 17 for perpendicular and Figure 18 for parallel parking.

6.4.2.2 Perpendicular parking

Parking slot recognition performance should be tested in a parking slot similar to the standard conditions shown in Figure 17.

Typical dimensions of the test target are defined in Figure 20 from which vehicle manufacturers may select the vehicle's relative position for the test.



Key

α 45,0° ± 5,0°

L 1,8 m ± 0,5 m

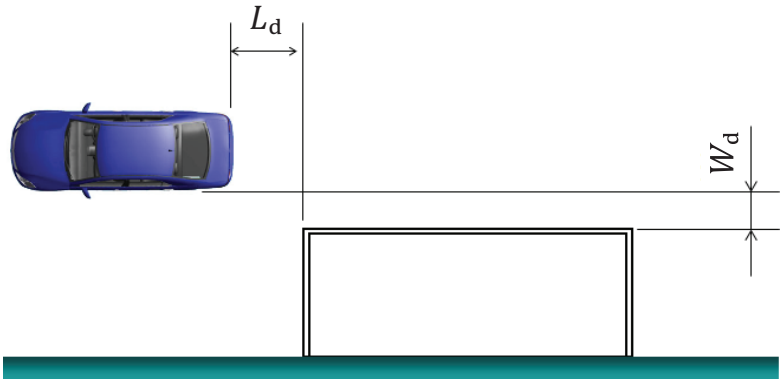
D 1,0 m ± 0,5 m

Figure 20 — Definition of test site APS type 2 perpendicular

6.4.2.3 Parallel parking

Parking slot recognition performance should be tested in a parking slot similar to the standard conditions shown in Figure 21.

Typical dimensions of the test target are defined in Figure 21 from which vehicle manufacturers may select the vehicle's relative position for the test.



Key

L_d L_v × 0,5 m ± 0,5 m

W_d W_v × 0,5 m ± 0,5 m

NOTE L_v is the vehicle length and W_v is the vehicle width.

Figure 21 — Definition of test site APS type 2 parallel

6.4.3 Environmental conditions — General

There shall be non-precipitating conditions (i.e. not raining, sleeting, snowing, etc.). Testing shall be conducted on a flat, dry 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). No extra marking on the surface, except the parking slot-defining lines, is allowed, and any objects, which may interfere with the image recognition process, shall be removed.

6.4.4 Test criteria

For this document, only the performance of the system regarding assisted parking is considered. The main test criterion for APS is the end position of the vehicle in the parking slot.

6.4.5 End position tests

6.4.5.1 General

Evaluate the vehicle position when parking assist is completed.

6.4.5.2 Perpendicular parking

Measure the angle, θ, relative to the centreline between the parking slot lines, the lateral margins, M_{fl}, M_{fr}, M_{rl}, and M_{rr}, from the centre of the parking slot line and the longitudinal margin, M_e, from the rearmost parking slot.

The vehicle reference points for the lateral margins are the outermost tire contact points with the ground, whereas the rearmost part of the vehicle body is for the longitudinal margin.

Criteria: $-3{,}0° \leq \theta \leq 3{,}0°$, $M_{fl} > m_0$, $M_{fr} > m_0$, $M_{rl} > m_0$, $M_{rr} > m_0$ (m_0 = 0,1 m), $M_e > m_e$ (m_e = 0,1 m)

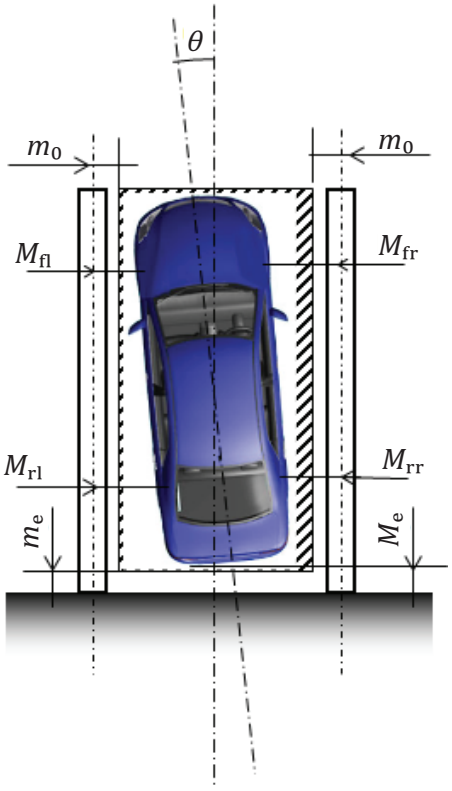


Figure 22 — Definition of end position tests APS type 2 perpendicular

6.4.5.3 Parallel parking

The vehicle shall be within the parking slot lines and not stay over the lines. Measure the angle, θ, relative to the outer-line of the slot and measure the deviations, M_f, M_r, and M_e, from the corresponding lines of the parking slot line as shown in Figure 23.

Criteria: $-3{,}0° \leq \theta \leq 3{,}0°$, $M_f > 0$ m, $M_r > 0$ m, $M_e > 0$ m

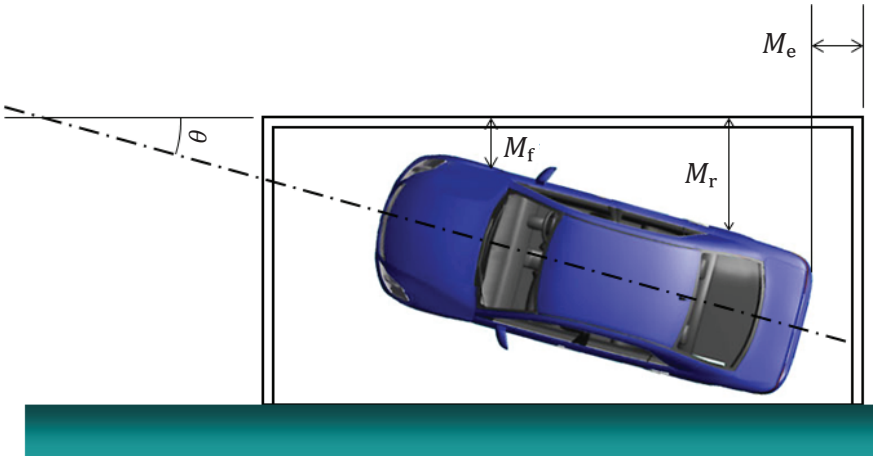


Figure 23 — Definition of end position tests APS type 2 parallel

Annex A
(informative)

Example of APS operation sequence

The APS function is executed in the following subsequent steps.

a) Vehicle placement

— The driver should move the vehicle manually to the position where the sensor can capture the parking slot defined by markings such as painted lines (① → ②).

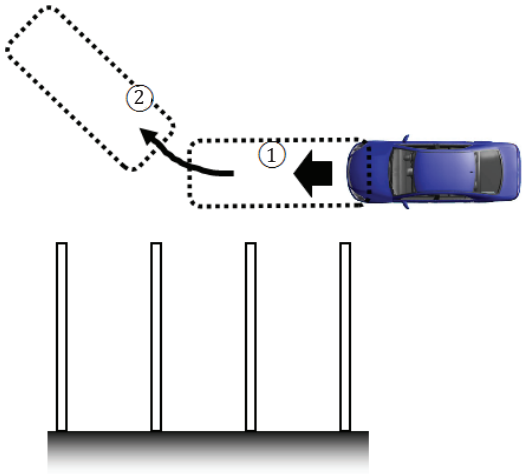


Figure A.1 — Vehicle placement for perpendicular parking

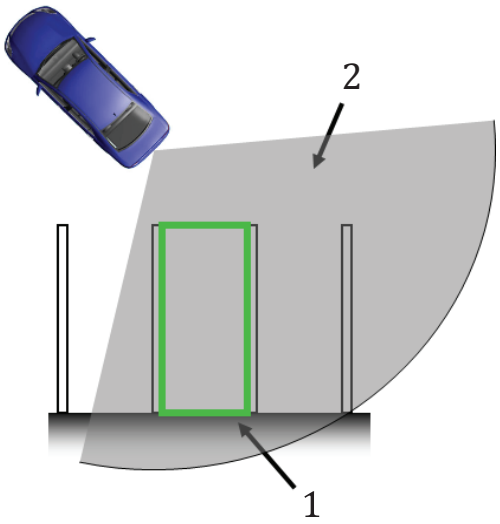
b) Turning the main switch on

— Main switch: the system should have a main switch for operation by the driver. After the driver turns the main switch on, the sequence after the selection of parking assist mode should be followed.

— When the main switch is turned off, all control should be cancelled.

c) Recognizing parking slot

— The APS recognizes slots where the vehicle can be parked, for example, from slot lines in the sensor image and overlay a grid (frame) on the same sensor image.



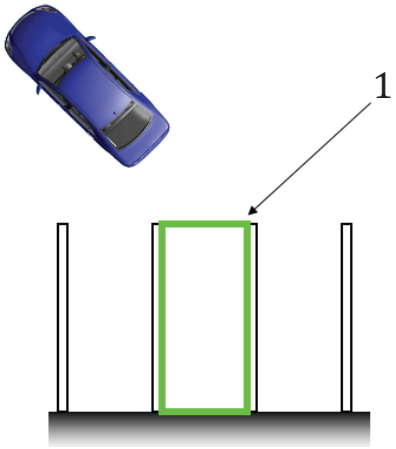
Key

1 recognized target parking slot

2 sensor FOV

Figure A.2 — Recognizing target slot for perpendicular parking

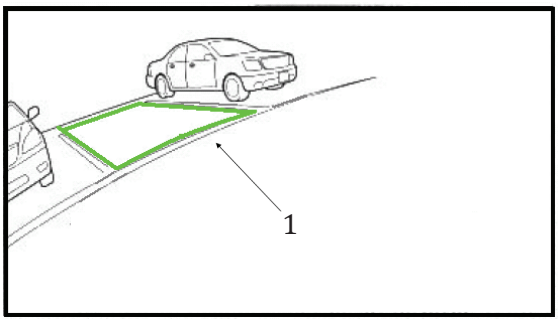
The method of overlaid display, such as a top view from above the vehicle or direct portrayal of the sensor image, depends on the manufacturer's design and there are no such restrictions.



Key

1 recognized target parking slot

Figure A.3 — Example of top view



Key

1 recognized target parking slot

Figure A.4 — Example of sensor image

d) Driver confirmation of the target-parking slot

— The system should be able to inform the driver about suitable parking slots found.

— The driver should be able to confirm the start of control before the vehicle moves toward a target-parking slot detected by the system or selected by the driver.

e) Assisted parking

— When the driver decides to park into the suitable parking slot found and stops the vehicle, the APS should assist the driver with advice and by actuating the steering during the parking manoeuvre.

— A warning may be issued in advance to remind the driver to be careful before the steering wheel starts to rotate by automatic control.

— The ability of the system to support the parking manoeuvre will depend on the actual starting position of the APS vehicle relative to the parking slot. The limitations of the permissible starting positions should be described in the owner's manual of the vehicle.

— The actuation of the steering should not start before the vehicle stands still.

— The driver should be able to take over lateral control of the APS vehicle at any time. In this case, the APS should terminate the automated actuation of the steering immediately.

f) End of assisted parking

— The driver should be informed when the parking manoeuvre is finished or aborted.

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