

IVISTA

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Intelligent Parking Index Memory Parking System Test Protocol

(Version 2023)

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Intelligent Parking Index Memory Parking System Test Protocol

1 Scope

This document specifies the test methods of IVISTA China Intelligent Vehicle Index - Intelligent Parking Index - Memory Parking System.

2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute indispensable provisions of this document. For dated references, only the dated edition applies to this document. For undated references, the latest edition (including all amendments) applies to this document.

GB 34660 Road Vehicles - Requirements and Test Methods of Electromagnetic Compatibility

GB 5768.3 Road Traffic Signs and Markings - Part 3: Road Traffic Markings

GB/T 18385-2005 Electric Vehicles - Power Performance - Test Method

GB/T 34590 Road Vehicles - Functional Safety (All Parts)

GB/T 39263-2020 Road Vehicles - Advanced Driver Assistance Systems - Terms and Definitions

GB/T 40429-2021 Taxonomy of Driving Automation for Vehicles

GB/T 41630-2022 Performance Requirements and Test Methods for Intelligent Parking Assist System

JGJ 100 Code for Design of Parking Garage Building

ISO 16787 Intelligent Transport Systems-Assisted Parking Systems (APS)-Performance Requirements and Test Procedures

3 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1

memory parking; MP

an intelligent parking function that memorizes the routes and limited parking spaces within the parking lot through learning and mapping, and assists the driver in controlling the vehicle for low-speed long-distance cruising based on the learning and mapping results during parking

3.2

vehicle under test, VUT

a vehicle equipped with a memory parking function for testing

[Source: GB/T 41630-2022, 3.2, modified]

3.3

target vehicle, TV

a vehicle that can interfere with the completion of the driving task for memory parking function of VUT when it is running ahead or near the VUT

3.4

background vehicle; BV

a necessary vehicle stationary near the VUT for constructing the test scenario

3.5

target parking space

a parking space used for parking and exiting tests on the memory parking function of the VUT

3.6

adult pedestrian target; APT

an adult pedestrian test device for testing the active safety system

3.7

child pedestrian target; CPT

a child pedestrian test device for testing the active safety system

3.8

crouched child target; CCT

a crouched child test device for testing the active safety system

3.9

dynamic driving task fallback

fallback response by the user to take over or by the driving automation system to implement the minimal risk maneuver in case of conditions dissatisfying the operational design condition, such as the imminent exit of the operational design domain, driving automation system failure, or other vehicle system failures

[Source: GB/T 40429-2021, 2.10]

3.10

request to intervene

a notice that the driving automation system requests the dynamic driving task fallback-ready user to take over

[Source: GB/T 40429-2021, 2.13]

3.11

take over

a behavior that the dynamic driving task fallback-ready user responds to the request to intervene and obtains the driving right of the vehicle from the driving automation system

[Source: GB/T 40429-2021, 2.14]

4 Test Requirements

4.1 Requirements for proving ground

4.1.1 Site requirements for closed proving ground

a) The proving ground shall be flat and dry pavement, without visible moisture, obvious pits, cracks and other defects.

b) Except for the ramp between floors, the ground slope shall be less than 1%.

- c) The outdoor proving ground shall be concrete or asphalt pavement, and the indoor proving ground shall be epoxy floor pavement.
- d) There shall be no barriers affecting the operation of the sensor on the proving ground.
- e) The parking space markings shall be in pristine condition and easily visible, characterized by white solid lines with a width of 15 cm.
- f) The lane lines can be white solid lines, white dotted lines, yellow solid lines and yellow dotted lines, which meet the requirements of GB 5768.3.

4.1.2 Site requirements of open parking lot

- a) The VUT shall be able to pass smoothly on the test route without any movable obstacles.
- b) The markings of the parking space shall be in pristine condition and easily visible.
- c) The size of the parking space shall be larger than the body size of the VUT.

4.2 Requirements for test environment

4.2.1 Environmental requirements for closed proving ground

- a) The wind speed shall not exceed 5 m/s, and there shall be no rain, snow, fog, dust, etc.
- b) The temperature shall be 0 °C-45 °C.
- c) Unless required by the test scenario, the ambient illuminance of the driving route and target parking space in the outdoor parking lot shall not be less than 1000 lux, and that in the indoor parking lot shall not be less than 30 lux.

4.2.2 Environmental requirements for open parking lots

- a) The temperature shall be 0 °C-45 °C.
- b) The ambient illuminance of the driving route and target parking space in the outdoor parking lot shall not be less than 1000 lux, and that in the indoor parking lot shall not be less than 5 lux.

4.3 Test equipment

4.3.1 Target object

Adult pedestrian target (APT), standing child pedestrian target (CPT), and crouched child target (CCT) (3 to 6 years old, height of 522 mm) shall be swingable-legged flexible targets with surface feature parameters that can represent the said adult, standing child, and crouched child. They shall also adapt to the sensor system. Refer to ISO 19206-2 for specific requirements.

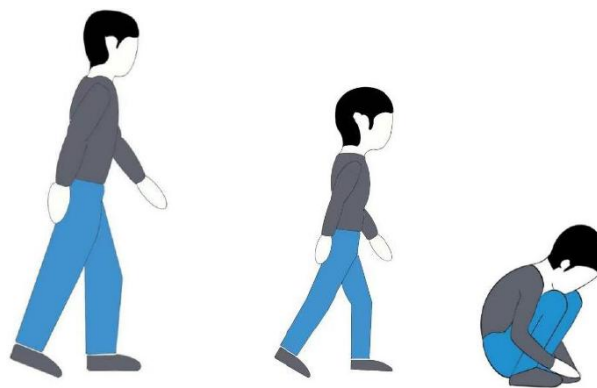


Fig. 1 Target Objects of Adult Dummy (Left), Standing Child Dummy (Middle), and Crouched Child Dummy (Right)

Note 1: For flexible target objects, after relevant national standards are published, the requirements of those national standards will prevail.

Note 1: If the manufacturer of the VUT believes that the flexible target does not meet the requirements of the VUT sensor for the target, please contact the IVISTA Management Center.

4.3.2 Data acquisition equipment

4.3.2.1 Requirements for test data acquisition equipment in closed proving ground:

- a) Sampling and storage frequency of dynamic data: not be less than 50 Hz.
- b) Speed accuracy of VUT: ± 1.0 km/h.
- c) Acceleration accuracy of VUT: ± 0.1 m/s².

4.3.2.2 Requirements for test data acquisition equipment in open parking lot:

- a) Sampling and storage frequency of dynamic data: not be less than 50 Hz.
- b) Speed accuracy of VUT: ± 1.0 km/h.

4.3.3 Background vehicle and target vehicle

M₁ passenger cars can be used as background vehicles and target vehicles, or dummy vehicles with the same reflection characteristics as M₁ passenger cars can be used as background vehicles and target vehicles.

Note: If the VUT's manufacturer considers that the background vehicle cannot meet the requirements of the VUT MP sensor for the target, please contact the IVISTA Management Center directly.

4.4 Vehicle under test (VUT)

4.4.1 System initialization

If necessary, the memory parking system can be initialized before the test, including calibration of sensors such as radar and camera.

4.4.2 Vehicle status confirmation

- a) The VUT shall be new with a travelled mileage of not more than 5000 km;
- b) The VUT shall be equipped with original new tires designated by the manufacturer. The tire pressure shall be the standard cold tire pressure recommended by the manufacturer. If more than one value is recommended for tire pressure, the tire shall be inflated to the pressure with the lightest load.
- c) The VUT shall be refueled to not less than 90% of the fuel tank capacity, with other fluids such as oil and water (e.g. coolant, brake fluid, and engine oil) added at least to the minimum indicated position. During the test, the fuel may decrease but shall not be lower than 50% of the fuel tank capacity.
- d) For off-vehicle-chargeable new energy vehicles, the traction battery shall be fully charged according to 5.1 of GB/T 18385-2005. For non-off-vehicle-chargeable new energy vehicles, the test shall be prepared in their normal operation states. During the test, the power of the vehicle may decrease, but it shall not be less than 50% SOC.

4.4.3 Functional check

Before the test, check whether the memory parking function of the VUT works normally, and check the memory parking function buttons and display mode of the VUT.

4.5 Data recording and processing

4.5.1 Data record content

4.5.1.1 Contents of closed field test data record:

- a) VUT speed;
- b) Longitudinal acceleration of VUT;
- c) Position and motion data of the target object;
- d) Video information reflecting the driver and human-machine interaction status;
- e) Video information reflecting the driving state and external environment of the VUT.

4.5.1.2 Contents of test data records in open parking lot:

- a) Video information reflecting the driver and human-machine interaction status;
- b) Video information reflecting the driving state and external environment of the VUT.

4.5.2 Data processing requirements

- a) The VUT velocity shall be the wheel speed, and the original data (in km/h) shall be used.
- b) The longitudinal acceleration data of the VUT needs to be filtered by a 12-pole phaseless Butterworth filter with a cutoff frequency of 6 Hz, the average value taken every 2 s and measured in m/s^2 .

4.6 Test photos

- a) Before installing the test equipment, take a photo of the front left 45° of the VUT and the nameplate of the vehicle.
- b) After the test equipment is installed, take photos of the test equipment inside and outside the VUT.

5 Test Method

5.1 Overview

The real vehicle test items of the memory parking system include two parts: closed field test and open parking lot test. The VUT shall be tested in the closed field first, followed by the open parking lot test.

5.2 Closed field test

5.2.1 The test parking lot for closed field tests includes indoor and outdoor parking lots. One of them is selected to carry out the test according to the situation where the memory parking function of the VUT is applicable. If both indoor and outdoor parking lots are applicable, the indoor parking lot is selected by default for the test. See Annex A for specific test rules.

5.2.2 Two test routes are set up in the parking lot for testing purposes, with each route having two test sections: learning and mapping and parking application. Learning and mapping are tested once per route, while parking application is tested twice (group A and group B) per route. For the same test route, the VUT first undergoes learning and mapping testing and then performs parking application testing based on the path obtained from the learning and mapping test.

Table 1 Overall Framework of Closed Field Test

| Type of Parking Lot | Test Route | Test Item | Group | Number of Test Scenarios | Number of Tests |
|----------------------------|---------------|----------------------|--------------|--------------------------|-----------------|
| Indoor/outdoor parking lot | Test route I | Learning and mapping | - | 3 | Up to 5 |
| | | Parking application | Group A test | 3 | 3 |
| | | | Group B test | 3 | 3 |
| | Test route II | Learning and mapping | - | 3 | Up to 5 |
| | | Parking application | Group A test | 3 | 3 |
| | | | Group B test | 3 | 3 |

5.2.3 The learning and mapping test and parking application test start from the "function activation area" of the parking lot and end at the "parking completion area" of the parking lot.

5.2.4 In the learning and mapping test, a total of three test scenarios are set on the test route, and each scenario appears once. The VUT has at most 5 learning and mapping opportunities for the same test route. The difficulty of learning and mapping are gradually reduced by reducing "the maximum speed of the VUT" and deleting "test scenarios". The parameter settings of each test are shown in Table 2. If the learning and mapping are still not successful after 5 opportunities, stop the test and restart the test after analyzing the causes.

Table 2 Learning and Mapping Test Parameters Setting

| Number of Tests | Maximum VUT Speed | Number of Test Scenarios |
|----------------------|-------------------|--------------------------|
| 1 st test | (20±1) km/h | 3 |
| 2 nd test | (15±1) km/h | 3 |
| 3 rd test | (10±1) km/h | 2 |
| 4 th test | (5±1) km/h | 1 |
| 5 th test | (5±1) km/h | 0 |

Note: The "test scenario" deleted in the next test is an "interference scenario" that affects the successful learning and mapping during the previous test. If the failure of the last learning and mapping test is not affected by some "test scenario", any "test scenario" will be randomly deleted.

5.2.5 In the parking application test, a total of 6 test scenarios are set up on the test route. The tests are carried out in groups A and B respectively, with 3 test scenarios in each group. Each scenario occurs once, and each group is tested 3 times.

5.2.6 The test personnel shall carry out the test according to the following steps:

a) The tester drives the VUT to enter the parking lot from the entrance/exit of the parking lot, stops in the "function activation area" set in the parking lot, and enables the learning and mapping function of memory parking according to the system prompt. When the VUT indicates that it is ready to begin learning and mapping, the tester drives the VUT along the test route to the "parking completion area," ensuring a safe passage through the "test scenario" without any collisions.

b) Upon reaching the vicinity of the "parking completion area," the VUT detects the target parking space. If successful, it prompts the activation of the parking assist function to support the driver. The tester then utilizes the function to park the vehicle in the target parking space. In case the target parking space isn't detected or the parking assist function is unavailable in the current mode, the tester manually reverses the VUT into the target parking space.

c) After successfully parking the VUT in the target parking space, if the memory parking system indicates the test route hasn't been learned and mapped, the tester will drive back to the "function activation area" of the parking lot and relearn the route. If the system confirms successful learning and mapping, all test scenarios are cleared. The tester drives the VUT back to the "function

activation area" and follows the system's learned and mapped route towards the target parking space, parks the vehicle, and verifies the learning and mapping results.

d) After the VUT successfully learns and maps the path, a parking application (Group A/B) test is carried out. The tester drives the VUT into the parking lot from the entrance/exit, stops in the "function activation area" set up in the parking lot, enables the parking application function of memory parking according to the system prompt, and drives towards the "parking completion area" according to the learned and mapped route.

e) During the process of driving the VUT from the "function activation area" through the "test scenario" to the "parking completion area", the tester focuses their attention on monitoring the operation status of the VUT and the memory parking system. Unless it is an emergency, no operations are performed on the speed and direction of the VUT.

f) If the VUT prompts to take over before the "test scenario" or stops for a long time without any prompt, the tester removes the test scenario and then continues to enable the memory parking function to drive towards the "parking completion area".

g) When the VUT parks smoothly in the target parking space of "parking completion area" and prompts that parking is completed, this test ends.

5.2.7 Test validity requirements:

- During the process of operating the VUT to learn and map paths, it is important for the tester to ensure that the wheels of the vehicle do not cross the outer edge of the road markings while it is in motion.
- During the process of learning and mapping, if the tester operates the VUT to park in the target parking space, the body outline of VUT (excluding the exterior rearview mirrors) shall not extend beyond the outer edges of the side and rear markings of the target parking space on the ground when projected. Additionally, the rear wheels shall be in contact with the wheel stoppers.
- During the process of verifying whether the learning and mapping is successful, the tester does not operate the direction and speed of the VUT unless a collision is imminent;
- When the parking application function of memory parking is enabled, the VUT shall be in the "function activation area" of the parking lot;
- Scenario parameters such as placement position, triggering time, movement speed of moving obstacle and deviation of movement route in the test scenario shall be within the allowable range.

5.2.8 The test ends when one of the following conditions occurs:

- Collision occurs when the memory parking system drives the vehicle;
- The number of learning and mapping tests exceeds 5;
- The number of parking application tests exceeds 3.

5.3 Open parking lot test

5.3.1 For the open parking lot test, either indoor parking lot or outdoor parking lot can be selected according to the application of memory parking function of the VUT. If both conditions are applicable, the indoor parking lot will be selected by default for testing.

5.3.2 IVISTA has selected 9 publicly accessible indoor parking lots and 9 publicly accessible outdoor parking lots in Chongqing for the open parking lot test. These parking lots were categorized into three different difficulty levels: easy, moderate, and challenging, based on factors like the number of floors, slope gradient, cruise distance, illumination level, traffic flow, and minimum passing width. Each difficulty level had 3 parking lots as options, each equipped with a designated

test route. During the test, one of the difficulty levels will be randomly selected for testing.

5.3.3 In indoor parking lot tests of a simple to medium difficulty level, there is no need to navigate across different floors. However, in more challenging parking lot tests, maneuvering through multiple floors is required.

5.3.4 In order to ensure the consistency of the test scenario element "traffic flow" in the open parking lot test, the test is carried out from 9:00-11:00 and 13:00-17:00 on working days.

5.3.5 When it comes to the same test route, the VUT is allowed a maximum of 5 chances to learn and map. If it fails to successfully learn and map within these 5 opportunities, the test will be discontinued.

5.3.6 When it comes to the same test route, the VUT is required to undergo 3 parking application tests. If the VUT fails to successfully complete the learning and mapping process for the route, the parking application test for that route will not be conducted.

5.3.7 The testers carry out the learning and mapping and parking application tests of open parking lot test with reference to the steps of closed field test.

5.3.8 The driving directions for the parking application test 3 times are divided into two cases, based on whether the memory parking function of the VUT supports reverse cruise from the target parking space to the entrance/exit of the parking lot, according to the learned and mapped route from the entrance/exit of the parking lot to the target parking space.

a) If the memory parking function of the VUT does not support reverse cruise control, the driving direction of the VUT for 3 times is "from the entrance/exit of the parking lot to the target parking space";

b) If the memory parking function of the VUT supports reverse cruise control, the driving directions of the VUT in the 3 tests are "from parking lot entrance/exit to target parking space", "from target parking space to parking lot entrance/exit" and "from parking lot entrance/exit to target parking space".

5.3.9 Refer to the closed field test for the test validity requirements and end-of-test conditions of open parking lot tests.

5.3.10 In the parking application test in an open parking lot, if the VUT cruises to the front of the target parking space, it is considered that the parking application task has been completed and there is no need to park into the target parking space.

5.3.11 During a parking application test in an open parking lot, if there are traffic jams, accidents or other short-term situations that completely prevent the VUT from detouring from its planned path, the test will be considered invalid. In such cases, the tester will select another test route based on the site conditions.

5.3.12 If, during the indoor parking lot test, the VUT fails to activate and enable its parking application function after traveling more than 50 meters upon entering the parking lot (i.e., due to shielding of the satellite positioning signal), it is deemed that the VUT cannot complete this test, and the test is terminated.

Annex A

Detailed Rules for Closed Field Test

A.1 Indoor parking lot test

The indoor parking lot for the closed field test is approximately 130 m long and 30 m wide. It consists of two-way dual lanes, each with a width of 2.5 m. Two test routes are set up in the parking lot, and each route is tested for learning and mapping, and parking application. Three test scenarios are set up on the test route during the learning and mapping process of the VUT, and six test scenarios are set up on the test route during the parking application process of the VUT. The tests are carried out in Group A and Group B. See Table A.1 for the list of test scenarios.

Table A.1 List of Test Scenarios for Indoor Parking Lot in Closed Field

| Test Route | Test Item | Group | Test Scenarios |
|---------------|----------------------|--------------|---|
| Test route I | Learning and mapping | - | Meeting at an intersection (turning right) |
| | | | Making way on a straight road |
| | | | Maneuvering around stationary vehicles ("T" shape) |
| | Parking application | Group A test | Making way on a straight road |
| | | | Maneuvering around stationary vehicles ("U" shape) |
| | | | Passing in narrow spaces |
| | | Group B test | Encounter a crouched child during a right turn |
| | | | Interference from forward vehicle exiting from perpendicular parking spot |
| | | | Interference in parking by following rear vehicle |
| Test route II | Learning and mapping | - | Making way on a straight road |
| | | | Maneuvering around stationary vehicles ("T" shape) |
| | | | Meeting at an intersection (turning left) |
| | Parking application | Group A test | Yield to the front vehicle to park in a parallel parking lot |
| | | | Interference from nearside crossing pedestrian |
| | | | Parking space occupancy |
| | | Group B test | Emergency brake of front vehicle |
| | | | Temporary obstacle |
| | | | Parking in dark environment |

A.1.1 Test route I

A.1.1.1 Learning and mapping test scenario

Three test scenarios are set for the learning and mapping test on the indoor parking lot test route I, namely, meeting at an intersection (turning right), making way on a straight road, and maneuvering around stationary vehicles ("T" shape).

Indoor Parking Lot: Test Route I - Learning and Mapping Test

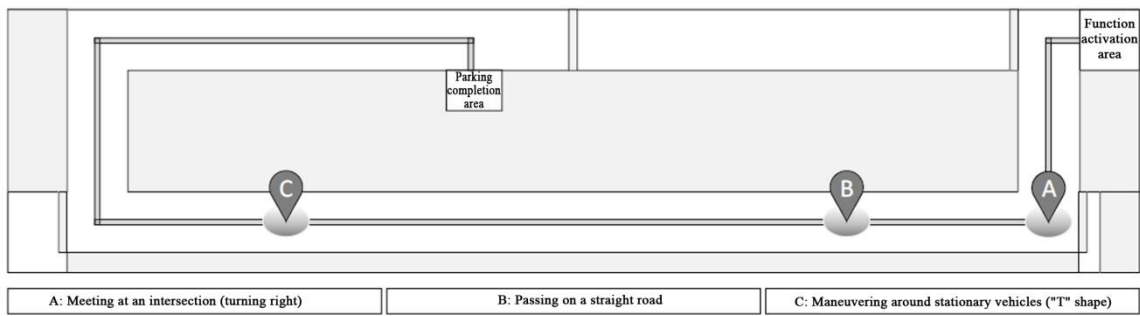


Fig. A.1 Test Scenario Setting for Learning and Mapping of Indoor Parking Lot Test Route I

A.1.1.1.1 Scenario of meeting at an intersection (turning right)

This scenario simulates the situation of the learning and mapping process where the VUT is about to turn right while other interfering vehicles are turning left at the intersection, and the VUT waits for the other vehicles to pass first before continuing to move forward.

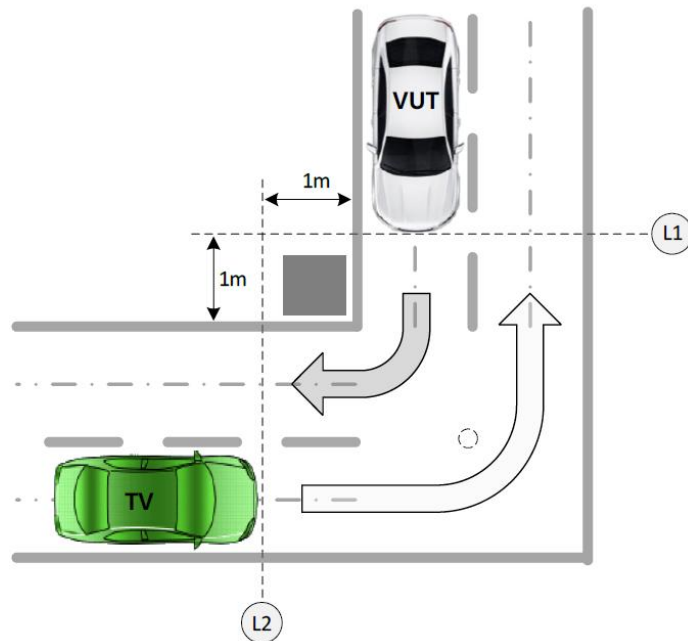


Fig. A.2 Scenario of Meeting at an Intersection (Turning Right)

As shown in Fig. A.2, the TV is stationary with its front end aligned with L2 in the initial state of the scenario. When the tester drives the VUT until its front end contacts L1, the TV starts to make a left turn at a speed not exceeding 5 km/h. The VUT stops at L1 and waits until the TV completes the left turn and aligns the body before starting to move forward.

A.1.1.1.2 Scenario of making way on a straight road

During the simulated learning and mapping process in this scenario, if the VUT encounters a situation where there is a stationary vehicle occupying the current lane ahead and it intends to overtake by using the opposite lane but encounters an oncoming vehicle, resulting in the need to reverse and give way to the oncoming vehicle before proceeding.

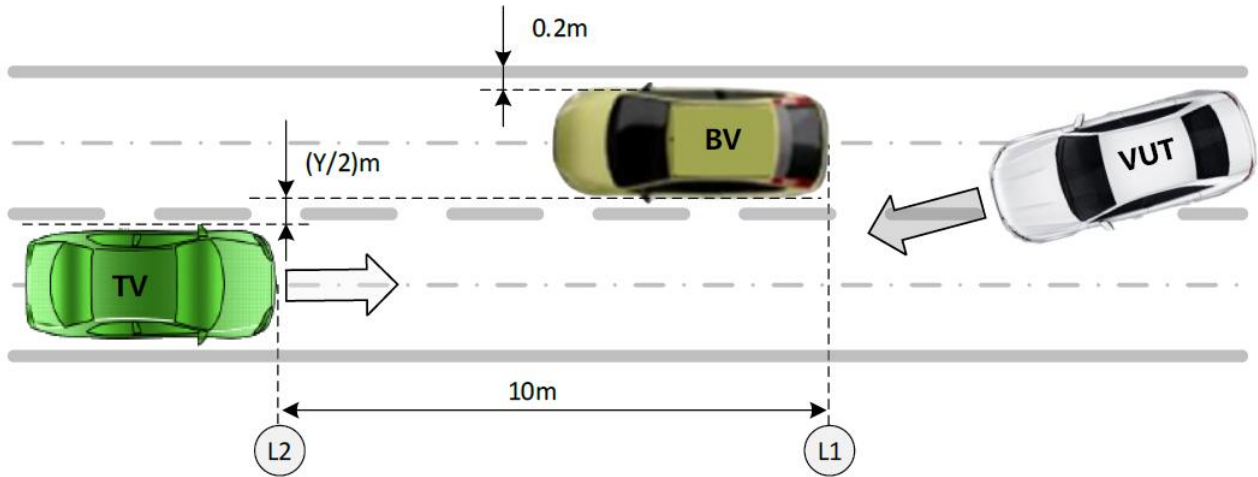


Fig. A.3 Scenario of Making Way on a Straight Road

As shown in Fig. A.3, the initial state of the scenario shows both the background vehicle and the target vehicle in a stationary position. The head of the target vehicle aligns with L2, and there is a distance of 10 m between the head of the target vehicle and the tail of the background vehicle. As the tester drives the VUT and reaches the point where its head contacts L1, the target vehicle begins to move forward at an average speed of 5 km/h to 8 km/h. Once the target vehicle is detected, the VUT initiates a reverse maneuver to create a passage space, ensuring a maximum reversing distance of 5 meters. Subsequently, when the target vehicle passes first, the VUT navigates around the stationary background vehicle to pass in this scenario.

A.1.1.1.3 Scenario of maneuvering around stationary vehicles ("T" shape)

During the simulated learning and mapping process in this scenario, the VUT navigates around obstacle vehicles that are stationary in both the current lane and the opposite lane.

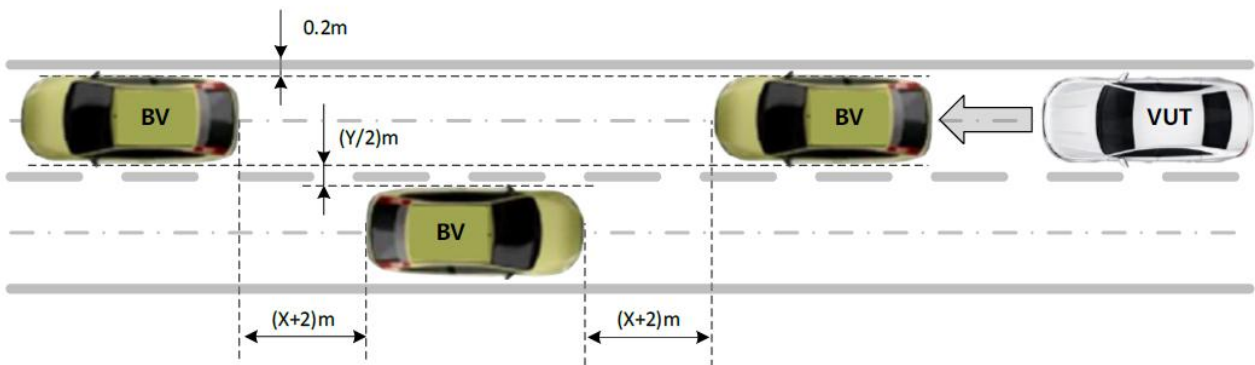


Fig. A.4 Scenario of Maneuvering around Stationary Vehicles ("T" Shape)

As shown in Fig. A.4, all three background vehicles are stationary from beginning to end, including two background vehicles in front of the lane where the VUT is located and one in the opposite lane. The longitudinal relative distance between the background vehicles is $(X+2)$ m and the lateral relative distance is $(Y/2)$ m. X and Y represent the body length and width of the VUT respectively (excluding exterior rearview mirrors). During the testing process, the tester drives the VUT to pass in this scenario at a speed not exceeding 5 km/h.

A.1.1.2 Group A parking application test scenario

For the group A parking application test on the indoor parking lot test route, 3 test scenarios are set up, namely, making way on a straight road, maneuvering around stationary vehicles ("U" shape), and passing in narrow space.

Indoor Parking Lot: Test Route I - Group A Parking Application Test

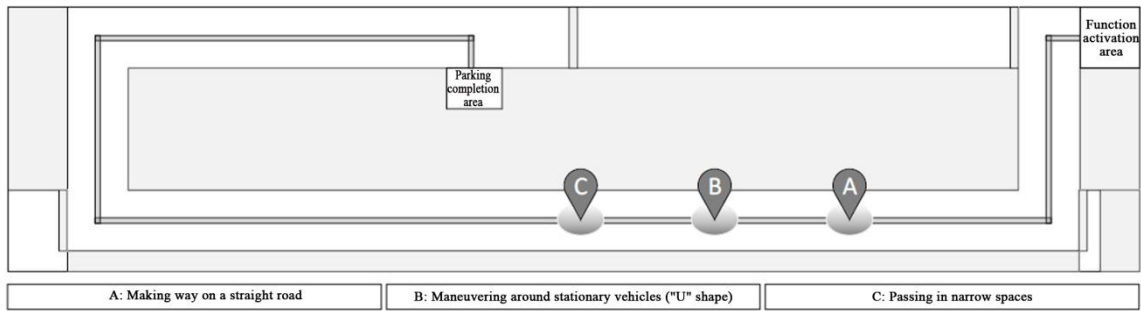


Fig. A.5 Test Scenario Setting for Group A Parking Application of Indoor Parking Lot Test Route I

A.1.1.2.1 Scenario of making way on a straight road

During the simulated parking application process in this scenario, if the VUT encounters a situation where there is a stationary vehicle occupying the current lane ahead and it intends to overtake by using the opposite lane but encounters an oncoming vehicle, resulting in the need to reverse and give way to the oncoming vehicle before proceeding.

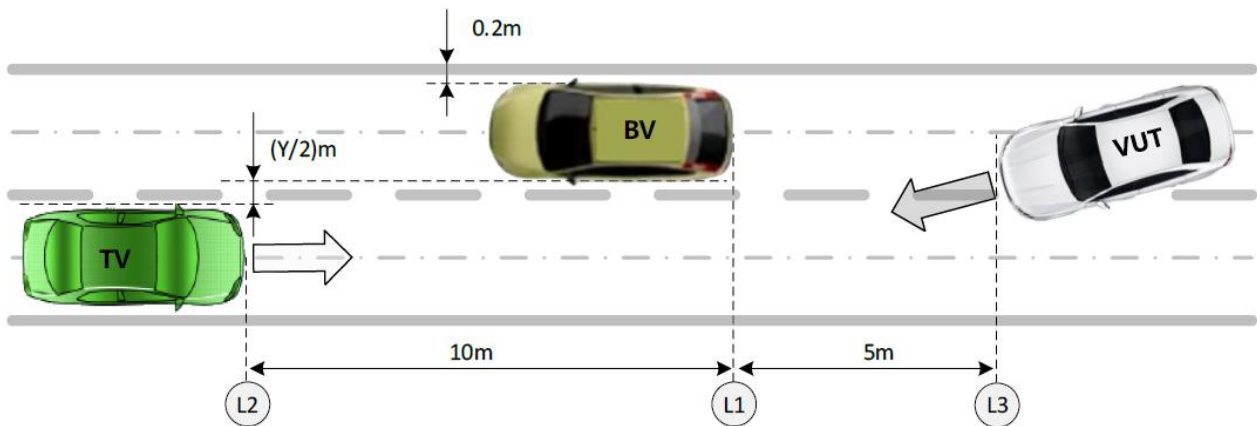


Fig. A.6 Scenario of Making Way on a Straight Road

As shown in Fig. A.6, the initial state of the scenario shows both the background vehicle and the target vehicle in a stationary position. The head of the target vehicle aligns with L2, and there is a distance of 10 m between the head of the target vehicle and the tail of the background vehicle, and the lateral relative distance from the backdrop vehicle is $(Y/2)$ m (Y , the width of VUT body). When the front of the VUT contacts L3, the target vehicle begins to move forward at an average speed of 5 km/h - 8 km/h.

A.1.1.2.2 Scenario of maneuvering around stationary vehicles ("U" shape)

During the simulated parking application process in this scenario, the VUT navigates around obstacle vehicles that are stationary in both the current lane and the opposite lane.

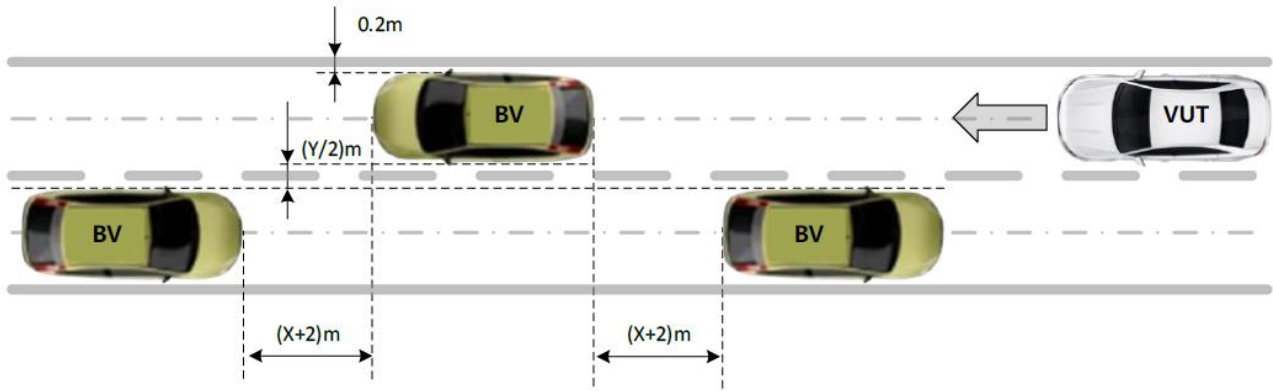


Fig. A.7 Scenario of Maneuvering around Stationary Vehicles ("U" Shape)

As shown in Fig. A.7, all three background vehicles are stationary from beginning to end, including one background vehicle in front of the lane where the VUT is located and two in the opposite lane. The longitudinal relative distance between the background vehicles is $(X+2)$ m and the lateral relative distance is $(Y/2)$ m. X and Y represent the body length and width of the VUT respectively (excluding exterior rearview mirrors).

A.1.1.2.3 Scenario of passing in narrow space

This scenario simulates the situation of parking application where the vehicle under test (VUT) cannot pass in a narrow space composed of a traffic cone and a stationary vehicle due to limited passage width, requiring a takeover by the driver.

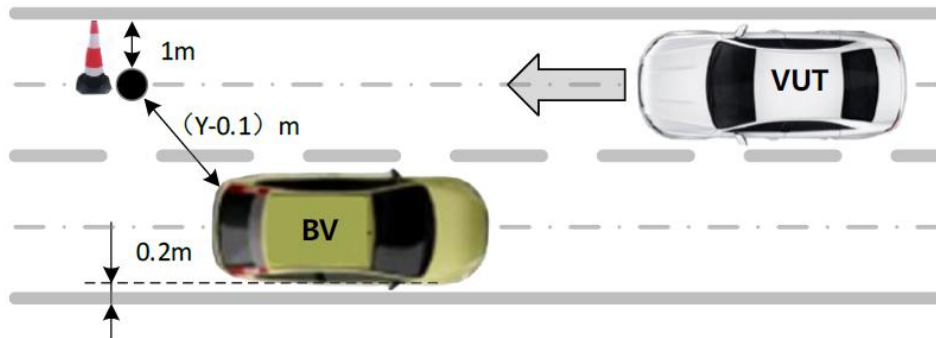


Fig. A.8 Scenario of Passing in Narrow Space

As shown in Fig. A.8, the background vehicle (BV) is stationary in the opposite lane, and there is a traffic cone in front of the VUT's lane. The traffic cone is 1 m away from the edge line of the road on the right side of the VUT, and the shortest distance between the traffic cone and the BV is $(Y-0.1)$ m. Y represents the body width of the VUT (excluding exterior rearview mirrors). When the VUT identifies that it cannot pass in this scenario and reminds the driver to take over the vehicle, the tester removes the traffic cone and reactivates the memory parking function of the VUT for forward driving.

A.1.1.3 Group B parking application test scenario

For the group B parking application test on indoor parking lot test route I, 3 test scenarios are set up, namely, encountering a crouched child during a right turn, interference from front vehicle exiting from perpendicular parking spot and interference in parking by following rear vehicle.

Indoor Parking Lot: Test Route I - Group B Parking Application Test

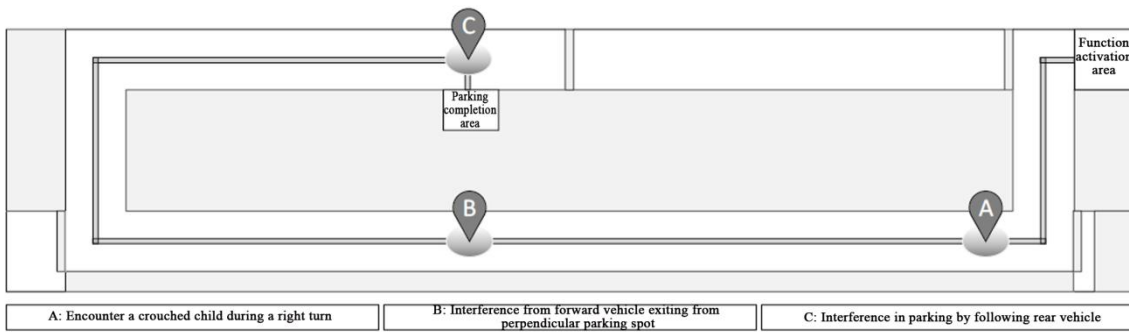


Fig. A.9 Test Scenario Setting for Group B Parking Application of Indoor Parking Lot Test Route I

A.1.1.3.1 Scenario of encountering a crouched child during a right turn

This scenario simulates the situation of parking application where the VUT encounters a crouched child blocked by a pillar in the blind spot when making a right turn at an intersection.

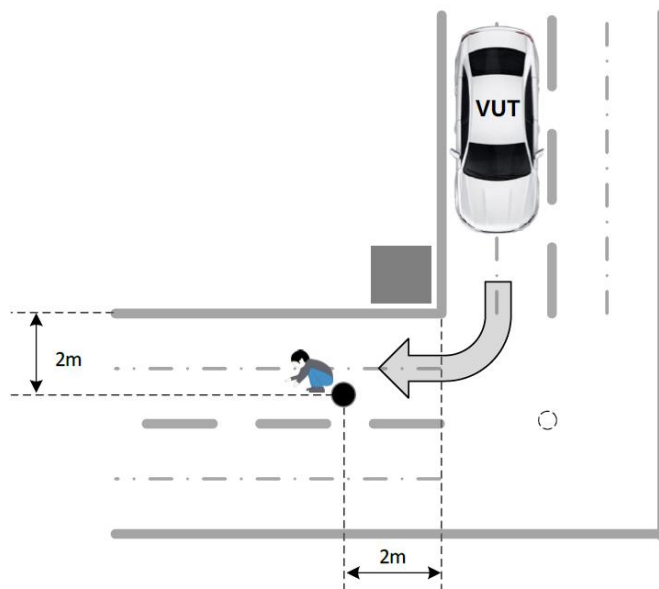


Fig. A.10 Scenario of Encountering a Crouched Child During a Right Turn

As shown in Fig. A.10, the crouched stationary child aged 3-6 years with the back facing the direction of oncoming vehicles. The child is located 2 m away from the intersection and from the right edge line of the road respectively.

A.1.1.3.2 Scenario of interference from front vehicle exiting from perpendicular parking spot

This scenario simulates the situation of parking application where the VUT passes through the fire door while other vehicles exit from the perpendicular parking spot located behind a wall.

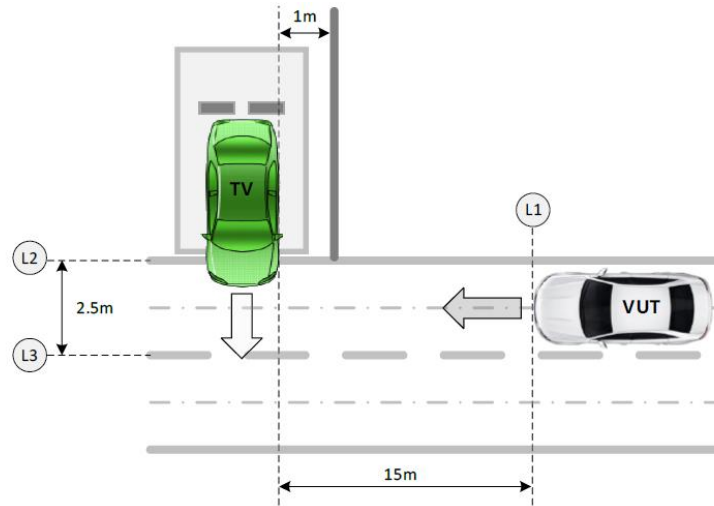


Fig. A.11 Scenario of Interference from Front Vehicle Exiting from Perpendicular Parking Spot

As shown in Fig. A.11, the target vehicle (TV) is stationary in the initial state of the scenario, with its front end aligned with the front edge line L2 of the parking spot; the left side of the TV is 1 m away from the wall. When the front end of VUT reaches L1 (the distance between L1 and the left edge of the TV is 15 m), the TV starts to exit from the perpendicular parking spot at a speed not exceeding 5 km/h and it comes to a complete stop when its front end reaches L3. The distance between L3 and L2 is 2.5 m.

A.1.1.3.3 Scenario of interference in parking by following rear vehicle

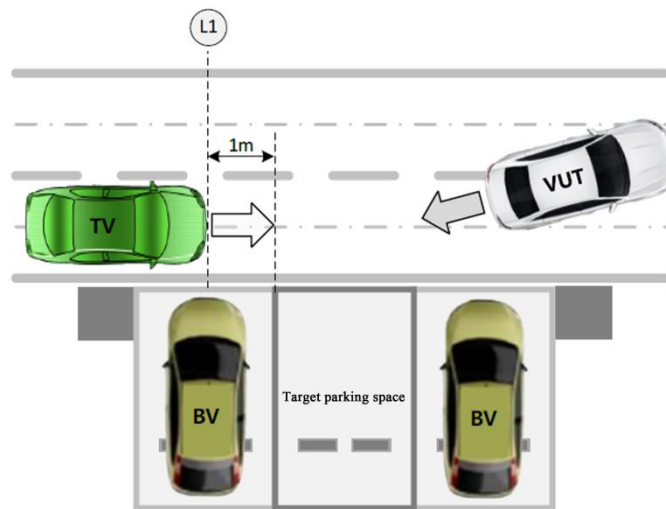


Fig. A.12 Scenario of Interference in Parking by Following Rear Vehicle

This scenario simulates the situation of parking application where the VUT experiences interference during reverse parking into the target parking space due to other vehicles approaching from behind.

As shown in Fig. A.12, the TV follows the VUT in the initial state of the scenario until its front end is aligned with L1 and then stops. when the VUT starts reversing, the TV moves forward at a speed not exceeding 5 km/h; when the VUT detects a risk of collision and stops, the TV reverses backward to vacate the target parking space, and the VUT continues to run into the target parking space.

A.1.2 Test route II

A.1.2.1 Learning and mapping test scenario

For the learning and mapping test on indoor parking lot test route II, 3 test scenarios are set up, namely, making way on a straight road, maneuvering around stationary vehicles ("T" shape) and meeting at an intersection (turning left).

Indoor Parking Lot: Test Route II - Learning and Mapping Test

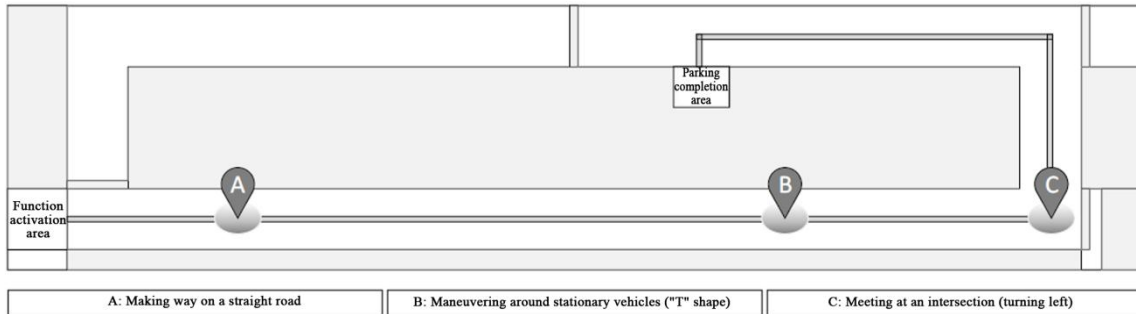


Fig. A.13 Test Scenario Setting for Learning and Mapping of Indoor Parking Lot Test Route II

A.1.2.1.1 Scenario of making way on a straight road

Same as A.1.1.1.2.

A.1.2.1.2 Scenario of maneuvering around stationary vehicles ("T" shape)

Same as A.1.1.1.3.

A.1.2.1.3 Scenario of meeting at an intersection (turning left)

This scenario simulates the situation of the learning and mapping process where the VUT is about to turn left while other interfering vehicles are turning right at the intersection, and the VUT waits for the other vehicles to pass first before continuing to move forward.

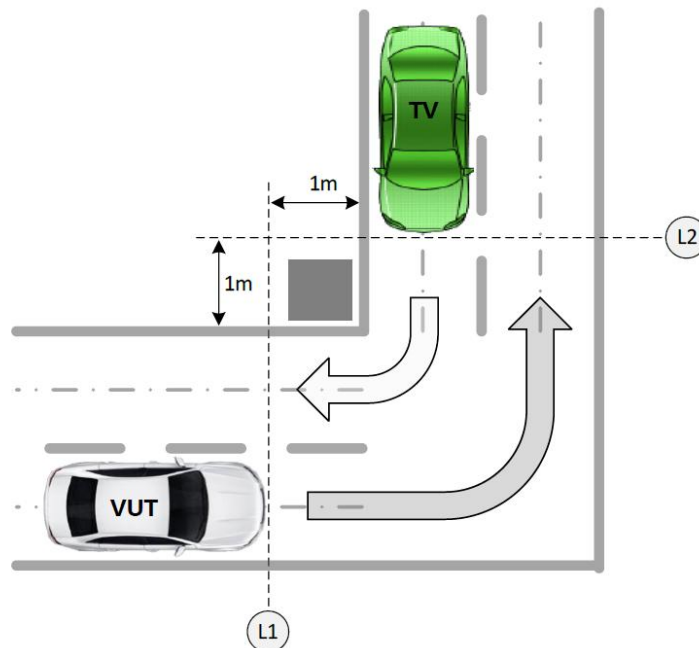


Fig. A.14 Scenario of Meeting at an Intersection (Turning Left)

As shown in Fig. A.14, the TV is stationary with its front end aligned with L2 in the initial

state of the scenario. When the tester drives the VUT until its front end contacts L1, the TV starts to make a right turn at a speed not exceeding 5 km/h. The VUT stops at L1 and waits until the TV completes the right turn and aligns the body before starting to move forward.

A.1.2.2 Group A learning and mapping test scenario

For the group A parking application test on indoor parking lot test route II, 3 test scenarios are set up, namely, yielding to the front vehicle to park in a parallel parking spot, interference from nearside crossing pedestrian and parking space occupancy.

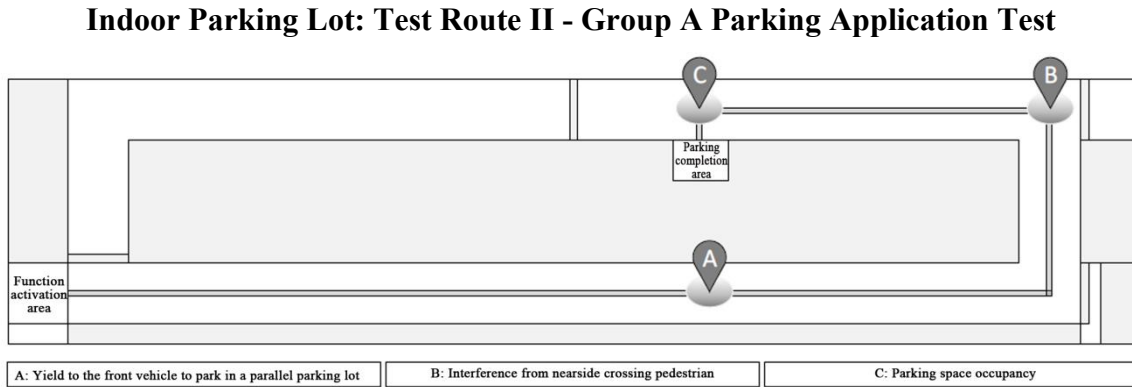


Fig. A.15 Test Scenario Setting for Group A Parking Application of Indoor Parking Lot Test Route II

A.1.2.2.1 Scenario of yielding to the front vehicle to park in a parallel parking spot

This scenario simulates the situation of parking application where other vehicles are parked in parallel parking spot on the roadside ahead of the VUT.

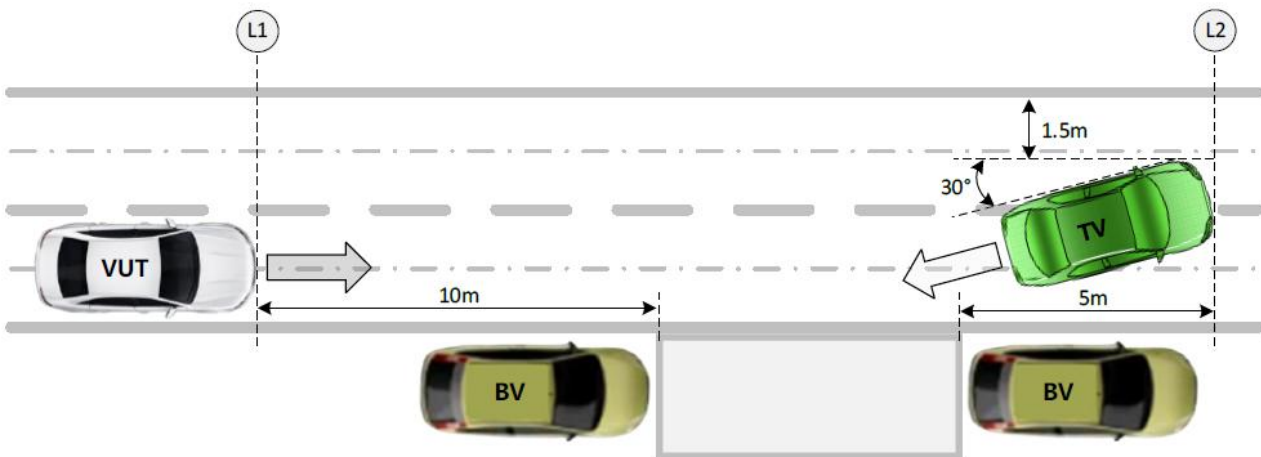


Fig. A.16 Scenario of Yielding to the Front Vehicle to Park in a Parallel Parking Spot

As shown in Fig. A.16, the TV is stationary in the middle of the road in the initial state of the scenario, with its front end in contact with L2 and its body forming a 30° angle with the edge of the road; when the VUT reaches L1, the TV starts to reverse at a speed not exceeding 5 km/h and parks in a parallel parking spot on the roadside.

A.1.2.2.2 Scenario of interference from nearside crossing pedestrian

This scenario simulates the situation of parking application where the VUT encounters a crossing pedestrian when passing a right-turn intersection.

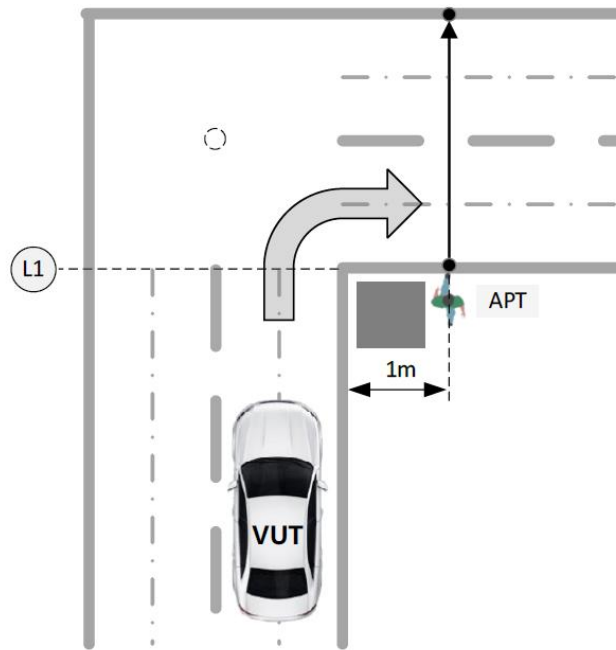


Fig. A.17 Scenario of Interference from Nearside Crossing Pedestrian

As shown in Fig. A.17, the adult pedestrian is stationary at the edge of the intersection pillar in the initial state of the scenario, and 1 m away from the intersection; when the VUT reaches L1, the pedestrian starts walking forward across the traffic road at a speed of (4 ± 1) km/h.

A.1.2.2.3 Scenario of parking space occupancy

This scenario simulates the situation of parking application where the VUT needs to be parked nearby as the target parking space is occupied and there are available adjacent parking spaces.

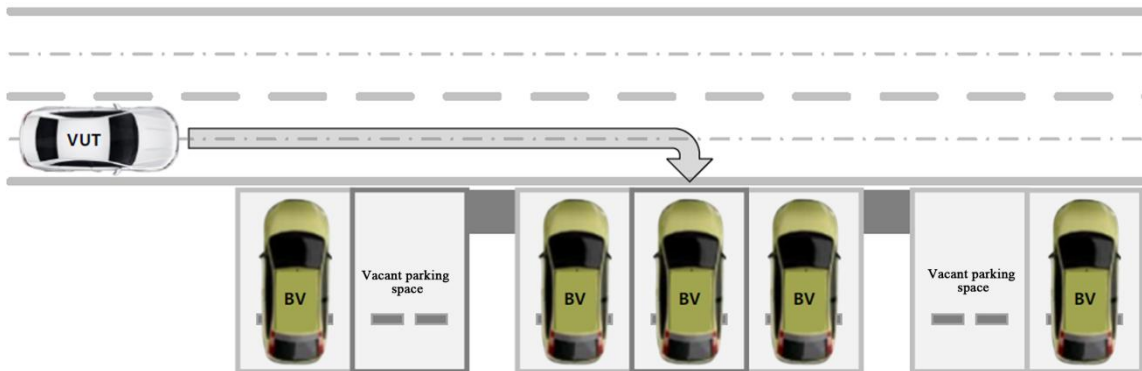


Fig. A.18 Scenario of Parking Space Occupancy

As shown in Fig. A.18, the target parking space intended for the VUT is occupied by a BV, and there is a vacant parking space in front of and behind the BV for parking the VUT.

A.1.2.3 Group B learning and mapping test scenario

For the group B parking application test on indoor parking lot test route II, 3 test scenarios are set up, namely, emergency braking by front vehicle, temporary obstacle and parking in dark environment.

Indoor Parking Lot: Test Route II - Group B Parking Application Test

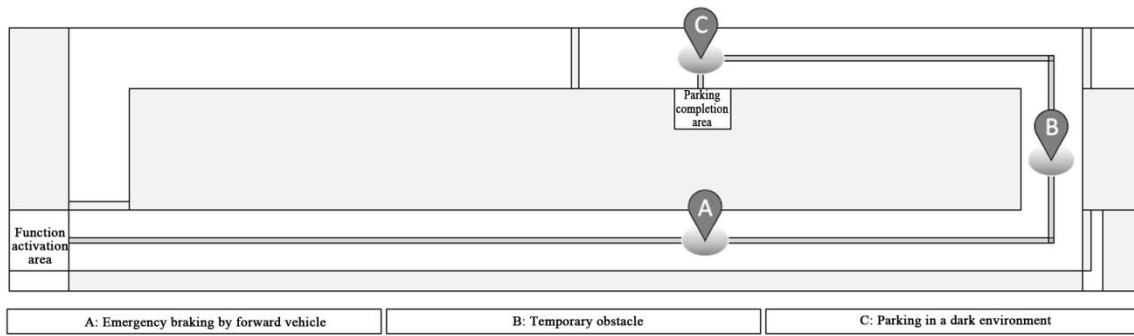


Fig. A.19 Test Scenario Setting for Group B Parking Application of Indoor Parking Lot Test Route II

A.1.2.3.1 Scenario of emergency braking by front vehicle

This scenario simulates the situation of parking application where the VUT encounters emergency braking by the front vehicle when stably following it.

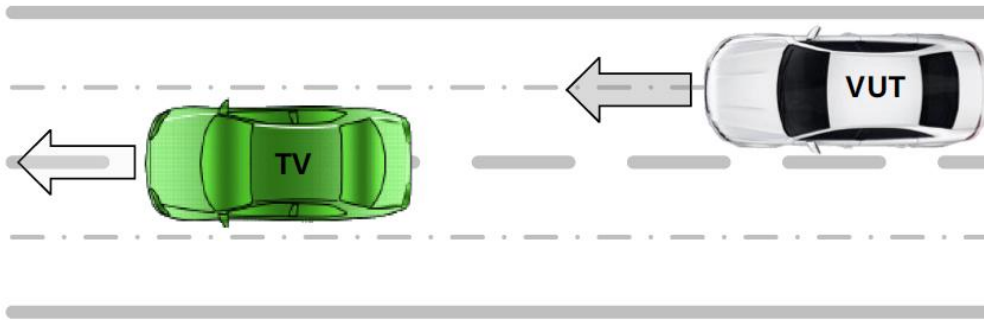


Fig. A.20 Scenario of Emergency Braking by Front Vehicle

As shown in Fig. A.20, the TV ahead runs at a constant speed along the middle of the road at (10 ± 1) km/h in the initial state of the scenario, and the VUT follows stably behind. When the VUT follows at a stable speed, the TV suddenly brakes at a deceleration of (0.3 ± 0.05) g to a stop.

A.1.2.3.2 Scenario of temporary obstacle

This scenario simulates the situation of parking application where the VUT needs to maneuver around a temporary stationary obstacle ahead in the same lane.

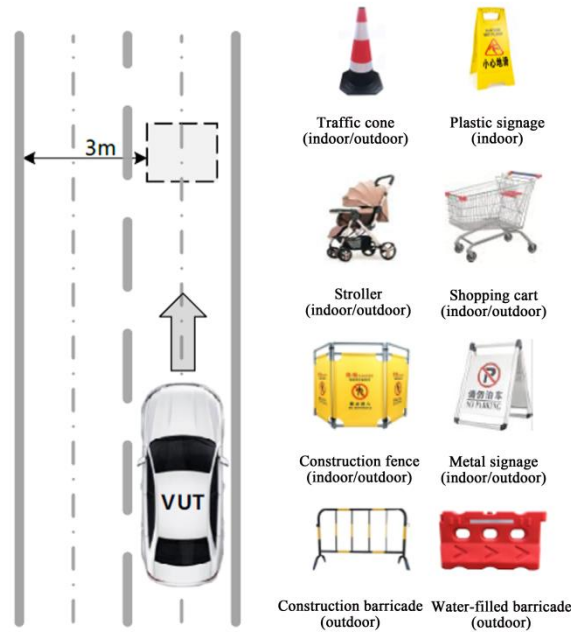


Fig. A.21 Scenario of Temporary Obstacle

As shown in Fig. A.21, there are occasional temporary obstacles ahead in the same lane of the VUT, with a distance of 3 m from the left edge line of the road. The obstacles can include traffic cones, plastic signage, metal signage, strollers, shopping carts and construction fences.

A.1.2.3.3 Scenario of parking in dark environment

This scenario simulates the situation of parking application where the VUT encounters a poor lighting environment near the target parking space and needs to be parked.

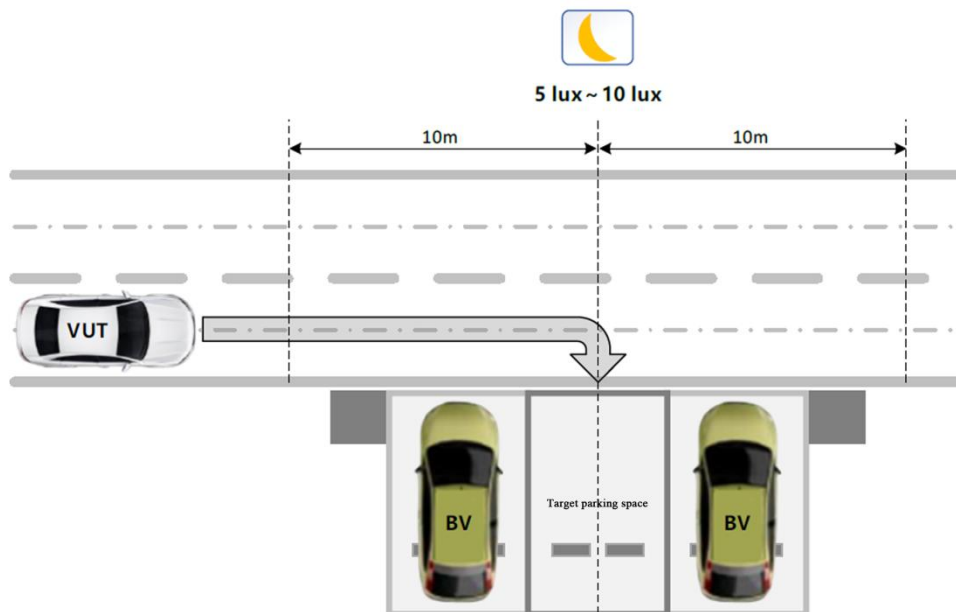


Fig. A.22 Scenario of Parking in Dark Environment

As shown in Fig. A.22, the illuminance of perpendicular target parking spaces on the front and rear sides of the road is between 5 lux and 10 lux within a distance of 10 m.

A.2 Outdoor parking lot test

The indoor parking lot for the closed field test is approximately 110 m long and 30 m wide. It

consists of two-way dual lanes, each with a width of 2.5 m. Two test routes are set up in the parking lot and both the learning and mapping test and the parking application test are carried out for each route; 3 test scenarios are set on the test route for the learning and mapping process, and 6 scenarios are set on the test route for the parking application process; group A and group B tests are carried out. See Table A.2 for the list of test scenarios.

Table A.2 List of Test Scenarios for Outdoor Parking Lot in Closed Field

| Test Route | Test Item | Group | Test Scenarios |
|---------------|----------------------|--------------|---|
| Test route I | Learning and mapping | - | Making way on a straight road |
| | | | Maneuvering around stationary vehicles ("T" shape) |
| | | | Meeting at an intersection (turning right) |
| | Parking application | Group A test | Making way on a straight road |
| | | | Maneuvering around stationary vehicles ("U" shape) |
| | | | Passing in narrow spaces |
| | | Group B test | Encounter a crouched child during a right turn |
| | | | Interference from forward vehicle exiting from perpendicular parking spot |
| | | | Interference in parking by following rear vehicle |
| Test route II | Learning and mapping | - | Making way on a straight road |
| | | | Maneuvering around stationary vehicles ("T" shape) |
| | | | Meeting at an intersection (turning left) |
| | Parking application | Group A test | Yield to the front vehicle to park in a perpendicular parking spot |
| | | | Interference from nearside crossing pedestrian |
| | | | Parking space occupancy |
| | | Group B test | Emergency brake of front vehicle |
| | | | Temporary obstacle |
| | | | Parking in narrow space |

A.2.1 Test route I

A.2.1.1 Learning and mapping test scenario

For the learning and mapping test on outdoor parking lot test route I, 3 test scenarios are set up, namely, making way on a straight road, maneuvering around stationary vehicles ("T" shape) and meeting at an intersection (turning left).

Outdoor Parking Lot: Test Route I - Learning and Mapping Test

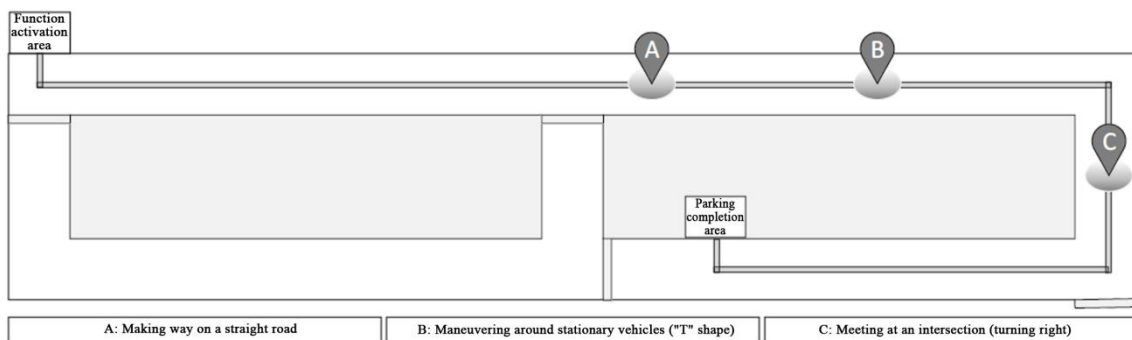


Fig. A.23 Test Scenario Setting for Learning and Mapping of Outdoor Parking Lot Test Route I

A.2.1.1.1 Scenario of making way on a straight road

Same as A.1.1.1.2.

A.2.1.1.2 Scenario of maneuvering around stationary vehicles ("T" shape)

Same as A.1.1.1.3.

A.2.1.1.3 Scenario of meeting at an intersection (turning right)

Same as A.1.1.1.1.

A.2.1.2 Group A test scenarios on test route I

For the group A parking application test on the outdoor parking lot test route, 3 test scenarios are set up, namely, making way on a straight road, maneuvering around stationary vehicles ("U" shape), and passing in narrow space.

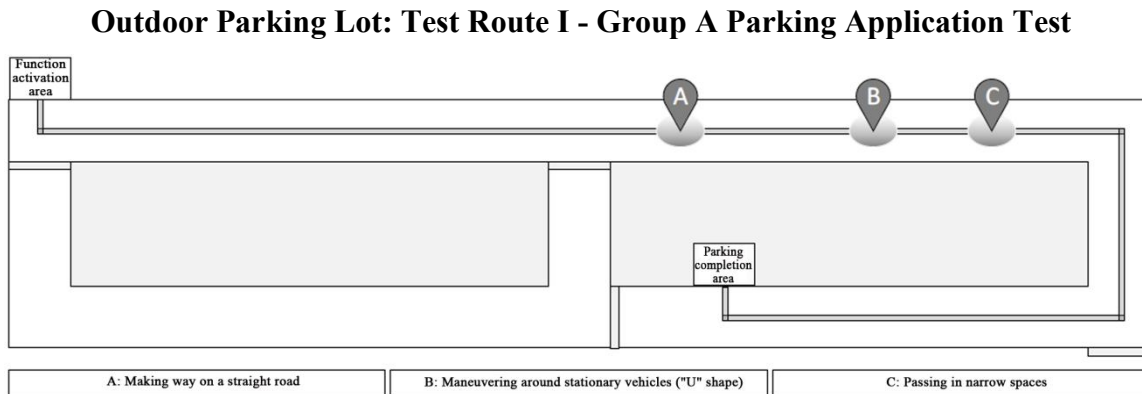


Fig. A.24 Test Scenario Setting for Group A Parking Application of Outdoor Parking Lot Test Route I

A.2.1.2.1 Scenario of making way on a straight road

Same as A.1.1.2.1.

A.2.1.2.2 Scenario of maneuvering around stationary vehicles ("U" shape)

Same as A.1.1.2.2.

A.2.1.2.3 Scenario of passing in narrow space

Same as A.1.1.2.3.

A.2.1.3 Group B test scenarios on test route I

For the group B parking application test on outdoor parking lot test route I, 3 test scenarios are set up, namely, encountering a crouched child during a right turn, interference from front vehicle exiting from perpendicular parking spot and interference in parking by following rear vehicle.

Outdoor Parking Lot: Test Route I - Group B Parking Application Test

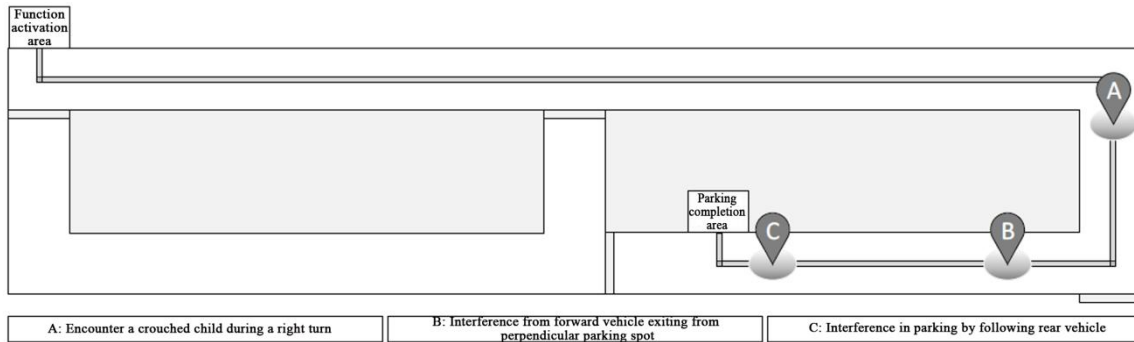


Fig. A.25 Test Scenario Setting for Group B Parking Application of Outdoor Parking Lot Test Route I

A.2.1.3.1 Scenario of encountering a crouched child during a right turn

Same as A.1.1.3.1.

A.2.1.3.2 Scenario of interference from front vehicle exiting from perpendicular parking spot

Same as A.1.1.3.2.

A.2.1.3.3 Scenario of interference in parking by following rear vehicle

Same as A.1.1.3.3.

A.2.2 Test route II

A.2.2.1 Learning and mapping test scenario

For the learning and mapping test on outdoor parking lot test route II, 3 test scenarios are set up, namely, making way on a straight road, maneuvering around stationary vehicles ("T" shape) and meeting at an intersection (turning left).

Outdoor Parking Lot: Test Route II - Learning and Mapping Test

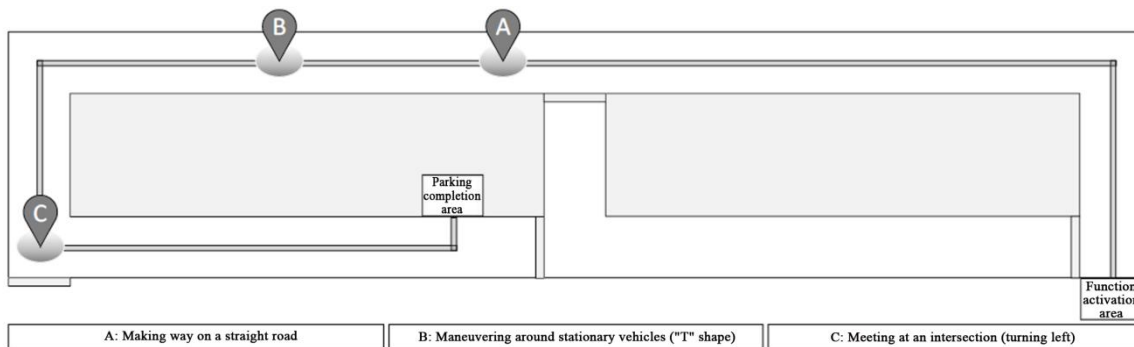


Fig. A 26 Test Scenario Setting for Learning and Mapping of Outdoor Parking Lot Test Route II

A.2.2.1.1 Scenario of making way on a straight road

Same as A.1.1.1.2.

A.2.2.1.2 Scenario of maneuvering around stationary vehicles ("T" shape)

Same as A.1.1.1.3.

A.2.2.1.3 Scenario of meeting at an intersection (turning left)

Same as A.1.2.1.3.

A.2.2.2 Group A parking application test scenario

For the group A parking application test on outdoor parking lot test route II, 3 test scenarios are set up, namely, yielding to the front vehicle to park in a perpendicular parking spot, interference from nearside crossing pedestrian and parking space occupancy.

Outdoor Parking Lot: Test Route II - Group A Parking Application Test

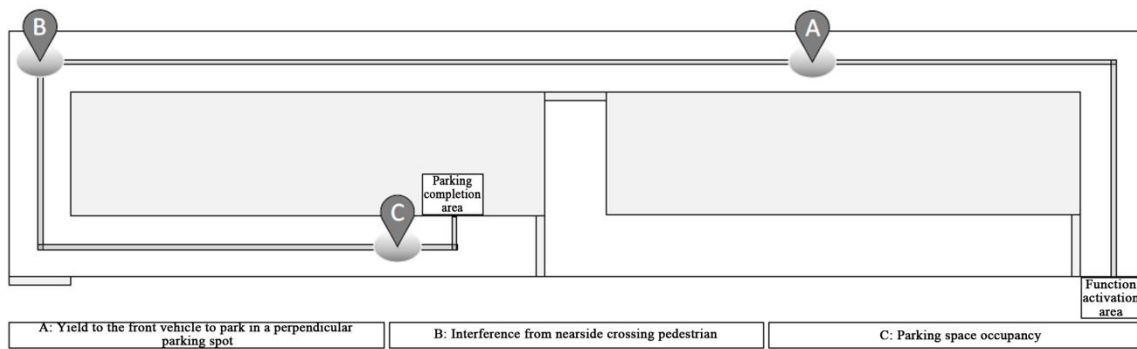


Fig. A.27 Test Scenario Setting for Group A Parking Application of Outdoor Parking Lot Test Route II

A.2.2.2.1 Scenario of yielding to the front vehicle to park in a perpendicular parking spot

This scenario simulates the situation of parking application where other vehicles are parking in a perpendicular parking spot ahead of the road through which the VUT passes.

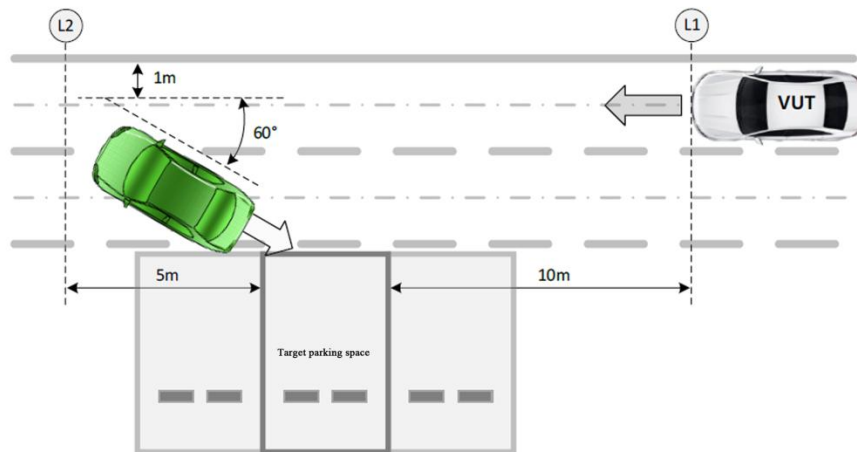


Fig. A.28 Scenario of Front Vehicle Parking into a Perpendicular Parking Spot

As shown in Fig. A.28, the TV is stationary in the middle of the road in the initial state of the scenario, with its front end in contact with L2 and its body forming a 60° angle with the edge of the road; when the VUT reaches L1, the TV starts to reverse and parks in a perpendicular parking spot.

A.2.2.2.2 Scenario of interference from nearside crossing pedestrian

Same as A.1.2.2.2.

A.2.2.2.3 Scenario of parking space occupancy

Same as A.1.2.2.3.

A.2.2.3 Group B parking application test scenario

For the group B parking application test on outdoor parking lot test route II, 3 test scenarios are set up, namely, emergency braking by front vehicle, temporary obstacle and parking in narrow space.

Outdoor Parking Lot: Test Route II - Group B Parking Application Test

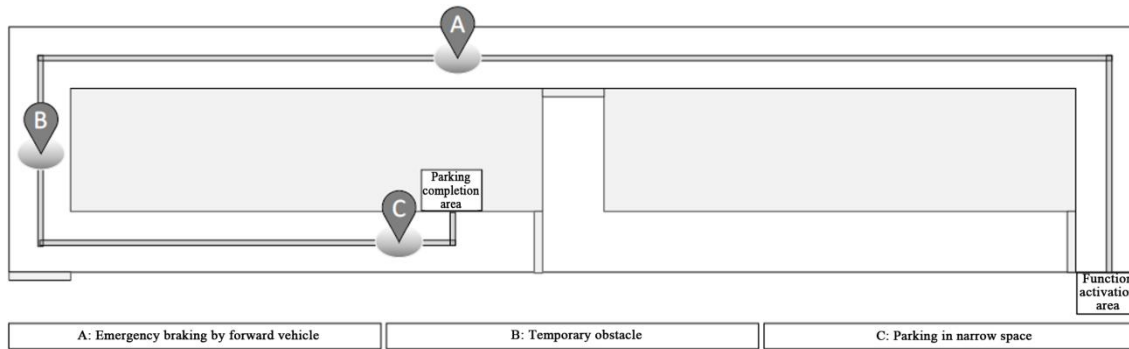


Fig. A.29 Test Scenario Setting for Group B Parking Application of Outdoor Parking Lot Test Route II

A.2.2.3.1 Scenario of emergency braking by front vehicle

Same as A.1.2.3.1.

A.2.2.3.2 Scenario of temporary obstacle

Same as A.1.2.3.2.

A.2.2.3.3 Scenario of parking in narrow space

This scenario simulates the situation of parking application where there is interference from stationary vehicles near the target parking space intended for the VUT, resulting in parking difficulties.

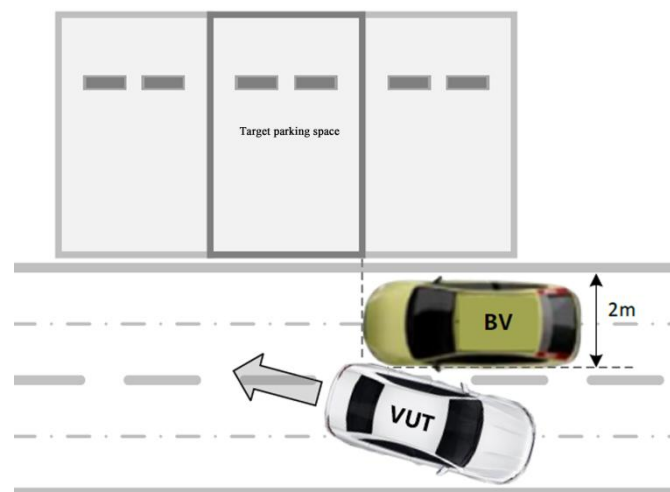


Fig. A.30 Scenario of Parking in Narrow Space

As shown in Fig. A.30, a BV is stationary near the target parking space, with its front end aligned with the extension edge line of the target parking space, and the distance between the left side body and the edge of the road is 2 m.