

IVASA

ASEAN NCAP Intelligent Vehicle Advanced Safety Assessment Program

Test Protocol for Intelligent Driving Assistance

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Contents

1 Scope	1
2 Terms and Definitions	1
3 Test Requirements	2
3.1 Public Road Test Environment Requirements	2
3.2 Test Equipment	2
3.3 Vehicle Preparation	3
3.4 Test Records	4
3.5 Test Photography	4
3.6 Data Processing Requirements	5
4 Test Methods	5
4.1 Overview	5
4.2 Public Road Test	5
Annex A (Normative) Detailed Requirements for the Highway Test	8
A.1 Stop-and-Go in Congested Traffic	8
A.2 Exiting a Highway via an Exit Ramp	9
A.3 Merging onto a Highway via an Entry Ramp	10
A.4 Route Selection on a Ramp	12
Annex B (Normative) Detailed Requirements for the Urban Road Test	15
B.1 Roundabout Negotiation	15
B.2 Intersection Negotiation	19

IVASA Test Protocol for Intelligent Driving Assistance

1 Scope

This document specifies the test methods for the intelligent driving assistance component of IVASA under the ASEAN NCAP Intelligent Vehicle Advanced Safety Assessment Program.

2 Terms and Definitions

The following terms and definitions apply to this document.

2.1

Inertial frame

This document uses the inertial frame specified in ISO 8855:2011. The X-axis points forward, the Y-axis points to the driver's left, and the Z-axis points upward, forming a right-handed coordinate system. When viewed from the origin in the positive directions of the X-, Y-, and Z-axes, clockwise rotations about those axes represent roll, pitch, and yaw, respectively. This coordinate system applies to both left-hand-drive and right-hand-drive VUTs.

2.2

Driver control assistance system (DCAS)

A system comprising hardware and software that continuously assists the driver in controlling the longitudinal and lateral motion of the vehicle.

2.3

Vehicle under test (VUT)

The vehicle equipped with a driver control assistance system and tested in accordance with this protocol.

2.4

Interfering surrounding vehicle

A vehicle in the test scenario that may affect the VUT's performance of the driving task.

2.5

Time to collision (TTC)

For two vehicles travelling on the same path with a non-zero relative speed, TTC is the time remaining before a collision would occur if the relative speed remained constant. It may be estimated by dividing the longitudinal gap between the VUT and the target vehicle by their relative speed, as shown in Equation (1). If the calculation conditions are not met or the calculated TTC is negative, a collision cannot occur under the stated assumptions.

$$TTC = \frac{X_0(t)}{V_r(t)} \quad (1)$$

where:

TTC — time to collision, in seconds (s);

$V_r(t)$ — relative speed, in metres per second (m/s);

$X_0(t)$ — longitudinal gap, in metres (m).

2.6

Operational design domain (ODD)

The external environmental conditions specified by design within which a driving automation system is intended to operate.

Note: Typical external environmental conditions include road, traffic, weather, and lighting conditions.

2.7

Operational design condition (ODC)

The collective conditions specified for the operation of a driving automation system, including its ODD, vehicle state, driver state, and any other necessary conditions.

2.8

Vulnerable road user (VRU)

A road user with limited protection, such as a pedestrian, bicyclist, or rider of a powered two-wheeler.

2.9

Pre-collision time (PCT)

The time required for the VUT, travelling at its current speed along the predefined path, to reach the pre-collision point with the target.

3 Test Requirements

3.1 Public Road Test Environment Requirements

The public road test shall meet the following requirements:

- a) it shall be conducted in favourable weather conditions;
- b) it shall not be conducted in adverse weather conditions such as heavy rain, snow, or blowing dust.

3.2 Test Equipment

3.2.1 Test Equipment Requirements

- a) dynamic data shall be sampled and stored at a frequency of not less than 50 Hz;
- b) the video acquisition equipment shall have a resolution of at least 1920×1080 pixels and a frame rate of at least 30 fps;
- c) except in tunnels, the following measurement accuracy requirements shall apply:
 - speed measurement error: no greater than 0.1 km/h;
 - acceleration measurement error: no greater than 0.1 m/s²;
 - lateral and longitudinal distance measurement error: no greater than 0.1 m;
- d) installation and operation of the test equipment shall not affect normal operation of the VUT or the DCAS.

3.3 Vehicle Preparation

3.3.1 System Initialisation

The system shall be initialised as follows:

Where necessary, the DCAS may be initialised before the test, including calibration of sensors such as radar and cameras.

3.3.2 Vehicle Condition Check

The following vehicle conditions shall be confirmed:

- a) the VUT shall be a new vehicle with an odometer reading of no more than 5,000 km;
- b) the VUT shall meet the following human-machine interface requirements:
 - the DCAS can be readily activated and deactivated manually;
 - system-status information is clearly visible;
- c) the VUT shall be fitted with new original-fitment tyres specified by the vehicle manufacturer. The tyres shall be inflated to the manufacturer's recommended standard cold inflation pressure. Where more than one pressure is specified, the pressure for the lightest load condition shall be used;
- d) the fuel level or battery state of charge shall be at least 90% of the fuel-tank capacity or full-charge state, respectively. All other vehicle fluids, including coolant, brake fluid, and engine oil, shall be at or above the indicated minimum level;
- e) where the VUT is equipped with an active bonnet system, the system shall be deactivated before the public road test equipment is installed;
- f) the VUT mass shall be no less than the complete vehicle kerb mass plus the combined mass of the driver and test equipment and no greater than the maximum permissible gross mass. The combined mass of the driver and test equipment shall not exceed (200 ± 20) kg. The VUT load condition shall not be changed after testing begins.

3.3.3 Functional Check

Before testing, verify that the VUT's DCAS functions, controls, instrument display, centre display, and related equipment operate normally.

3.3.4 System Settings

The system settings shall meet the following requirements:

- a) during the public road test, if the following-time-gap setting of the VUT's DCAS is adjustable, it shall be set to the middle level. If it is not adjustable, the vehicle's default setting shall be used. Where an even number of levels is available, the higher of the two middle levels shall be selected, as shown in Figure 1;

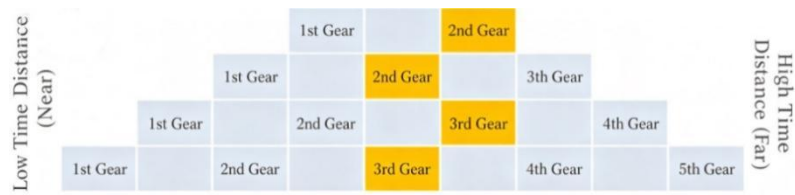


Figure 1 Following-time-gap setting

- b) if the VUT provides multiple driving modes, the standard mode shall be used throughout the test unless otherwise specified;
- c) if the VUT provides an adjustable lane-change assertiveness setting, the standard setting shall be used throughout the test unless otherwise specified. If no such setting is provided or it is not adjustable, the VUT's default setting shall be used;
- d) if the VUT's DCAS permits selection of a speed offset or speed-control mode, the speed offset shall be set to 0 km/h or 0%, or the speed-control mode shall be set to a mode that complies with traffic regulations, throughout the test;
- e) if the VUT's AEB, FCW, LDW, or LDP function is adjustable, it shall be set to the middle level during the public road test. Where an even number of levels is available, the earlier of the two middle levels shall be selected, as shown in Figure 2.



Figure 2 Warning-level setting

3.4 Test Records

The following information shall be recorded throughout the public road test:

- the VUT control mode;
- video of the traffic environment outside the VUT;
- the lateral and longitudinal distances between the VUT and surrounding vehicles;
- video and audio of driver interaction inside the VUT;
- VUT motion-state data.

3.5 Test Photography

- a) Before installing the test equipment, photograph the VUT from a 45° left-front view and photograph the vehicle identification plate.
- b) After installing the test equipment, photograph the equipment installed inside and outside the VUT.

3.6 Data Processing Requirements

Test data shall be processed as follows:

- a) VUT speed shall be the raw GPS speed, expressed in km/h;
- b) VUT longitudinal and lateral acceleration data shall be filtered using a 12th-order Butterworth filter with a cut-off frequency of 1.6 Hz.

4 Test Methods

4.1 Overview

Intelligent driving assistance shall be tested through a public road test.

4.2 Public Road Test

4.2.1 The public road test shall be conducted on the specified test route with the DCAS activated. The specified scenarios and test conditions shall be assessed while the VUT is in motion. One test run for a given test condition is considered completed when the parameters of the VUT and surrounding vehicles remain within the specified validity ranges and no traffic accident occurs. Each test route shall be tested three times.

4.2.2 If the system issues a request to confirm a speed-limit change, the test personnel shall confirm it within 2 s after the request is issued.

4.2.3 Detailed requirements for the highway and urban road portions of the public road test are specified in Annex A and B, respectively.

4.2.4 Two public road test route shall be used, as specified below:

Highway Test Route: MIROS (Malaysian Institute of Road Safety Research, 125–135 Jalan TKS 1, Taman Kajang Sentral, 43000 Kajang, Selangor) — Negeri Sembilan — Mahmudul — MIROS. The total route length is approximately 79.5 km, as shown in Figure 3.

Urban Road Test Route: Malaysian Institute of Road Safety Research (MIROS) — Masjid Universiti UKM — AL-MAsia Car Wash — Bangi Nursery&Landscape — Perkuburan Hindu Bangi Lama — PPU SERENE HEIGHTS — MIROS. The total route length is approximately 32.9 km, as shown in Figure 4.

4.2.5 Time for public road test:

Highway test:

- a) Daytime off-peak test departure time from the starting point: 10:00–10:10; 14:00–14:10
- b) Daytime peak-hour test departure time from the starting point: 7:30–7:40

Urban roads test:

- a) Daytime off-peak test departure time from the starting point: 10:00–10:10; 14:00–14:10

- b) Daytime peak-hour test departure time from the starting point: 7:30–7:40

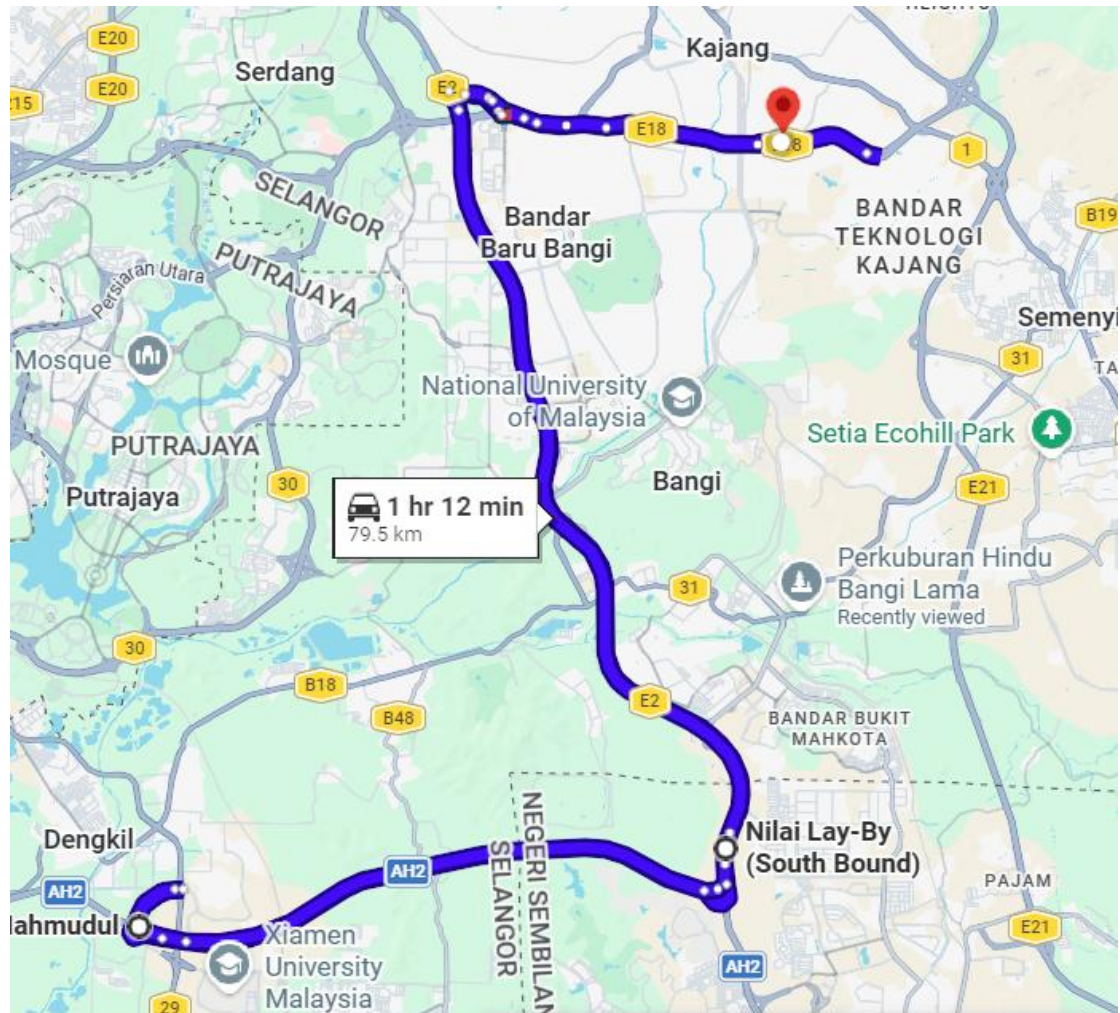


Figure 3 Highway test route

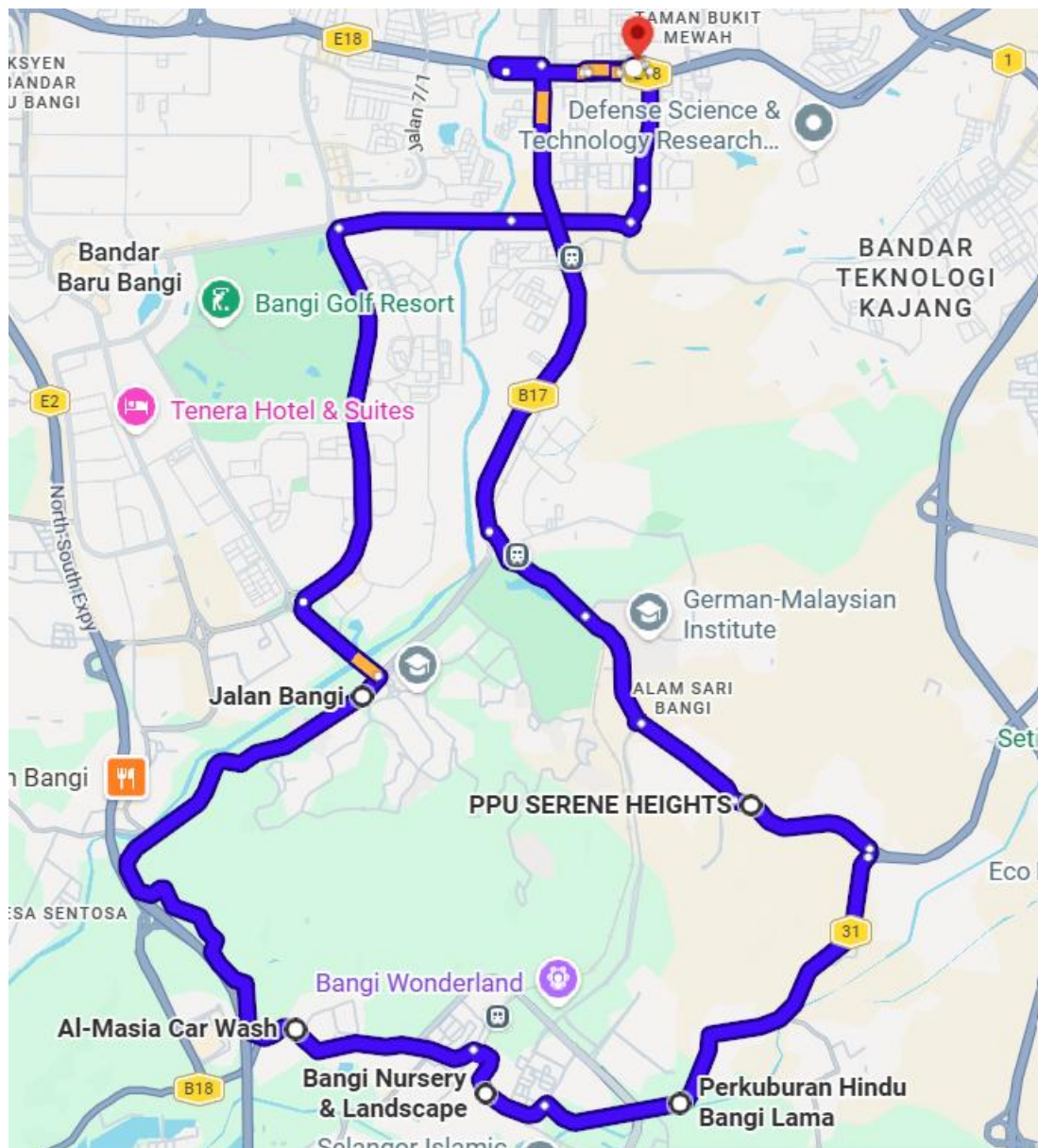


Figure 4 Urban road test route

Annex A
(Normative)

Detailed Requirements for the Highway Test

A.1 Stop-and-Go in Congested Traffic

A.1.1 Scenario description

With the DCAS activated, the VUT shall follow the specified route and gradually enter a congested road section ahead, as shown in Figure A.1.

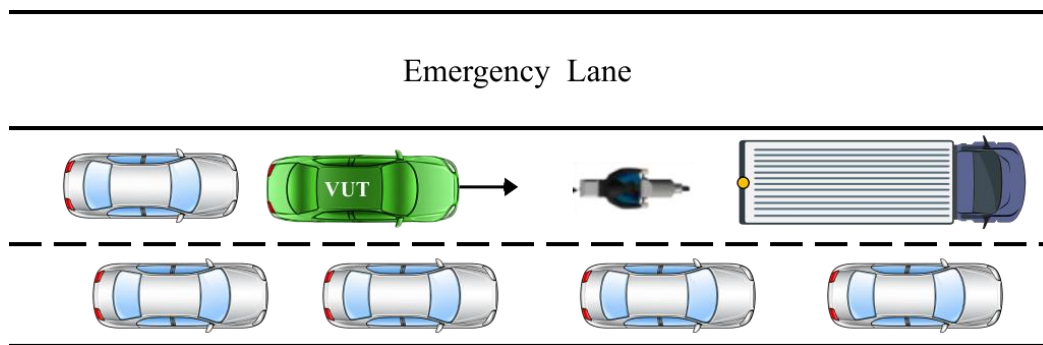


Figure A.1 Stop-and-go in congested traffic

A.1.2 Test locations

- a) MIROS—E18—210 Kajang;

A.1.3 Test procedure

- a) the test personnel shall ensure that the VUT travels through the selected congested road section in accordance with the test-route requirements;
- b) with the DCAS activated, the VUT shall follow the test route through the congested road section;
- c) after each stop-and-go test run, completion of the driving task and the associated VUT data shall be recorded.

A.1.4 Test termination conditions

- a) the VUT leaves the specified route during the specified period;
- b) the VUT is involved in a traffic accident;
- c) the VUT's electric parking brake (EPB) is activated during a stop-and-go test run;
- d) the test personnel take control of the VUT and terminate the test to ensure driving safety.

A.1.5 Test validity requirements

The following requirement shall be met to ensure test validity:

If the VUT's EPB is activated during a stop-and-go test run, the result of that run shall be excluded from scoring.

A.2 Exiting a Highway via an Exit Ramp

A.2.1 Scenario description

With the DCAS activated, the VUT shall follow the specified test route, diverge from the highway mainline into the deceleration lane, and enter the exit ramp, as shown in Figure A.2. The scenario comprises two test cases: no interfering surrounding vehicle when exiting the highway, and an interfering surrounding vehicle when exiting the highway.

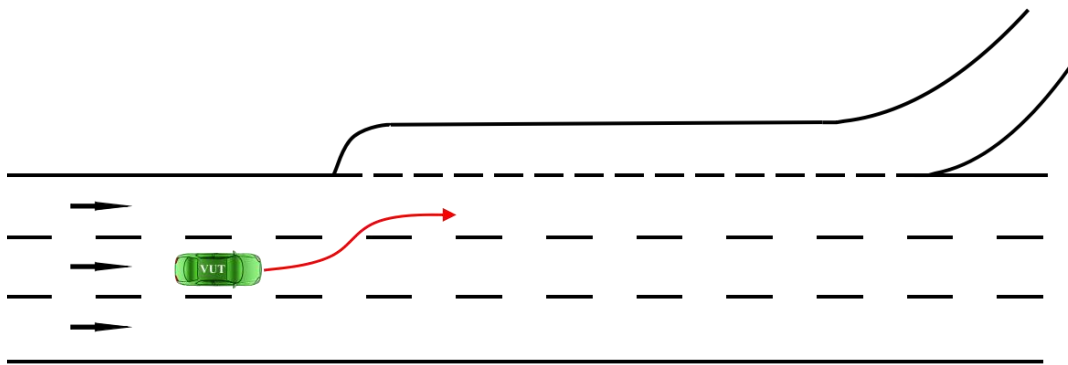


Figure A.2 Exiting a highway via an exit ramp

A.2.2 Test locations

- Exit at Plaza Tol Kajang, enter the connecting ramp linking E18 and E2.
- Exit at 214 Nilai Utara, merge onto the connecting ramp linking E2 and AH2.
- Exit from AH2, enter the connecting ramp linking AH2 and Persiaran Bandar Serenia.
- Exit from Persiaran Bandar Serenia, enter the connecting ramp linking Persiaran Bandar Serenia and AH2.
- Exit from AH2, enter the connecting ramp linking AH2 and E2.
- Exit from E2, enter the connecting ramp linking E2 and E18.
- Exit from E18 onto Jalan TKS 1.

A.2.3 Test procedure

- the test personnel shall ensure that the VUT travels through the selected highway exit-ramp scenario in accordance with the test-route requirements;
- with the DCAS activated, the VUT shall follow the test route through the highway exit-ramp section;
- recording of valid test data shall begin when the distance from VUT to the ramp diverge point is 1.5 km;
- each time the VUT travels through the highway exit-ramp section, completion of the driving task and the associated data shall be recorded.

A.2.4 Test termination conditions

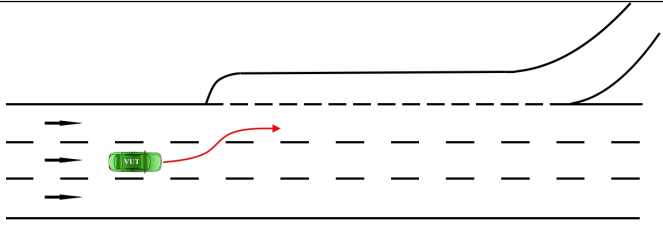
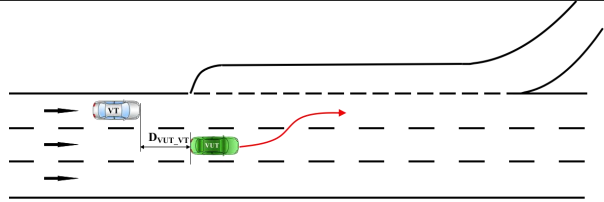
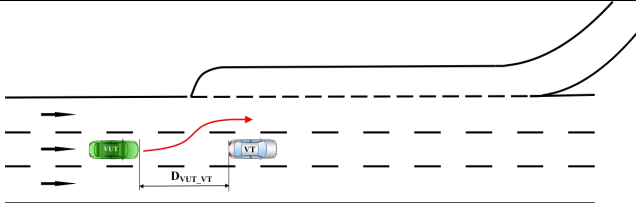
- a) all wheels of the VUT have entered the ramp;
- b) the VUT is involved in a traffic accident;
- c) the test personnel take control of the VUT and terminate the test to ensure driving safety;
- d) the VUT fails to exit the highway onto the ramp in time, causing any wheel to cross a solid line or enter the painted gore area, or the VUT reaches the ramp exit without having entered the ramp.

A.2.5 Test validity requirements

The following requirement shall be met to ensure test validity. The validity parameter ranges and associated layout diagrams are provided in Table A.1.

During testing, the lane ahead of the ramp shall not be obstructed by roadworks or a traffic accident.

Table A.1 Test conditions for exiting a highway via an exit ramp

Test condition		Validity parameter range
1	No interfering surrounding vehicle when exiting the highway	None
		
2	Interfering surrounding vehicle when exiting the highway	The longitudinal distance between the VUT and the interfering vehicle in the adjacent lane shall be within $[-60, -2]$ m or $[2, 100]$ m.
		
		The longitudinal distance between the VUT and the interfering vehicle ahead in the same lane shall be within $[2, 100]$ m.
		

A.3 Merging onto a Highway via an Entry Ramp

A.3.1 Scenario description

With the DCAS activated, the VUT shall follow the specified test route and merge from the entry ramp onto the highway mainline, as shown in Figure A.3. The scenario comprises two test cases: no interfering surrounding vehicle when merging onto the highway, and an interfering surrounding vehicle when merging onto the highway.

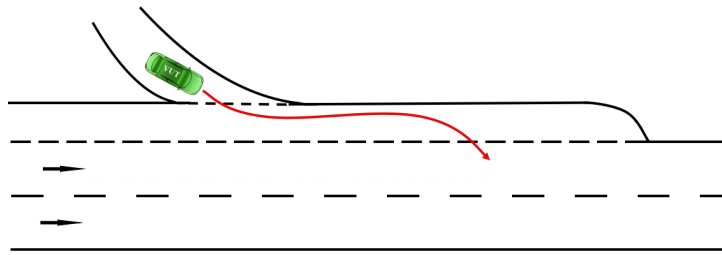


Figure A.3 Merging onto a highway via an entry ramp

A.3.2 Test locations

- a) The E18–E2 connecting ramp merges onto E2.
- b) The E2–AH2 connecting ramp merges onto AH2.
- c) The AH2–Persiaran Bandar Serenia connecting ramp merges onto Persiaran Bandar Serenia.
- d) The Persiaran Bandar Serenia–AH2 connecting ramp merges onto AH2.
- e) The AH2–E2 connecting ramp merges onto E2.
- f) The E2–E18 connecting ramp merges onto E18.

A.3.3 Test procedure

- a) the test personnel shall ensure that the VUT travels through the selected entry-ramp merge section in accordance with the test-route requirements;
- b) with the DCAS activated, the VUT shall follow the test route through the entry-ramp merge section;
- c) recording of valid test data shall begin when the distance from VUT to the end of the acceleration lane is 1.5 km;
- d) each time the VUT travels through the entry-ramp merge section, completion of the driving task and the associated data shall be recorded.

A.3.4 Test termination conditions

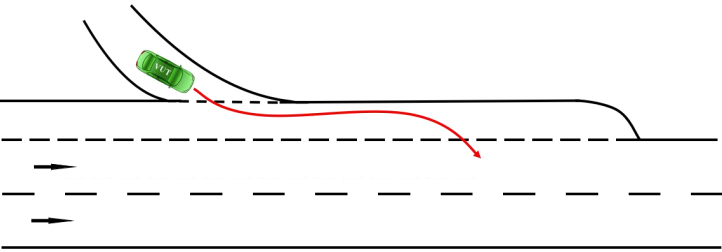
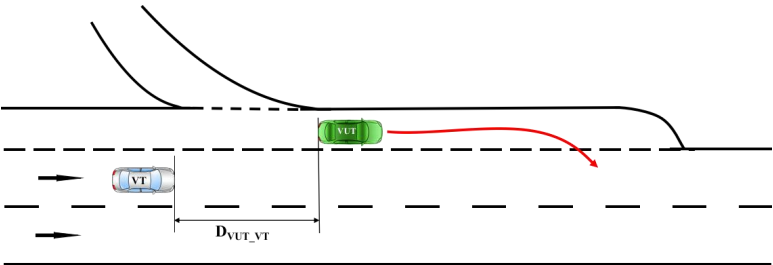
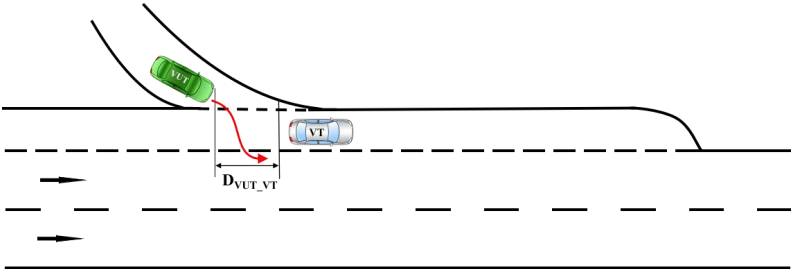
- a) all wheels of the VUT have entered the highway mainline;
- b) the VUT is involved in a traffic accident;
- c) the test personnel take control of the VUT and terminate the test to ensure driving safety;
- d) the VUT fails to merge from the ramp onto the mainline in time, causing any wheel to cross a solid line, enter the painted gore area, or enter the emergency lane.

A.3.5 Test validity requirements

The following requirement shall be met to ensure test validity. The validity parameter ranges and associated layout diagrams are provided in Table A.2.

During testing, the lane ahead of the ramp exit shall not be obstructed by roadworks or a traffic accident.

Table A.2 Test conditions for merging onto a highway via an entry ramp

Test condition		Validity parameter range
1	No interfering surrounding vehicle when merging onto the highway	None
		
2	Interfering surrounding vehicle when merging onto the highway	The longitudinal distance between the VUT and the interfering vehicle in the adjacent lane shall be within $[-60, -2]$ m or $[2, 100]$ m.
		
		The longitudinal distance between the VUT and the interfering vehicle ahead in the same lane shall be within $[2, 100]$ m.
		

A.4 Route Selection on a Ramp

A.4.1 Scenario description

With the DCAS activated, the VUT shall follow the specified route along a ramp. Where the ramp diverges ahead, the VUT shall select the correct branch and continue along the specified route, as shown in Figure A.4.

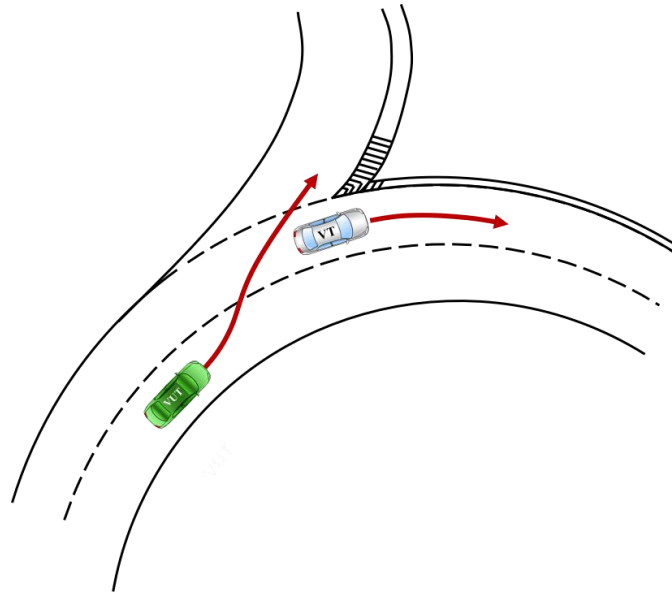


Figure A.4 Route selection on a ramp

A.4.2 Test locations

- a) At 612 Nilai (U), a directional branch for E2/AH2 needs to be selected on the AH2 to E2 connecting ramp.

A.4.3 Test procedure

- a) the test personnel shall ensure that the VUT travels through the selected road section in accordance with the test-route requirements;
- b) with the DCAS activated and the test route set, the VUT shall travel through the Y-shaped diverge within the ramp;
- c) recording of valid test data shall begin when the VUT starts to exit the highway onto the ramp;
- d) each time the VUT encounters this scenario, completion of the driving task and the associated data shall be recorded.

A.4.4 Test termination conditions

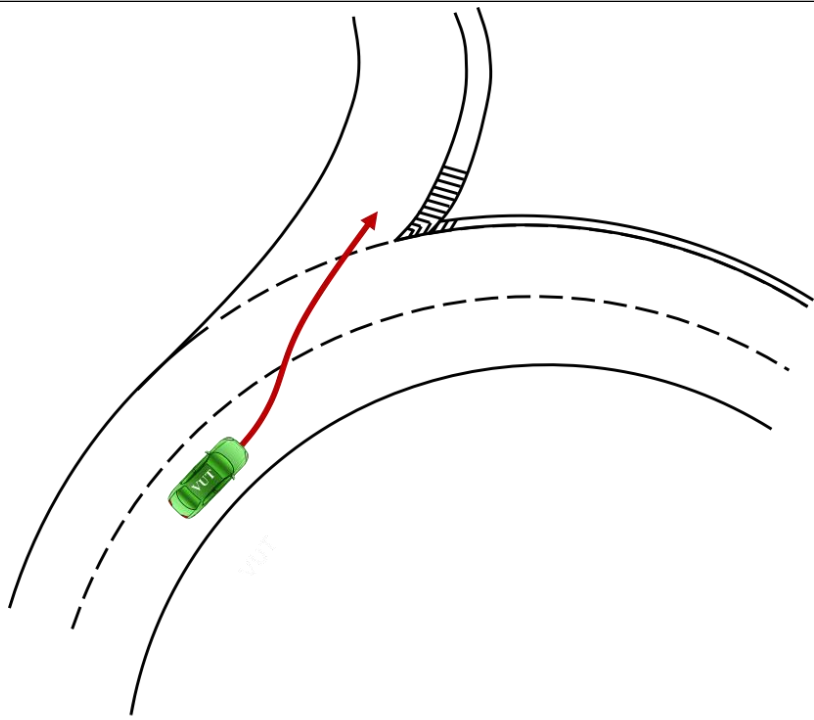
- a) the VUT enters the correct ramp in accordance with the test route and all wheels are within that ramp;
- b) the VUT is involved in a traffic accident;
- c) the test personnel take control of the VUT and terminate the test to ensure driving safety;
- d) the VUT fails to enter the correct ramp, any wheel crosses a solid line, or the VUT enters the channelising area.

A.4.5 Test validity requirements

The following requirement shall be met to ensure test validity. The validity parameter ranges and associated layout diagrams are provided in Table A.3.

During testing, the lane ahead of the ramp diverge shall not be obstructed by roadworks or a traffic accident.

Table A.3 Test conditions for route selection on a ramp

Test condition		Validity parameter range
1	No surrounding vehicle ahead of the VUT or in an adjacent lane	None
		 The diagram shows a green vehicle labeled 'VUT' on a road with a dashed center line and solid outer lines. The road is curved to the right. A red arrow points from the vehicle towards the outer edge of the road, indicating a lane change or a specific driving path. The road ahead is clear of other vehicles.

Annex B
(Normative)
Detailed Requirements for the Urban Road Test

B.1 Roundabout Negotiation

B.1.1 Scenario description

With the DCAS activated, the VUT shall follow the specified route and pass a roundabout, as shown in Figures B.1 to B.3. The scenario comprises six test cases: with or without an interfering surrounding vehicle when entering the roundabout, with or without an interfering surrounding vehicle when travelling within the roundabout, and with or without an interfering surrounding vehicle when exiting the roundabout.

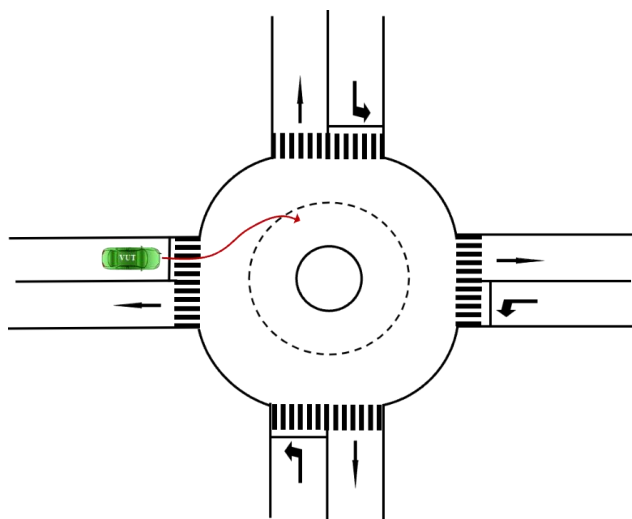


Figure B.1 VUT entering a roundabout

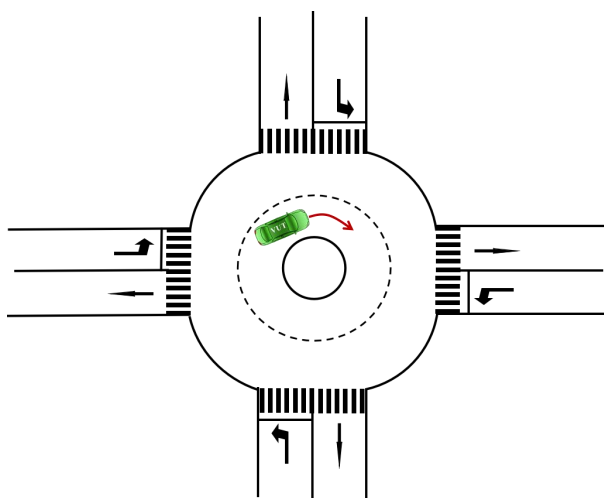


Figure B.2 VUT travelling within a roundabout

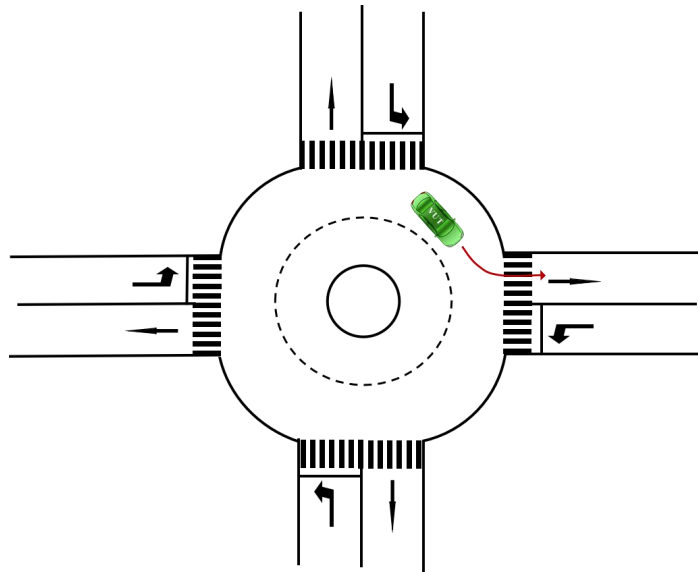


Figure B.3 VUT exiting a roundabout

B.1.2 Test locations

- At the roundabout where Persiaran Kajang 2 meets Persiaran Kajang, exit via Roundabout Exit 3.
- At the roundabout where Persiaran Bangi meets Persiaran Pekeliling, exit via Roundabout Exit 1.
- At the roundabout where Persiaran Pekeliling meets Persiaran Universiti, exit via Roundabout Exit 1.
- At the roundabout where Jalan Bangi Avenue 1/8 meets Route 31, exit via Roundabout Exit 2.
- At the roundabout where Jln Alam Sari meets Jln Alam Sari Utama, exit via Roundabout Exit 2.
- At the roundabout where Jln Alam Sari meets Jln Alam Sari, exit via Roundabout Exit 3.

B.1.3 Test procedure

- the test personnel shall ensure that the VUT travels through the selected roundabout scenario in accordance with the test-route requirements;
- with the DCAS activated, the VUT shall follow the test route and gradually approach the selected roundabout;
- recording of valid test data shall begin 20 s before the VUT reaches the roundabout entry;
- the VUT shall enter and travel through the roundabout safely in accordance with traffic regulations, then exit at the exit specified by the test route;
- each time the VUT completes the roundabout scenario, completion of the driving task and the associated data shall be recorded.

B.1.4 Test termination conditions

- the VUT passes the specified exit and its rear wheels leave the roundabout area;
- the VUT is involved in a traffic accident;

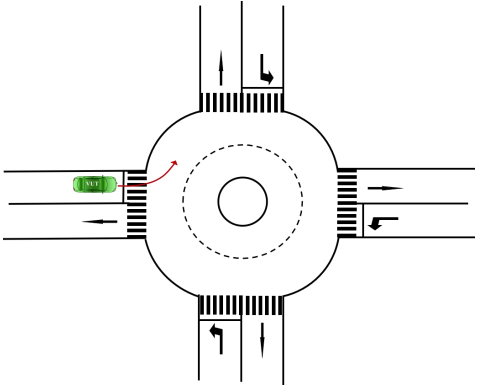
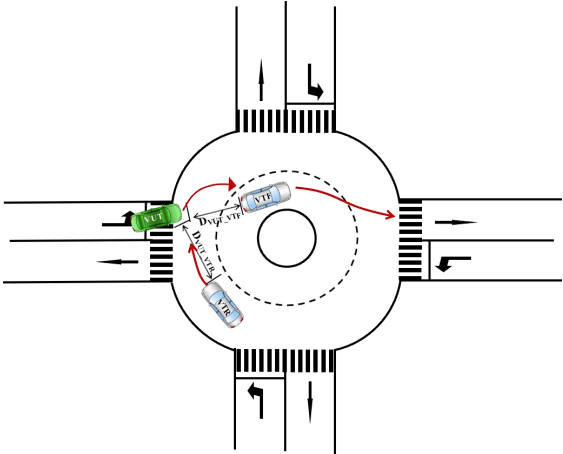
- c) the test personnel intervene and terminate the test to ensure driving safety;
- d) the VUT fails to select the specified exit and the test personnel intervene to terminate the test.

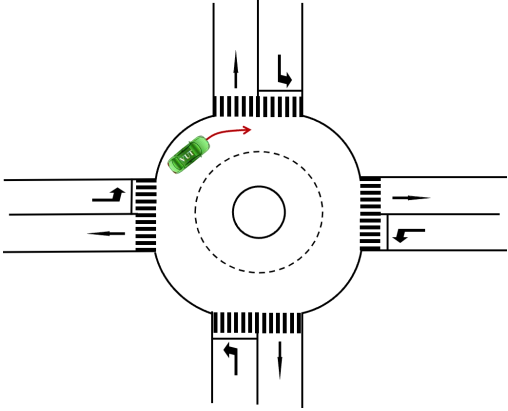
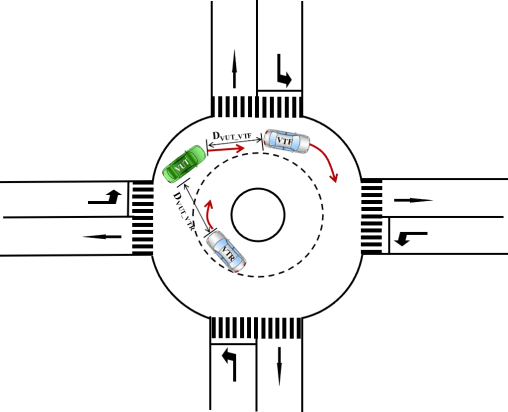
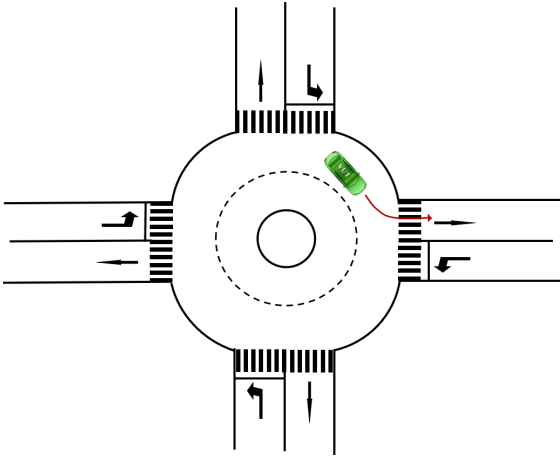
B.1.5 Test validity requirements

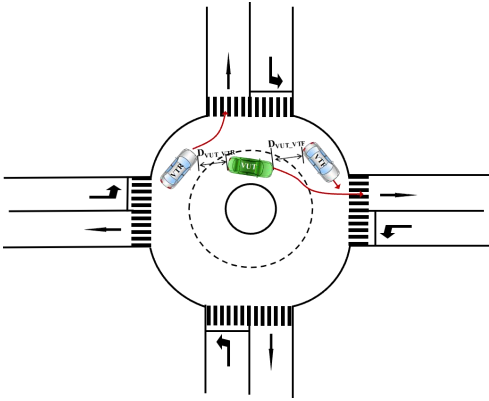
The following requirement shall be met to ensure test validity:

During testing, the roundabout scenario shall be free from roadworks, road closures, and lane obstruction caused by a traffic accident. The validity parameter ranges and associated layout diagrams are provided in Table B.1.

Table B.1 Test conditions for roundabout negotiation

Test condition		Validity parameter range
1	No interfering surrounding vehicle when entering the roundabout	None
		
2	Interfering surrounding vehicle when entering the roundabout	The longitudinal distance between the VUT and the rear target vehicle (VT_R) shall satisfy $D_{VUT_VTR} = [-50, -1]$ m; The longitudinal distance between the VUT and the front target vehicle (VT_F) shall satisfy $D_{VUT_VTF} = [1, 50]$ m.
		

3	No interfering surrounding vehicle when travelling within the roundabout	None
		
4	Interfering surrounding vehicle when travelling within the roundabout	The longitudinal distance between the VUT and the rear target vehicle (VT_R) shall satisfy $D_{VUT_VTR} = [-50, -1]$ m; The longitudinal distance between the VUT and the front target vehicle (VT_F) shall satisfy $D_{VUT_VTF} = [1, 50]$ m.
		
5	No interfering surrounding vehicle when exiting the roundabout	None
		

6	Interfering surrounding vehicle when exiting the roundabout	The longitudinal distance between the VUT and the rear target vehicle (VT_R) shall satisfy $D_{VUT_VTR} = [-50, -1]$ m; The longitudinal distance between the VUT and the front target vehicle (VT_F) shall satisfy $D_{VUT_VTF} = [1, 50]$ m. 
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B.2 Intersection Negotiation

B.2.1 Scenario description

With the DCAS activated, the VUT shall follow the specified route and pass an intersection, as shown in Figures B.4 to B.6. The scenario comprises six test cases: with or without an interfering surrounding vehicle before the VUT enters the intersection, with or without an interfering vehicle ahead while the VUT is stopped at the intersection, and with or without an interfering surrounding vehicle while the VUT passes through the intersection.

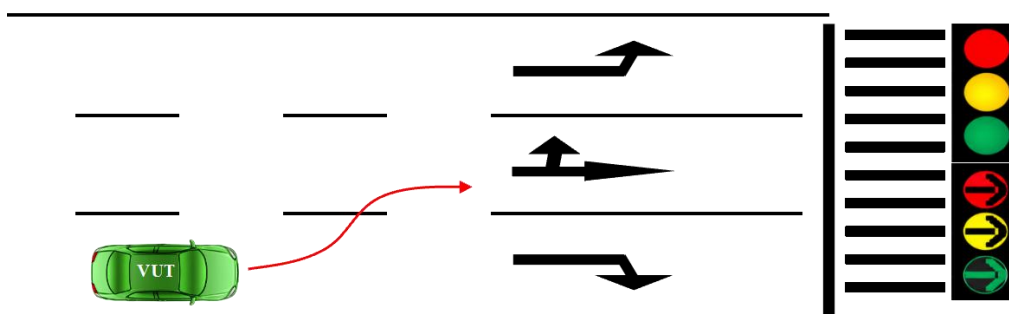


Figure B.4 VUT approaching an intersection

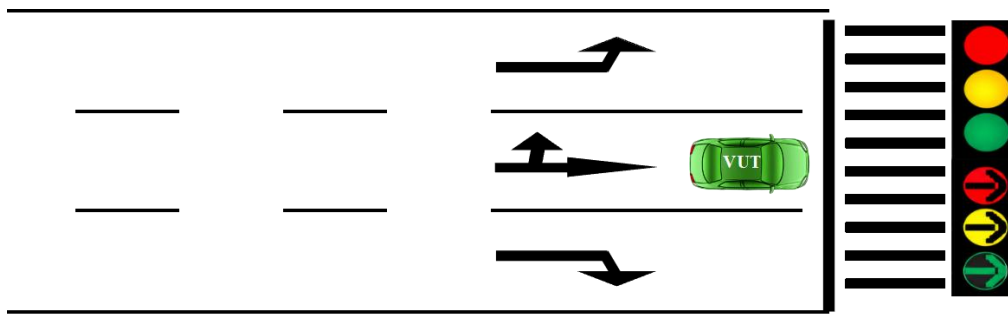


Figure B.5 VUT stopped at an intersection

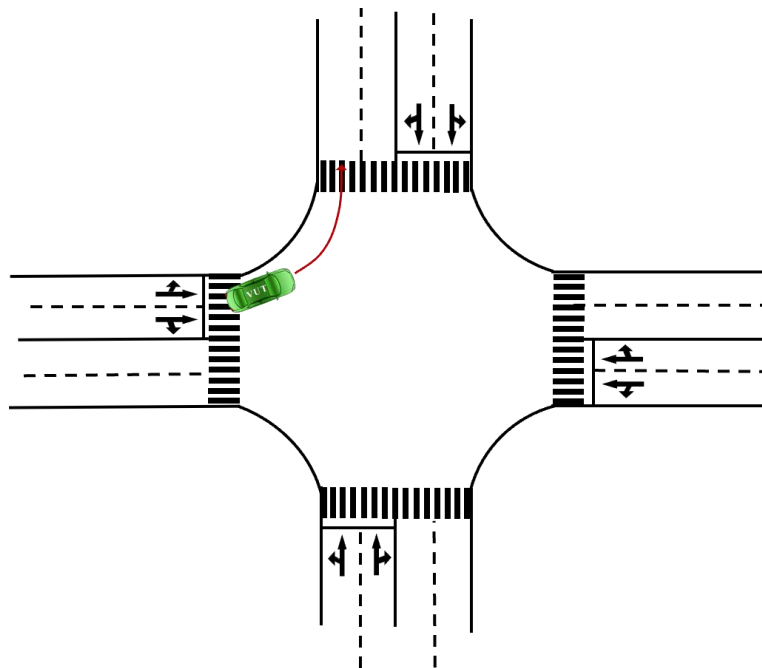


Figure B.6 VUT passing through an intersection

B.2.2 Test locations

- Persiaran Pekeliling — Jalan Bandar Baru Bangi junction, go straight
- Persiaran Pekeliling — Jalan 3/4 junction, go straight
- Persiaran Pekeliling — Jalan 2 junction, go straight
- Persiaran Pekeliling — Jalan 2/1j / Jalan 3/1 junction, go straight
- Persiaran Universiti — Jln Bangi junction, turn right
- Jln Bangi Lama — Jalan Bunga Raya junction, go straight
- Jln Alam Sari — Jalan Sari Ilham junction, go straight
- Persiaran KWSP — Jln TB 1/1 junction, turn right
- B17 — Jalan Reko Jaya junction, turn left

B.2.3 Test procedure

- a) the test personnel shall ensure that the VUT travels through the selected intersection scenario in accordance with the test-route requirements;
- b) with the DCAS activated, the VUT shall follow the test route and gradually approach the selected intersection;
- c) recording of valid test data shall begin 30 s before the VUT reaches the stop line at the intersection in the direction of travel;
- d) the VUT shall pass safely through the specified intersection in accordance with traffic regulations;
- e) each time the VUT completes the intersection scenario, completion of the driving task and the associated data shall be recorded.

B.2.4 Test termination conditions

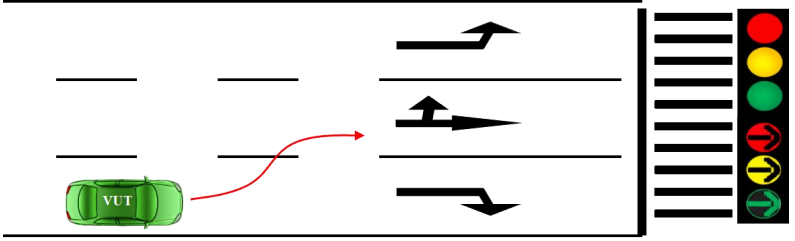
- a) the VUT enters the specified lane, passes through the intersection, and completes the driving task for the scenario;
- b) the VUT is involved in a traffic accident;
- c) the test personnel intervene and terminate the test to ensure driving safety;
- d) the VUT fails to enter the specified lane and the test personnel intervene to terminate the test.

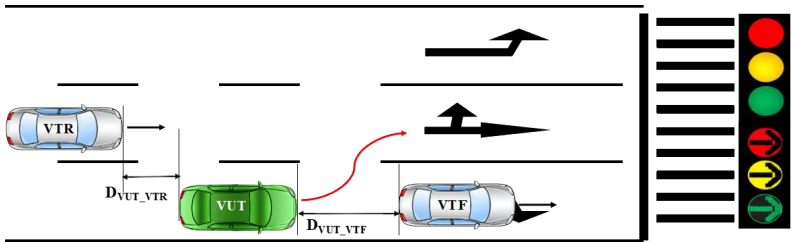
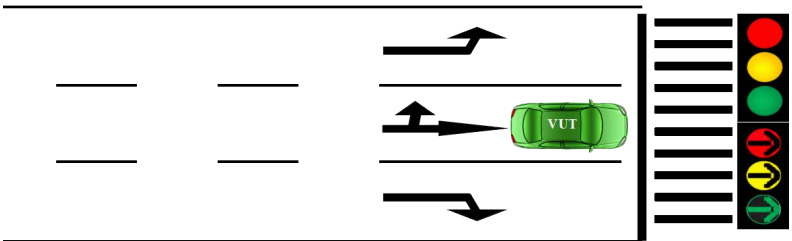
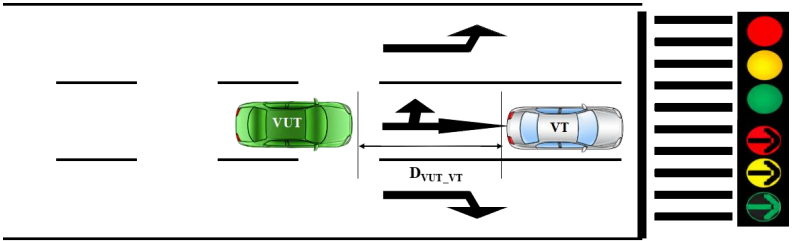
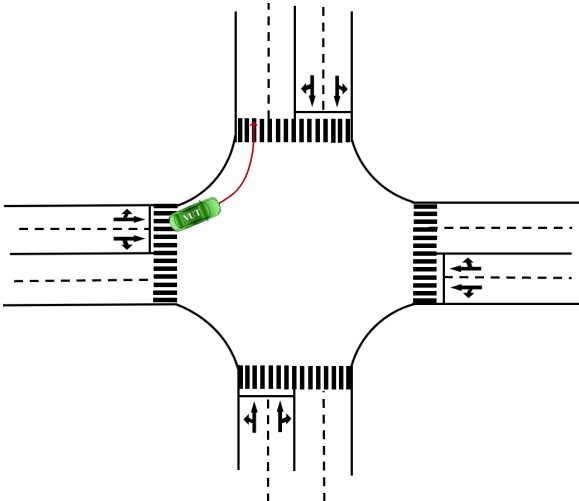
B.2.5 Test validity requirements

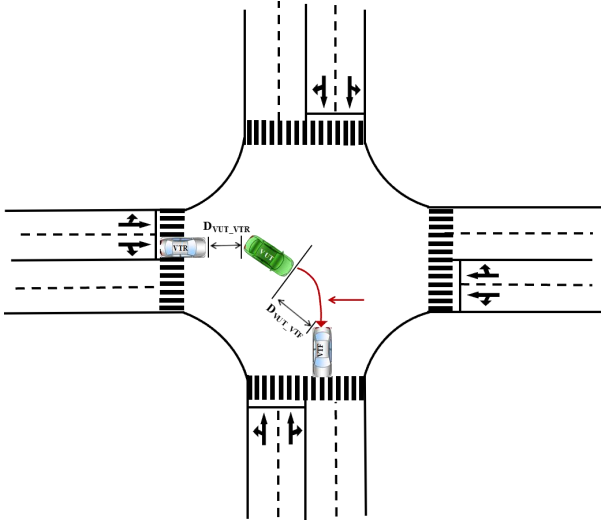
The following requirement shall be met to ensure test validity:

During testing, the intersection scenario shall be free from roadworks, road closures, and lane obstruction caused by a traffic accident. The validity parameter ranges and associated layout diagrams are provided in Table B.2.

Table B.2 Test conditions for intersection negotiation

Test condition		Validity parameter range
1	No interfering surrounding vehicle before the VUT enters the intersection	None
		
2	Interfering surrounding vehicle	The longitudinal distance between the VUT and the rear target vehicle (VTR) shall satisfy $D_{VUT_VTR} = [-50, -1] \text{ m}$;

	before the VUT enters the intersection	The longitudinal distance between the VUT and the front target vehicle (VT_F) shall satisfy $D_{VUT_VTF} = [1, 60]$ m. 
3	No interfering vehicle ahead while the VUT is stopped at the intersection	None 
4	Interfering vehicle ahead while the VUT is stopped at the intersection	The longitudinal distance between the VUT and the front target vehicle (VT_F) shall satisfy $D_{VUT_VTF} = [1, 60]$ m. 
5	No interfering surrounding vehicle while the VUT passes through the intersection	None 

6	Interfering surrounding vehicle while the VUT passes through the intersection	The longitudinal distance between the VUT and the rear target vehicle (VT_R) shall satisfy $D_{VUT_VTR} = [-30, -1]$ m; The longitudinal distance between the VUT and the front target vehicle (VT_F) shall satisfy $D_{VUT_VTF} = [1, 60]$ m.
		 The diagram illustrates a four-way intersection with a central circular area. A green vehicle (VUT) is positioned in the center, moving towards the bottom. A blue vehicle (VT_R) is positioned to the left of the VUT, and a red vehicle (VT_F) is positioned below the VUT. The longitudinal distance between the VUT and the rear target vehicle (VT_R) is labeled D_{VUT_VTR}. The longitudinal distance between the VUT and the front target vehicle (VT_F) is labeled D_{VUT_VTF}. The intersection has four lanes, each with a dashed center line and solid outer lines. Arrows indicate the direction of traffic flow: straight ahead, left turn, and right turn.