IVASA

ASEAN NCAP Intelligent Vehicle Advanced Safety Assessment Program

Test Protocol for Basic Driving Assistance

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IVASA Test Protocol for Basic Driving Assistance

1 Scope

This document specifies the test methods for the basic 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

The inertial frame specified in ISO 8855:2011 shall be used. 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. 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 vehicles.

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 DCAS and tested in accordance with this protocol.

2.4

Vehicle target (VT)

A vehicle or surrogate vehicle target used for testing in accordance with this protocol.

2.5

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.

2.6

Operational design condition (ODC)

The collective conditions specified for operation of a driving automation system, including its ODD,

vehicle state, driver state, and any other necessary conditions.

2.7

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 distance between the VUT and the VT 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.

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

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).

2.8

Lateral offset

The difference between the distances from the planned path to the centre of the VUT front axle and the centre of the VT rear axle. The lateral offset is zero when the VUT and VT centre lines coincide with the planned path. Where no VT is present, it is the distance from the centre of the VUT front axle to the planned path, as illustrated in Figure 1.

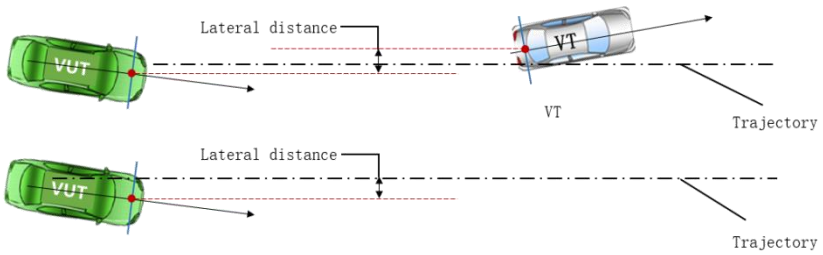

Figure 1 Lateral offset

2.9

Longitudinal offset

The distance, measured along the planned VUT path, between the centre of the VUT front end and the VT, as illustrated in Figure 2.

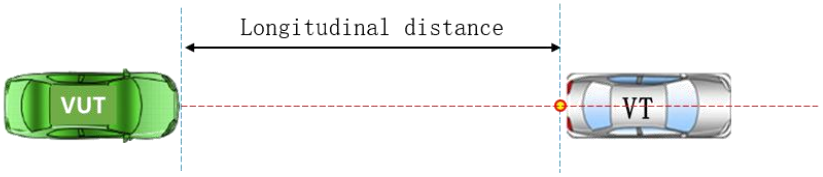

Figure 2 Longitudinal offset

3 Test Requirements

3.1 Requirements for Test Site and Test Environment

3.1.1 Test Site Requirements

The closed test site shall meet the following requirements:

a) the test surface shall be flat, free from evident potholes, cracks, or other defects, and have a gradient of less than 1%;

b) the test surface shall be dry, have no visible moisture or damp patches, and have a peak coefficient of friction of at least 0.7;

c) the test site shall be free from objects that could interfere with sensor operation;

d) the test road shall be at least 500 m long;

e) the test-road lane width shall be 3.50 m to 3.75 m, and the lane markings may be solid white, broken white, solid yellow, or broken yellow lines;

f) for curve tests, the test road shall comprise a straight section connected to a curve. The curve shall be long enough for at least 5 s of vehicle travel and shall comprise constant-curvature and transition sections. The constant-curvature value is specified in Table 1. The transition section connects the straight and constant-curvature sections; its curvature shall increase linearly from 0 to C, with dc/ds not exceeding 4×10^{-5} m^{-2}, as shown in Figure 3.

Note: Under rain-test conditions, the test road need not meet requirement b).

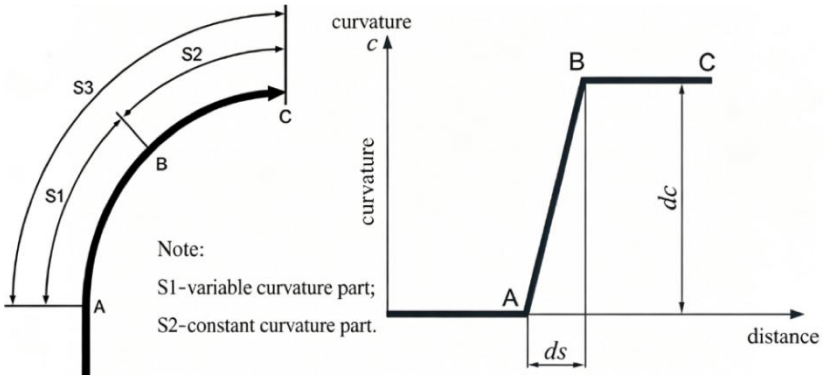

Figure 3 Curve curvature

Table 1 Relationship between curve radius and curvature

Curve radius R (m)	250	500
Curvature C (m^{-1})	0.004	0.002

3.1.2 Test Environment Requirements

a) weather conditions shall be favourable, with no rain, snow, blowing dust, or other adverse weather except in specified scenarios;
b) except for night-time and rain scenarios, testing shall be conducted under uniform natural illumination. Unless the vehicle manufacturer specifies a lower limit, illuminance shall be at least 2,000 lx for daytime tests and background illuminance shall not exceed 5 lx for night-time tests;
c) rain scenarios shall use short-duration moderate rainfall at 3.5 ± 0.3 mm/h, with an illuminance of at least 180 lx;
d) the ambient temperature shall be from 0 °C to 45 °C;
e) the average wind speed shall not exceed 5 m/s and the maximum instantaneous wind speed shall not exceed 10 m/s;
f) the vehicle travel direction shall not be parallel to direct sunlight.

3.2 Test Equipment Requirements

During proving-ground testing, the data-acquisition equipment installed on the VUT shall meet the following requirements:

a) dynamic data shall be sampled and stored at a frequency of at least 100 Hz, and VUT and target data shall be synchronised using GPS time;
b) longitudinal-speed measurement error shall not exceed 0.1 km/h;
c) lateral-speed measurement error shall not exceed 0.05 m/s;
d) longitudinal-acceleration measurement error shall not exceed 0.02 m/s^2;
e) lateral-acceleration measurement error shall not exceed 0.02 m/s^2;
f) longitudinal-position measurement error shall not exceed 0.02 m;
g) lateral-position measurement error shall not exceed 0.02 m;
h) installation and operation of the test instruments and equipment shall not affect normal operation of the VUT or DCAS.

3.2.1 Targets

3.2.1.1 Passenger Car Target

The passenger car target shall be a mass-produced M1-category passenger car or a soft target whose surface characteristics represent an M1-category passenger car and are suitable for sensor-system detection, as shown in Figure 4. Detailed requirements shall comply with ISO 19206-3.

Figure 4 Soft passenger car target (3D full-vehicle target without a lighting system and with a lighting system)

3.2.1.2 Motorcycle-with-Child Target

The motorcycle-with-child target shall be a soft target whose detection characteristics represent a scooter-type powered two-wheeler and its rider and are suitable for sensor-system detection, as shown in Figure 5. Its principal dimensions are specified in Table 2.

Figure 5 Motorcycle-with-child target

Table 2 Principal dimensions of the motorcycle-with-child target

Dimension	Value (mm)
Length	1720 ± 10
Width	630 ± 10
Height	1000 ± 10
Seat height	730 ± 10
Overall height	1680 ± 20

3.2.1.3 Motorcycle Rider Target

The scooter rider target shall be a soft target whose surface characteristics represent a motorcycle rider for ASEAN market and are suitable for sensor-system detection, as shown in Figure 6. Its principal dimensions are specified in Table 3.

Figure 6 Motorcycle rider target

Table 3 Principal dimensions of the motorcycle rider target

Dimension	Value (mm)
Overall height	1615 ± 20
Seat height	760 ± 20
Track width	1260 ± 30
Rider shoulder width	430 ± 20

3.2.1.4 Adult and Child Pedestrian Targets

The adult pedestrian target (APT) and child pedestrian target (CPT) shall be articulated soft targets whose surface characteristics represent the applicable adult or child and are suitable for sensor-system detection, as shown in Figure 7. Detailed requirements shall comply with ISO 19206-2.

Figure 7 Adult pedestrian target (left) and standing child pedestrian target (right)

3.2.1.5 Heavy-Truck Target

The heavy-truck target shall be a series-produced N3-category goods vehicle or a soft target whose surface characteristics represent an N3-category goods vehicle and are suitable for sensor-system detection, as shown in Figure 8. Its principal dimensions are specified in Table 4.

Figure 8 Soft heavy-truck target

Table 4 Principal dimensions of the soft heavy-truck target

Dimension	Value (mm)
Overall height	3900 ± 50
Cargo-body width	2500 ± 50
Cargo-body height	2700 ± 50
Bumper ground clearance	440 ± 10
Bumper length	2340 ± 30
Bumper width	120 ± 5

3.2.1.6 Light-Truck Target

The light-truck target shall be a series-produced N2-category goods vehicle or a soft target whose surface characteristics represent an N2-category goods vehicle and are suitable for sensor-system detection, as shown in Figure 9. Its principal dimensions are specified in Table 5.

Figure 9 Soft light-truck target

Table 5 Principal dimensions of the soft light-truck target

Dimension	Value (mm)
Overall length	6000 ± 50
Overall height	3140 ± 50
Overall width	2210 ± 50
Cargo-body width	2060 ± 50
Cargo-body length	4210 ± 50

Cargo-body height	2200 ± 50
Cab height	2680 ± 50
Cab length	1690 ± 30
Cab width	1860 ± 30
Wheelbase	3360 ± 50
Tailboard height	1600 ± 20
Rear ground clearance	400 ± 20

3.2.1.7 Cow Target

The cow target shall be a soft surrogate target whose surface characteristics represent the body shape and movement posture of an adult wild cow and are suitable for detection by vehicle sensors, as shown in Figure 10. Its principal dimensions and shape parameters shall comply with Table 6.

Figure 10 Cow Target

Table 6 Principal dimensions of the cow target

Dimension	Value (mm)
Height	1040 ± 10
Body length	980 ± 10
Chest circumference	1270 ± 10

3.2.1.8 Wild Boar Target

The wild boar target shall be a soft surrogate target whose surface characteristics represent the body shape and movement posture of an adult wild boar and are suitable for detection by vehicle sensors, as shown in Figure 11. Its principal dimensions and shape parameters shall comply with Table 7.

Figure 11 Wild Boar Target

Table 7 Principal dimensions of the wild boar target

Dimension	Value (mm)
Height	700 ± 10
Body length	1200 ± 10
Head circumference	950 ± 10

3.2.1.9 Traffic Cone

The traffic cone shall be at least 70 cm high, have a base diameter of at least 40 cm, and use alternating red-and-white or yellow-and-white colours. The recommended dimensions are 90 cm × 45 cm. A representative traffic-cone target is shown in Figure 12.

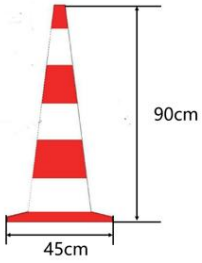

Figure 12 Traffic-cone target

3.2.1.10 Real-Vehicle Target

For DCAS scenarios involving a passenger car target cutting out, a real M1-category passenger car shall be used as the target. Its overall length shall be from 475 cm to 500 cm and its maximum width from 178 cm to 193 cm. Vehicle colour is unrestricted.

3.2.2 VUT Requirements

3.2.2.1 System Initialisation

The system shall be initialised as follows:

a) where necessary, the DCAS may be initialised before testing, including calibration of radar, cameras, and other sensors;

b) before testing, the VUT manufacturer may incorporate test-road information into the product map or modify the DCAS activation conditions, provided it demonstrates that the safety performance of the VUT's DCAS is not changed.

3.2.2.2 Vehicle Condition Check

Before testing, the VUT shall meet the following requirements:

a) the VUT shall be new and have 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 and inflated to the manufacturer's recommended standard cold 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 capacity before testing and shall not fall below 50% during proving-ground testing. All other vehicle fluids shall be at or above the indicated minimum level;

e) where the VUT is equipped with an active bonnet system, it shall be deactivated before the proving-ground 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;

3.2.2.3 Functional Check

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

3.3 System Settings

The system settings shall meet the following requirements:

a) during proving-ground testing, if the DCAS following-time-gap setting is adjustable, it shall be set to the lowest level; otherwise, the vehicle's default setting shall be used;

b) if the VUT provides multiple driving modes, the standard mode shall be used throughout testing unless otherwise specified;

c) if an adjustable lane-change assertiveness setting is provided, the standard mode shall be used throughout testing unless otherwise specified; otherwise, the VUT's default setting shall be used;

d) unless otherwise specified, AES shall be enabled while the DCAS is following a vehicle throughout testing;

e) if the VUT's AEB, FCW, LDW, or LDP function is adjustable, it shall be set to the lowest level during proving-ground testing;

f) for night-time and rain tests, the VUT lighting shall be set as follows:

1) where the system can be activated only when the relevant lighting control is set to AUTO, the VUT headlamps shall be set to AUTO;

2) where the system can be activated only with dipped-beam headlamps, the VUT headlamps shall be set to dipped beam;

3) where the system can be activated only with main-beam headlamps, the VUT headlamps shall be set to main beam;

4) where the system can be activated with dipped beam, main beam, and/or the relevant AUTO setting, the VUT headlamps shall be set to dipped beam.

3.3.1 Test Records

The following information shall be recorded throughout proving-ground testing:

a) DCAS software version information;

b) VUT control mode;

c) position of the VUT geometric centre or centre of mass;

d) VUT longitudinal and lateral position;

e) VUT longitudinal and lateral speed;

f) VUT longitudinal and lateral acceleration;

g) in-vehicle video showing the driver and human-machine interaction state;

h) video showing the VUT driving state;

i) target position and motion data.

3.3.2 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.

3.3.3 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-acceleration data shall be filtered using a 12th-order Butterworth filter with a cut-off frequency of 6 Hz.

4 Test Methods

4.1 Overview

Basic driving assistance shall be tested on a closed course.

4.2 Proving-Ground Testing

4.2.1 Proving-ground testing shall meet the following basic requirements:

Each test condition may be run up to three times. The condition passes if two of the three runs meet the safety criteria. The better of the two qualifying runs shall be used to score the experience criterion. If the first two runs meet the requirements, a third run shall not be conducted;

Unless otherwise specified, settings shall not be changed in any test scenario and the driver shall not operate the accelerator or brake pedal or provide manual steering assistance. To prevent DCAS disengagement during testing, the driver shall keep both hands on the steering wheel or apply appropriate steering torque when required.

4.2.2 The proving-ground test scenarios are specified in Table 8:

Table 8 Proving-ground test scenarios

No.	Basic driving assistance test area	Test scenario
1	Car-to-Vehicle	Stationary passenger car ahead on a straight road
2		Stationary passenger car ahead on a curve
3		Moving light truck ahead on a straight road
4		Stationary light truck ahead on a curve
5		Passenger car cutting in at night

6		Passenger car crossing
7		Stationary heavy truck ahead in rain
8		Moving heavy truck ahead
9		VUT travelling straight with an oncoming passenger car turning right
10	Car-to-VRU	Stationary motorcycle carrying a child ahead in rain
11		Moving motorcycle carrying a child ahead
12		Motorcycle carrying a child cutting in ahead at night
13		Motorcycle carrying a child crossing ahead
14		Motorcycle crossing ahead (obstructed)
15		Pedestrian crossing
16		Pedestrian walking longitudinally at night
17		Secondary target vehicle (motorcycle)
18		VUT travelling straight with an oncoming motorcycle turning right
19	Car-to-Obstacle	Cow crossing
20		Wild boar crossing
21		Secondary collision
22	Car-to-Road-Infrastructure	Traffic-signal recognition and response
23		Stop-sign recognition and response
24		Speed-limit-sign recognition and response
25		Roadworks-zone navigation

4.3 Car-to-Vehicle Scenario Test Methods

4.3.1 Stationary passenger car ahead on a straight road

4.3.1.1 Scenario Description

Under daytime conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall approach a stationary passenger car VT ahead, as shown in Figure 13.

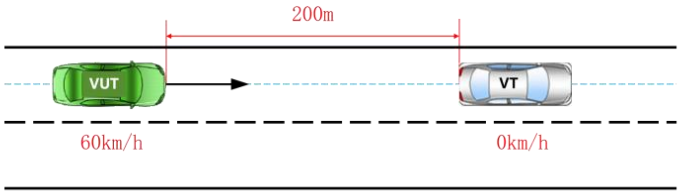

Figure 13 Stationary passenger car ahead on a straight road

4.3.1.2 Test Procedure

a) the VT shall be positioned stationary in the centre of the VUT lane as shown in Figure 13;
b) with the DCAS activated, the VUT shall travel along the straight road at a set speed of 60 km/h and gradually approach the VT after its speed has stabilised;
c) the VUT shall reach the specified speed at least 200 m before the VT.

4.3.1.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the VT.

4.3.2 Stationary passenger car ahead on a curve

4.3.2.1 Scenario Description

Under daytime conditions, the test road shall comprise a long straight followed by a curve. Either a left or right curve may be selected. After entering the curve from the straight, the VUT shall approach a stationary passenger car VT, as shown in Figure 14.

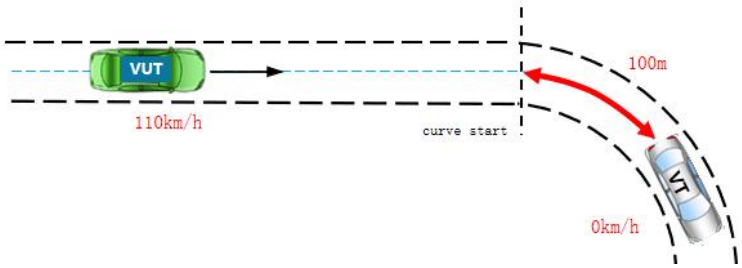

Figure 14 Stationary passenger car ahead on a curve

4.3.2.2 Test Procedure

a) the VT shall be positioned stationary in the centre of the VUT lane as shown in Figure 14; the curve radius shall be 500 m;

b) with the DCAS activated, the VUT shall enter the curve from the straight at a set speed of 110 km/h and gradually approach the VT;

c) the VUT shall reach the specified speed at least 200 m before the VT.

4.3.2.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the VT.

4.3.3 Moving light truck ahead on a straight road

4.3.3.1 Scenario Description

Under daytime conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall approach a moving light-truck VT ahead, as shown in Figure 15.

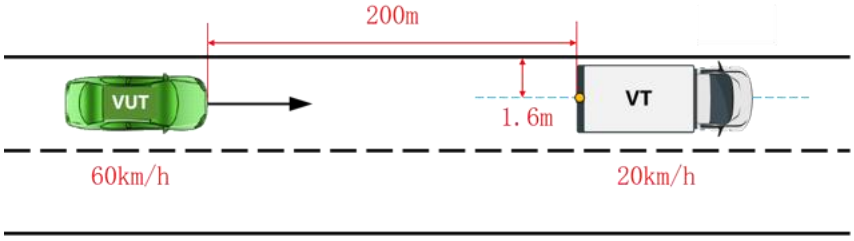

Figure 15 Moving light truck ahead

4.3.3.2 Test Procedure

a) the VT shall travel ahead of the VUT in the same lane as shown in Figure 15, with its longitudinal centreline located 1.6 m from the left lane marking;

b) with the DCAS activated, the VUT shall travel along the straight road at a set speed of 60 km/h and gradually approach the VT travelling steadily ahead at 20 km/h;

c) the VUT shall reach the specified speed at least 200 m before the VT.

4.3.3.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the VT.

4.3.4 Stationary light truck ahead on a curve

4.3.4.1 Scenario Description

Under daytime conditions, the test road shall comprise a long straight followed by a curve. Either a left or right curve may be selected. After entering the curve from the straight, the VUT shall approach a stationary light-truck VT, as shown in Figure 16.

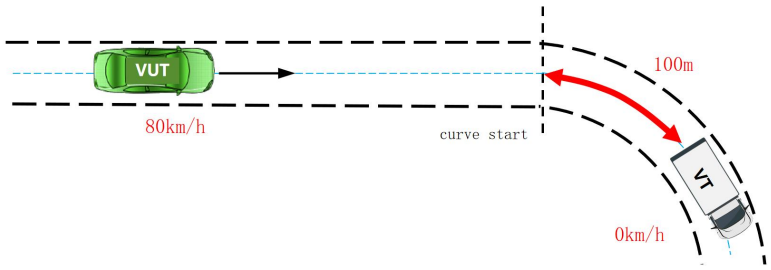

Figure 16 Stationary light truck ahead on a curve

4.3.4.2 Test Procedure

a) the VT shall be positioned stationary in the centre of the VUT lane as shown in Figure 16; the curve radius shall be 250 m;

b) with the DCAS activated, the VUT shall enter the curve from the straight at a set speed of 80 km/h and gradually approach the VT;

c) the VUT shall reach the specified speed at least 200 m before the VT.

4.3.4.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the VT.

4.3.5 Passenger car cutting in at night

4.3.5.1 Scenario Description

Under night-time conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall travel in its lane while the passenger car VT travels more slowly in the adjacent lane. As the VUT approaches after stabilising its speed, the VT shall cut in ahead, as shown in Figure 17.

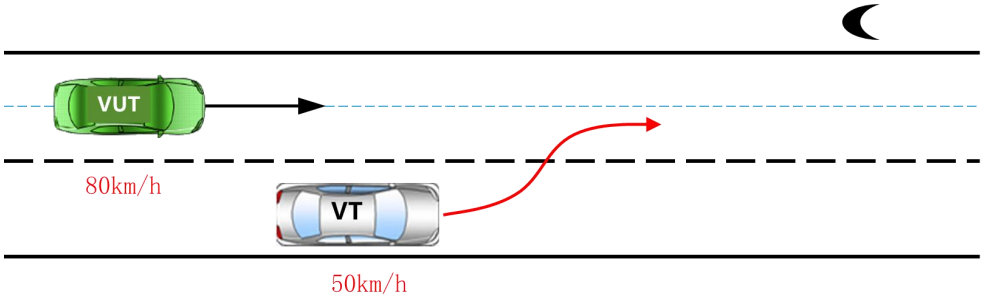

Figure 17 Passenger car cutting in at night

4.3.5.2 Test Procedure

a) with the DCAS activated, the VUT shall travel steadily along the straight road at a set speed of 80 km/h;

b) the VT shall travel at a constant 50 km/h ahead in the adjacent lane and shall cut in ahead of the VUT when TTC reaches 2.0 s;

c) the VT cut-in path is shown in Figure 18 and its parameters are specified in Table 9.

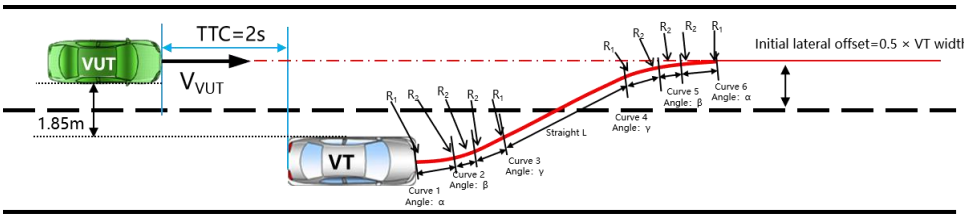

Figure 18 VT cut-in path

Table 9 VT cut-in path parameters

Curve 1	Start radius R1 (m)	1500
	End radius R2 (m)	200
	Angle α (°)	1.2
Curve 2	Arc radius R2 (m)	200
	Angle β (°)	3.6
Curve 3	Start radius R2 (m)	200
	End radius R1 (m)	1500
	Angle γ (°)	1.2
Straight L	Straight-segment length L (m)	8.8
Curve 4	Start radius R2 (m)	1500
	End radius R1 (m)	200
	Angle γ (°)	1.2
Curve 5	Arc radius R2 (m)	200
	Angle β(°)	3.6
Curve 6	Start radius R1 (m)	200
	End radius R2 (m)	1500
	Angle α (°)	1.2

4.3.5.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the VT.

4.3.6 Passenger car crossing

4.3.6.1 Scenario Description

Under daytime conditions, the test road shall contain a four-way intersection with no traffic signals or with signals that remain inactive. The VUT shall travel along the straight road and encounter a crossing passenger car VT at the intersection, as shown in Figure 19.

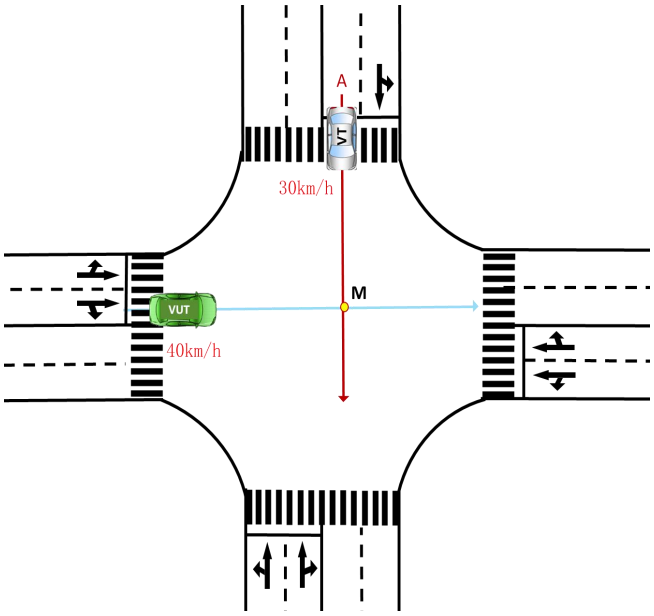

Figure 19 Passenger car crossing

4.3.6.2 Test Procedure

a) the VUT and VT paths are shown in Figure 19;

b) with the DCAS activated, the VUT shall stabilise at a set speed of 40 km/h at least 150 m before the intersection centre. Three preliminary runs without a crossing VT shall be conducted; the test collision point shall be the mean of the predicted intersection points between the three VUT paths and the VT crossing path;

c) with the DCAS activated, the VUT shall travel steadily at a set speed of 40 km/h and proceed straight through the intersection. The VT shall travel straight through the intersection along the specified path at 30 km/h.

4.3.6.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the VT.

4.3.7 Stationary heavy truck ahead in rain

4.3.7.1 Scenario Description

Under rain conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall approach a stationary heavy-truck VT ahead, as shown in Figure 20.

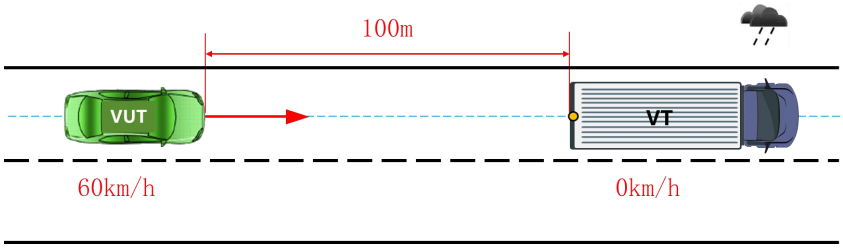

Figure 20 Stationary heavy truck ahead in rain

4.3.7.2 Test Procedure

a) the VT shall be positioned stationary ahead in the centre of the VUT lane as shown in Figure 20;
b) with the DCAS activated, the VUT shall travel along the straight road at a set speed of 60 km/h and gradually approach the VT after its speed has stabilised;
c) the VUT shall reach the specified speed at least 100 m before the VT.

4.3.7.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the VT.

4.3.8 Moving heavy truck ahead

4.3.8.1 Scenario Description

Under daytime conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall approach a moving heavy-truck VT ahead, as shown in Figure 21.

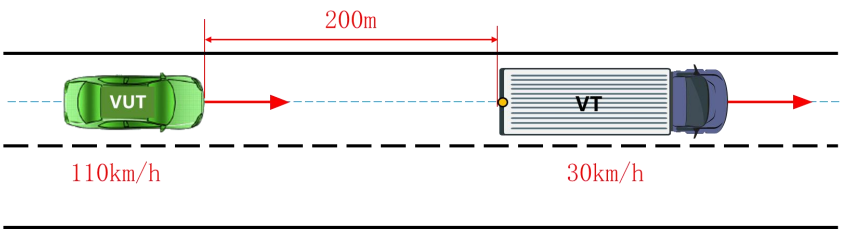

Figure 21 Moving heavy truck ahead

4.3.8.2 Test Procedure

a) the VT shall travel ahead in the centre of the VUT lane as shown in Figure 21;

b) with the DCAS activated, the VUT shall travel along the straight road at a set speed of 110 km/h and gradually approach the VT travelling ahead at a constant 30 km/h;

c) the VUT shall reach the specified speed at least 200 m before the VT.

4.3.8.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the VT.

4.3.9 VUT travelling straight with an oncoming passenger car turning right

4.3.9.1 Scenario Description

Under daytime conditions, the test road shall contain a four-way intersection with no traffic signals or with signals that remain inactive. The VUT shall travel along the straight road and encounter an oncoming passenger car VT turning right at the intersection, as shown in Figure 22.

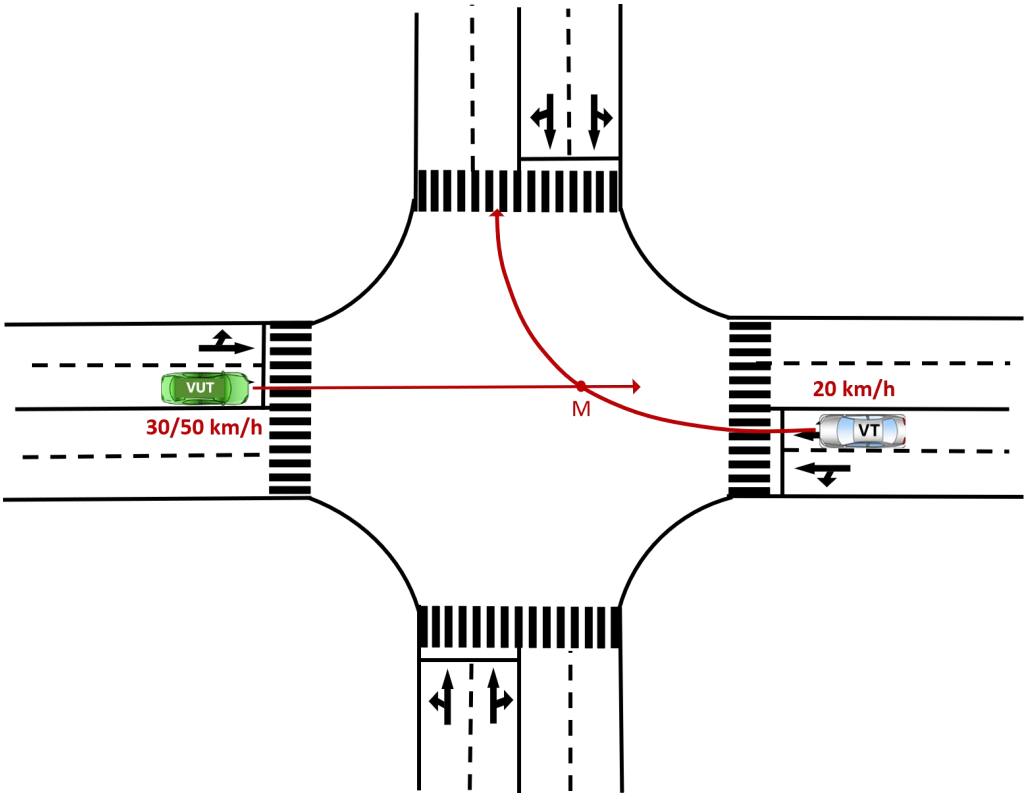

Figure 22 VUT travelling straight with an oncoming passenger car turning right

4.3.9.2 Test Procedure

a) with the DCAS activated, the VUT shall stabilise at the specified speed at least 150 m before the intersection centre. Three preliminary runs without an oncoming right-turning VT shall be conducted; the test collision point shall be the mean of the predicted intersection points between the three VUT paths and the right-turning VT path;

b) with the DCAS activated, the VUT shall travel steadily at the specified speed and proceed straight through the intersection. The VT shall turn right through the intersection along the specified path at 20 km/h.

c) the VT right-turn path is shown in Figure 23 and its parameters are specified in Table 11.

Table 10 Test conditions for the VUT travelling straight with an oncoming passenger car turning right

No.	VUT speed (km/h)	Passenger car VT speed (km/h)
1	30	20
2	50	20

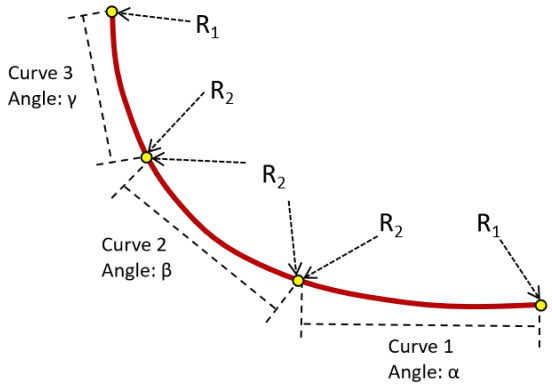

Figure 23 VT right-turn path

Table 11 VT right-turn path parameters

Speed (km/h)	Curve 1			Curve 2			Curve 3		
	Initial radius R1 (m)	Final radius R2 (m)	Angle α (deg)	Initial radius R2 (m)	Final radius R2 (m)	Angle β (deg)	Initial radius R2 (m)	Final radius R1 (m)	Angle α (deg)
30	1500	11.75	20.93	11.75	11.75	48.14	11.75	1500	20.93

4.3.9.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the VT.

4.4 Car-to-VRU Scenario Test Methods

4.4.1 Stationary motorcycle carrying a child ahead in rain

4.4.1.1 Scenario Description

Under rain conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall approach a stationary motorcycle-with-child target ahead, as shown in Figure 24.

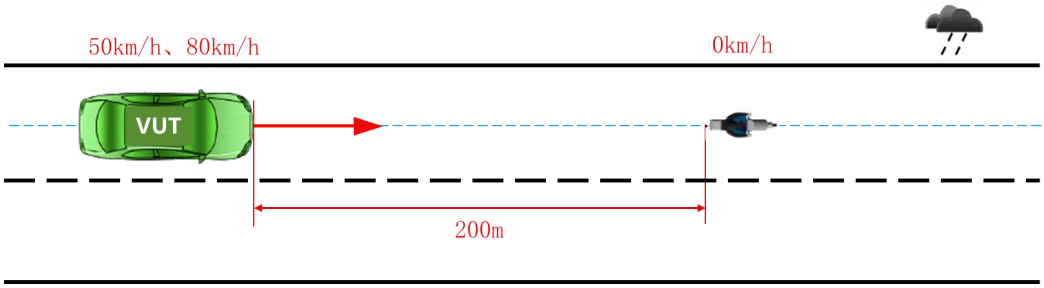

Figure 24 Stationary motorcycle carrying a child ahead in rain

4.4.1.2 Test Procedure

a) the target shall be positioned stationary ahead in the centre of the VUT lane as shown in Figure 24;

b) with the DCAS activated, the VUT shall travel along the straight road at the specified speed and gradually approach the target ahead after its speed has stabilised;

c) the VUT shall reach the specified speed at least 100 m before the target.

Table 12 Test conditions for a stationary motorcycle carrying a child ahead in rain

No.	VUT speed (km/h)	Target speed (km/h)
1	50	0
2	80	0

4.4.1.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the target.

4.4.2 Moving motorcycle carrying a child ahead

4.4.2.1 Scenario Description

Under daytime conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall approach a moving motorcycle-with-child target ahead, as shown in Figure 25.

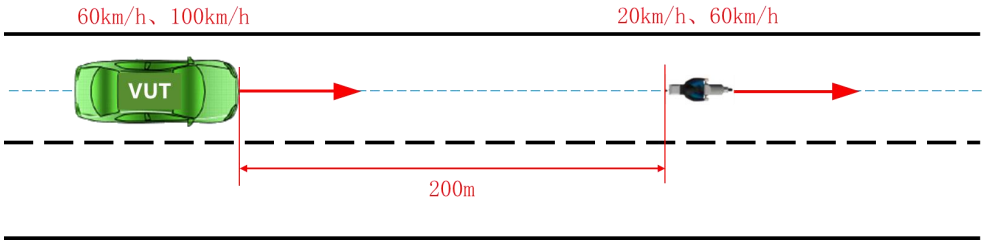

Figure 25 Moving motorcycle carrying a child ahead

4.4.2.2 Test Procedure

a) the motorcycle-with-child target shall travel ahead in the centre of the VUT lane as shown in Figure 25.

b) with the DCAS activated, the VUT shall travel along the straight road at the specified speed and, after stabilising, gradually approach the target travelling straight ahead at its specified constant speed;

c) the VUT shall reach the specified speed at least 200 m before the target.

Table 13 Test conditions for a moving motorcycle carrying a child ahead

No.	VUT speed (km/h)	Target speed (km/h)
1	60	20
2	100	60

4.4.2.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the target.

4.4.3 Motorcycle carrying a child cutting in ahead at night

4.4.3.1 Scenario Description

Under night-time conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall travel in its lane while the motorcycle-with-child target travels more

slowly in the adjacent lane. As the VUT approaches after stabilising its speed, the target shall cut in ahead, as shown in Figure 26.

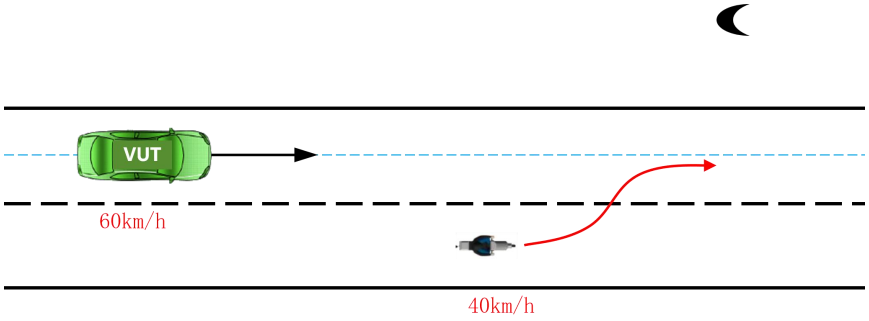

Figure 26 Motorcycle carrying a child cutting in ahead at night

4.4.3.2 Test Procedure

a) with the DCAS activated, the VUT shall travel steadily along the straight road at a set speed of 60 km/h;

b) the target shall travel at a constant 40 km/h ahead in the lane adjacent to the VUT and shall cut in ahead of the VUT when TTC reaches 2.0 s;

c) the target cut-in path is shown in Figure 27 and its parameters are specified in Table 14.

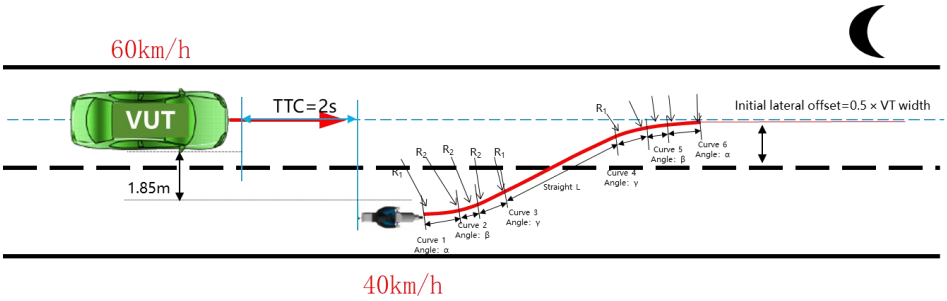

Figure 27 Target cut-in path

Table 14 Target cut-in path parameters

Curve 1	Start radius R1 (m)	1500
	End radius R2 (m)	120
	Angle α (°)	1.75
Curve 2	Arc radius R2 (m)	120
	Angle β (°)	4.0
Curve 3	Start radius R2 (m)	120
	End radius R1 (m)	1500

	Angle γ (°)	1.75
Straight L	Straight-segment length L (m)	7.2
Curve 4	Start radius R2 (m)	1500
	End radius R1 (m)	120
	Angle γ (°)	1.75
Curve 5	Arc radius R2 (m)	120
	Angle β (°)	4.0
Curve 6	Start radius R1 (m)	120
	End radius R2 (m)	1500
	Angle α (°)	1.75

4.4.3.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the target.

4.4.4 Motorcycle carrying a child crossing ahead

4.4.4.1 Scenario Description

Under daytime conditions, the test road shall contain a four-way intersection with no traffic signals or with signals that remain inactive. The VUT shall travel along the straight road and encounter a crossing motorcycle-with-child target at the intersection, as shown in Figure 28.

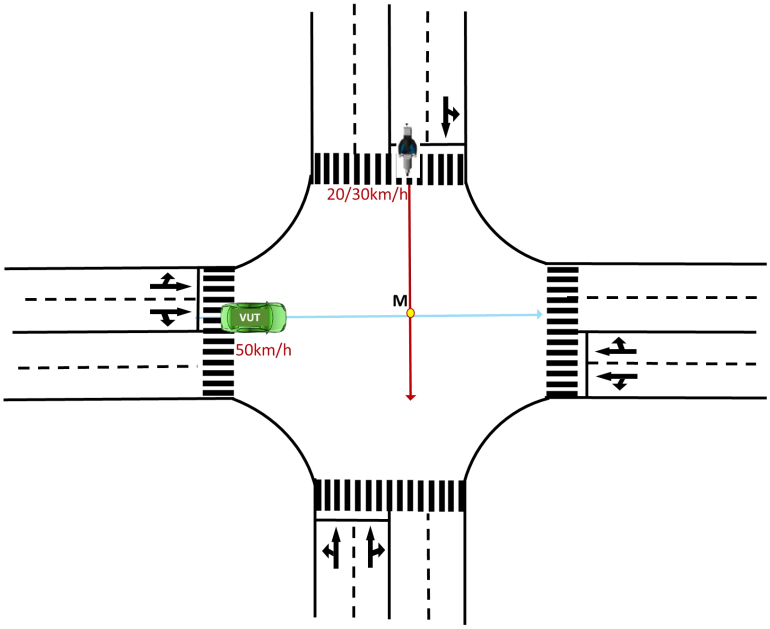

Figure 28 Motorcycle carrying a child crossing ahead

4.4.4.2 Test Procedure

a) the VUT and target paths are shown in Figure 28;

b) with the DCAS activated, the VUT shall stabilise at a set speed of 50 km/h at least 150 m before the intersection centre. Three preliminary runs without the crossing target shall be conducted; the test collision point shall be the mean of the predicted intersection points between the three VUT paths and the target crossing path;

c) with the DCAS activated, the VUT shall travel steadily at a set speed of 50 km/h and proceed straight through the intersection. The target shall travel straight through the intersection along the specified path at the specified speed.

Table 15 Test conditions for a motorcycle carrying a child crossing ahead

No.	VUT speed (km/h)	Target speed (km/h)
1	50	20
2	50	30

4.4.4.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the target.

4.4.5 Motorcycle crossing ahead (obstructed)

4.4.5.1 Scenario Description

Under daytime conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall travel straight, two stationary VTs shall be parked on the right, and the motorcycle target shall cross on a path perpendicular to the VUT path, as shown in Figure 29.

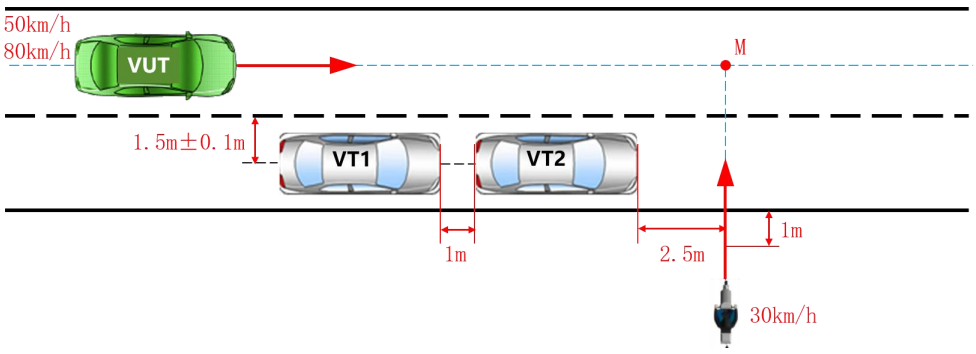

Figure 29 Obstructed motorcycle crossing ahead

4.4.5.2 Test Procedure

a) the VUT and target paths are shown in Figure 29; VT1 and VT2 shall be positioned stationary in the right-hand lane as shown in Figure 29;
b) with the DCAS activated, the VUT shall travel along the straight road at the specified speed;
c) the target path shall be perpendicular to the VUT path. The target shall travel at the specified speed along the specified path, with the collision point at the 50% VUT impact position;
d) the VUT shall reach the specified speed at least 200 m before reaching the target.

Table 16 Test conditions for an obstructed motorcycle crossing ahead

No.	VUT speed (km/h)	Target speed (km/h)
1	50	30
2	80	30

4.4.5.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the target.

4.4.6 Pedestrian crossing

4.4.6.1 Scenario Description

Under daytime conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall travel straight while the child pedestrian target crosses on a path perpendicular to the VUT path, as shown in Figure 30.

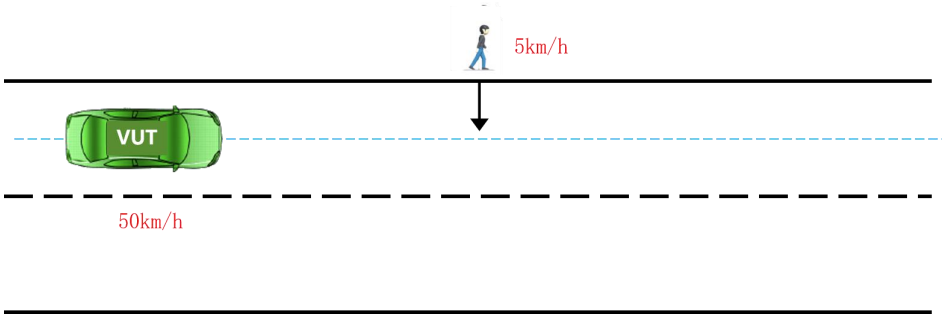

Figure 30 Pedestrian crossing

4.4.6.2 Test Procedure

a) the VUT and target paths are shown in Figure 30;
b) with the DCAS activated, the VUT shall travel along the straight road at a set speed of 50 km/h;

c) the target path shall be perpendicular to the VUT path. The target shall travel at 5 km/h along the specified path, with the collision point at the 50% VUT impact position;

d) the VUT shall reach the specified speed at least 200 m before reaching the target.

4.4.6.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the target.

4.4.7 Pedestrian walking longitudinally at night

4.4.7.1 Scenario Description

Under night-time conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall travel along the straight road while an adult pedestrian target walks ahead in the same direction, as shown in Figure 31.

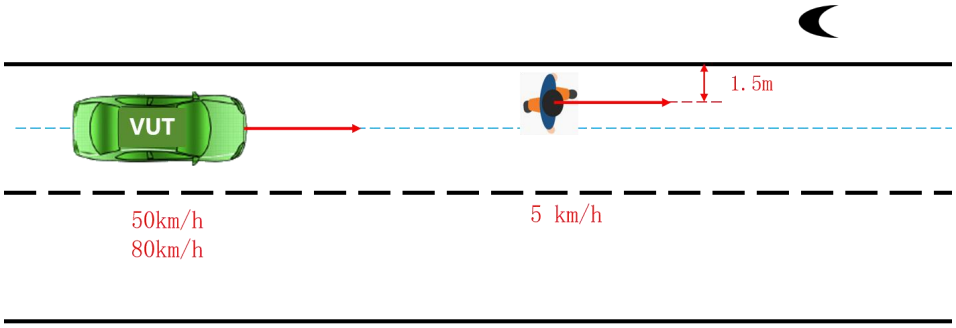

Figure 31 Pedestrian walking longitudinally at night

4.4.7.2 Test Procedure

a) the pedestrian target shall walk steadily in the lane at 5 km/h as shown in Figure 31, with its longitudinal centreline 1.5 m from the left-hand lane marking;

b) with the DCAS activated, the VUT shall travel along the straight road at the specified speed and gradually approach the target ahead after its speed has stabilised.

c) the VUT shall reach the specified speed at least 200 m before reaching the target.

Table 17 Test conditions for a pedestrian walking longitudinally at night

No.	VUT speed (km/h)	Pedestrian speed (km/h)
1	50	5
2	80	5

4.4.7.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the target.

4.4.8 Secondary target vehicle (motorcycle)

4.4.8.1 Scenario Description

Under daytime conditions, the test road shall be a long straight one-way road with at least two lanes. The VUT shall follow the VT steadily. As the VT approaches the motorcycle target, it shall cut out into the adjacent lane, as shown in Figure 32.

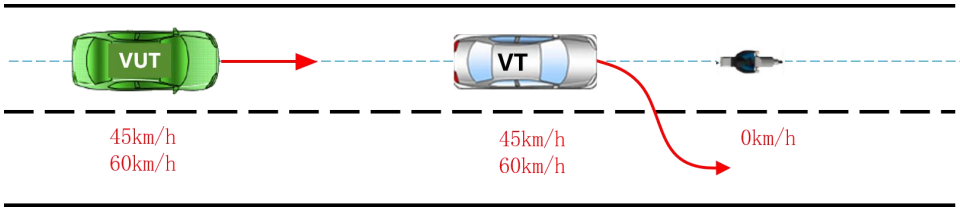

Figure 32 Secondary target vehicle (motorcycle)

4.4.8.2 Test Procedure

a) the motorcycle target shall be stationary in the centre of the lane ahead of the VT;

b) with the DCAS activated, the VUT shall follow the VT steadily along the straight road at the specified speed. When distance D between the VT and motorcycle meets the trigger condition, the VT shall cut out into the adjacent lane along the lane-change path;

c) the VT cut-out path is shown in Figure 33 and its parameters are specified in Table 19;

d) with the DCAS activated, the VUT shall follow the VT steadily along the straight road at the specified speed;

e) when the distance between the VT and motorcycle meets the trigger condition, the VT shall change lanes and cut out into the adjacent lane.

Table 18 Test conditions for a secondary target vehicle (motorcycle)

No.	VUT speed (km/h)	VT speed (km/h)	Motorcycle speed (km/h)	Distance between the VT and motorcycle (m)
1	45	45	0	25
2	60	60	0	34

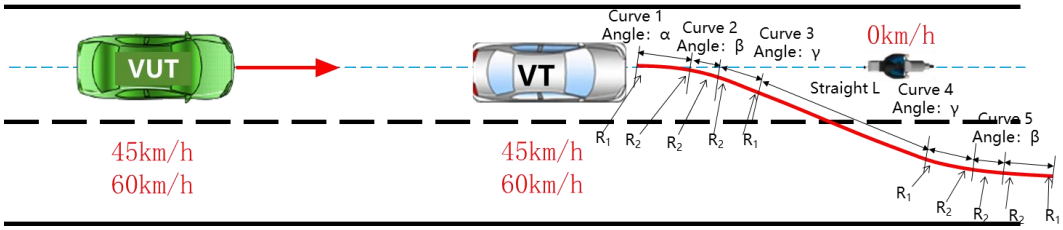

Figure 33 VT cut-out path

Table 19 VT cut-out path parameters

Speed (km/h)		45	60
Curve 1	Start radius R1 (m)	1500	1500
	End radius R2 (m)	150	280
	Angle α (°)	1.5	0.8
Curve 2	Arc radius R2 (m)	150	280
	Angle β (°)	3.8	3.2
Curve 3	Start radius R2 (m)	150	280
	End radius R1 (m)	1500	1500
	Angle γ (°)	1.5	0.8
Straight L	Straight-segment length L (m)	8.6	16.4
Curve 4	Start radius R2 (m)	1500	1500
	End radius R1 (m)	150	280
	Angle γ (°)	1.5	0.8
Curve 5	Arc radius R2 (m)	150	280
	Angle β(°)	3.8	3.2
Curve 6	Start radius R1 (m)	150	280
	End radius R2 (m)	1500	1500
	Angle α (°)	1.5	0.9

4.4.8.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the target.

4.4.9 VUT travelling straight with an oncoming motorcycle turning right

4.4.9.1 Scenario Description

Under daytime conditions, the test road shall contain a four-way intersection with no traffic signals or with signals that remain inactive. The VUT shall travel along the straight road and encounter an oncoming motorcycle target turning right at the intersection, as shown in Figure 34.

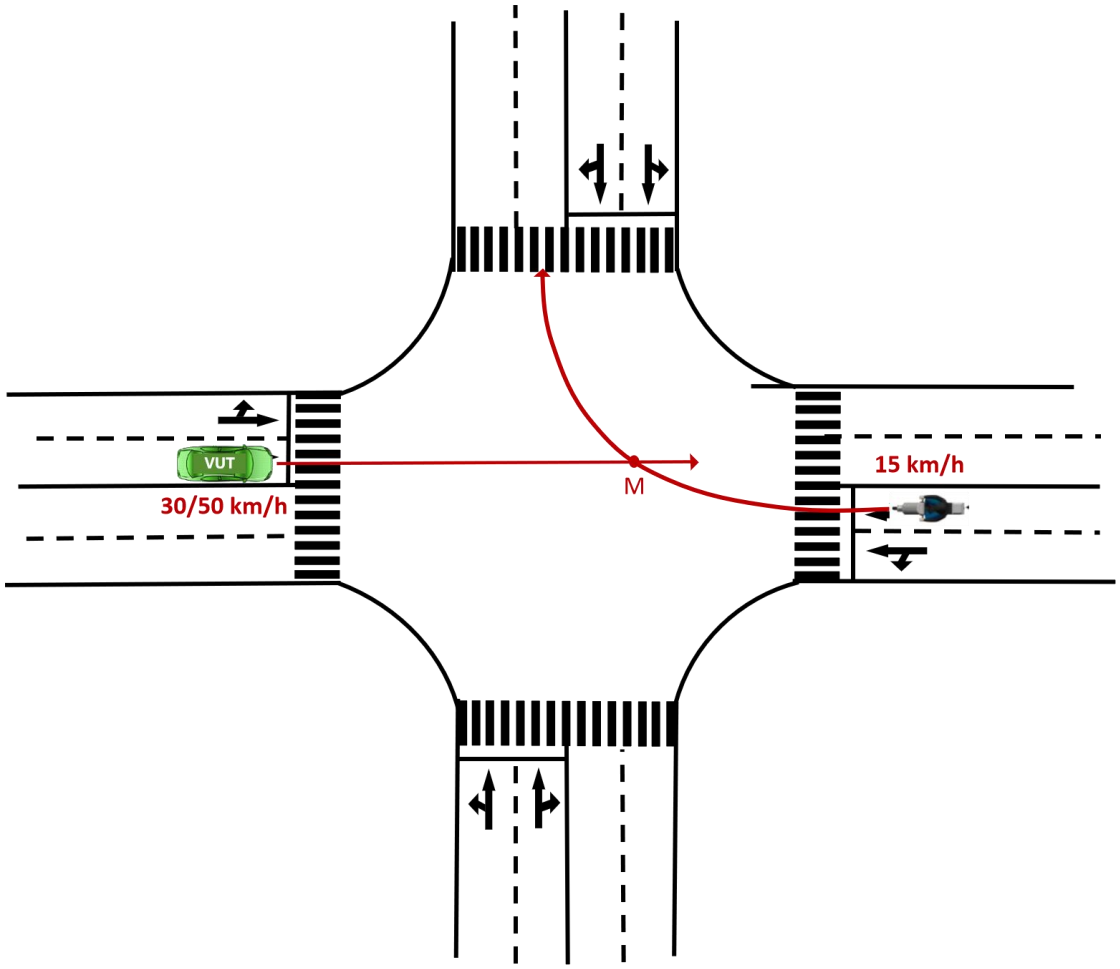

Figure 34 VUT travelling straight with an oncoming motorcycle turning right

4.4.9.2 Test Procedure

a) with the DCAS activated, the VUT shall stabilise at the specified speed at least 150 m before the intersection centre. Three preliminary runs without an oncoming right-turning target shall be conducted; the test collision point shall be the mean of the predicted intersection points between the three VUT paths and the right-turning target path;

b) with the DCAS activated, the VUT shall travel steadily at the specified speed and proceed straight through the intersection. The target shall turn right through the intersection along the specified path at 15 km/h;

c) the target right-turn path is shown in Figure 35 and its parameters are specified in Table 21.

Table 20 Test conditions for the VUT travelling straight with an oncoming motorcycle turning right

No.	VUT speed (km/h)	Motorcycle rider target speed (km/h)
1	30	15
2	50	15

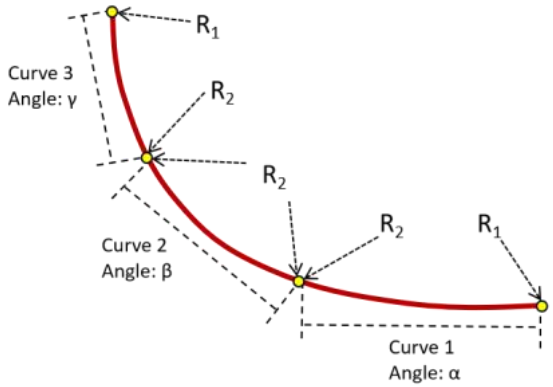

Figure 35 Target right-turn path

Table 21 Target right-turn path parameters

Speed (km/h)	Curve 1			Curve 2			Curve 3		
	Initial radius R1 (m)	Final radius R1 (m)	Angle α(deg)	Initial radius R2 (m)	Final radius R2 (m)	Angle α(deg)	Initial radius R3 (m)	Final radius R3 (m)	Angle α(deg)
15	1500	11.75	20.93	11.75	11.75	48.14	11.75	1500	20.93

4.4.9.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the target.

4.5 Car-to-Obstacle Scenario Test Methods

4.5.1 Cow crossing

4.5.1.1 Scenario Description

Under daytime conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall travel straight while the cow target crosses on a path perpendicular to the VUT path, as shown in Figure 36.

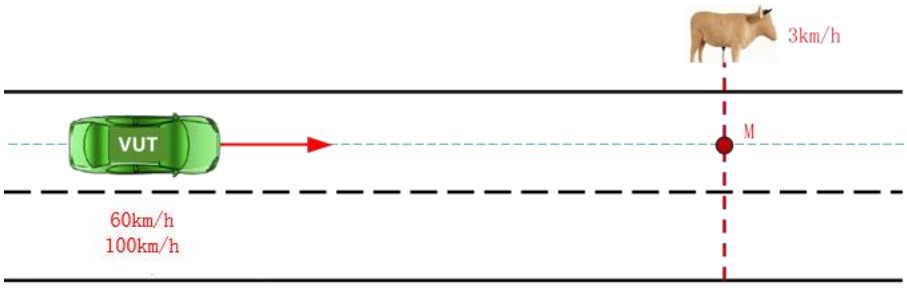

Figure 36 Cow crossing

4.5.1.2 Test Procedure

a) the VUT and target paths are shown in Figure 36;

b) with the DCAS activated, the VUT shall travel along the straight road at the specified speed;

c) the target path shall be perpendicular to the VUT path. The target shall travel at 3 km/h along the specified path, with the collision point at the 50% VUT impact position;

d) the VUT shall reach the specified speed at least 200 m before reaching the target.

Table 22 Cow crossing test conditions

No.	VUT speed (km/h)	Cow target speed (km/h)
1	60	3
2	100	3

4.5.1.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the target.

4.5.2 Wild boar crossing

4.5.2.1 Scenario Description

Under daytime conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall travel straight while the wild boar target crosses on a path perpendicular to the VUT path, as shown in Figure 37.

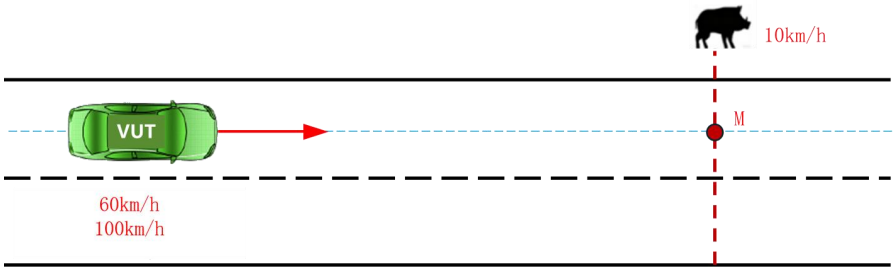

Figure 37 Wild boar crossing

4.5.2.2 Test Procedure

a) the VUT and target paths are shown in Figure 37;

b) with the DCAS activated, the VUT shall travel along the straight road at the specified speed;

c) the target path shall be perpendicular to the VUT path. The target shall travel at 10 km/h along the specified path, with the collision point at the 50% VUT impact position;

d) the VUT shall reach the specified speed at least 200 m before reaching the target.

Table 23 Wild boar crossing test conditions

No.	VUT speed (km/h)	Wild boar target speed (km/h)
1	60	10
2	100	10

4.5.2.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the target.

4.5.3 Secondary collision

4.5.3.1 Scenario Description

Under daytime conditions, the test road shall be a long straight one-way road with at least two lanes separated by a broken line. The VUT shall travel straight towards a fallen scooter rider target and a stationary passenger car target positioned obliquely ahead, as shown in Figure 38.

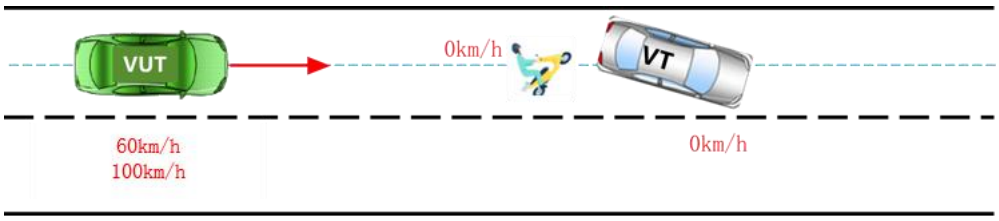

Figure 38 Secondary-collision scenario

4.5.3.2 Test Procedure

a) the fallen scooter rider target and passenger car target shall be positioned stationary ahead in the VUT lane as shown in Figure 38. The projection of the geometric centre of the VT shall lie on the lane centreline, and the angle between the longitudinal centreline of the VT and the lane centreline shall be 30° . The fallen scooter rider target shall be positioned 0.3 m from the rear edge of the VT;

b) with the DCAS activated, the VUT shall travel along the straight road at the specified speed and gradually approach the fallen scooter rider target ahead after its speed has stabilised;

c) the VUT shall reach the specified speed at least 200 m before the targets.

Table 24 Secondary collision test conditions

No.	VUT speed (km/h)	Scooter rider target speed (km/h)	Passenger car VT speed (km/h)
1	60	0	0
2	100	0	0

4.5.3.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with the target.

4.6 Car-to-Road-Infrastructure Scenario Test Methods

4.6.1 Traffic-signal recognition and response

4.6.1.1 Scenario Description

Under daytime conditions, the test road shall be a long straight road with at least one lane and a traffic signal. The VUT shall travel in the centre of the lane towards the signal. The lateral distance between the centreline of the VUT lane and the traffic signal pole shall not exceed 5 m, and the red signal shall remain continuously illuminated, as shown in Figure 39.

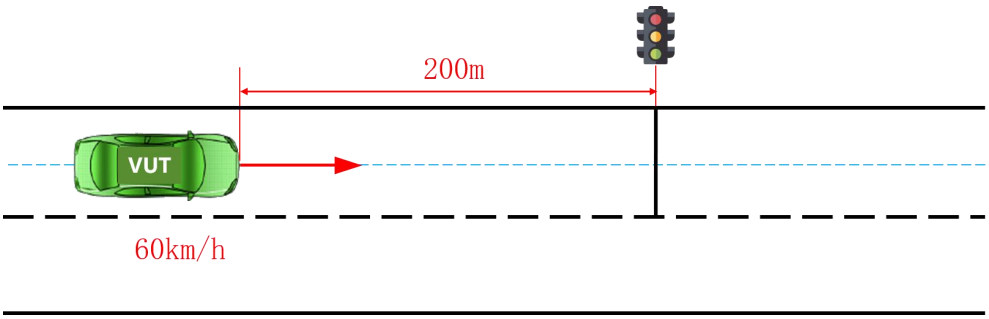

Figure 39 Traffic-signal recognition and response

4.6.1.2 Test Procedure

a) with the DCAS activated, the VUT shall travel steadily at a set speed of 60 km/h and gradually approach the traffic signal;

b) the VUT shall reach the specified speed at least 200 m before the traffic signal.

4.6.1.3 Test Termination Conditions

a) the VUT stops before the stop line;

b) the test run shall end 5 s after the rear of the VUT passes the stop line.

4.6.2 Stop-sign recognition and response

4.6.2.1 Scenario Description

Under daytime conditions, the test road shall be a long straight road with at least one lane and a stop sign. The VUT shall travel in the centre of the lane towards the stop sign. The lateral distance between the centreline of the VUT lane and the stop signpost shall not exceed 5 m, as shown in Figure 40.

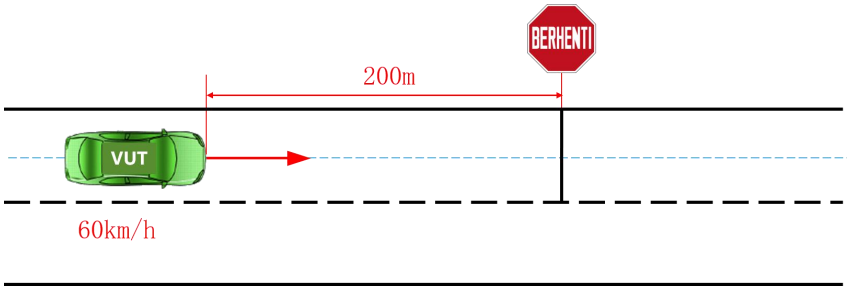

Figure 40 Stop-sign recognition and response

4.6.2.2 Test Procedure

a) one of the three stop signs used in Malaysia, Thailand, and Indonesia shall be selected for testing;

b) with the DCAS activated, the VUT shall travel steadily at a set speed of 60 km/h and gradually approach the stop sign;

c) the VUT shall reach the specified speed at least 200 m before the stop sign.

Table 25 Stop signs used in three countries

No.	Country	Stop sign
1	Malaysia	

No.	Country	Stop sign
2	Thailand	
3	Indonesia	

4.6.2.3 Test Termination Conditions

a) the VUT stops before the stop line;

b) the test run shall end 5 s after the rear of the VUT passes the stop line.

4.6.3 Speed-limit-sign recognition and response

4.6.3.1 Scenario Description

Under daytime conditions, the test road shall be a long straight road with at least one lane and two speed-limit signs positioned 200 m apart. The VUT shall travel in the centre of the lane towards the signs. The lateral distance between the centreline of the VUT lane and each speed-limit signpost shall not exceed 5 m, as shown in Figure 41.

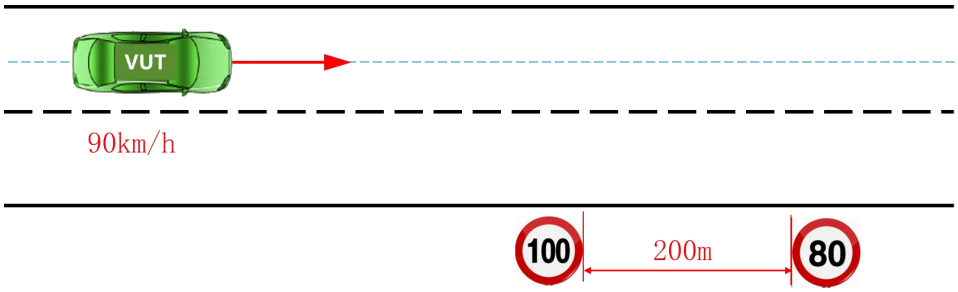

Figure 41 Speed-limit-sign recognition and response

4.6.3.2 Test Procedure

a) with the DCAS activated, the VUT shall travel steadily at a set speed of 90 km/h and gradually approach the first speed-limit sign;

b) after its speed has stabilised, the VUT shall pass the first sign displaying 100 km/h;

c) the VUT shall maintain its original set speed and pass the second sign displaying 80 km/h.

4.6.3.3 Test Termination Conditions

The test run shall end 5 s after the rear of the VUT passes the plane of the second speed-limit sign.

4.6.4 Roadworks-zone navigation

4.6.4.1 Scenario Description

Under daytime conditions, a traffic-cone closure shall be placed ahead in the VUT lane on a long, straight one-way road with at least two lanes, as shown in Figure 42.

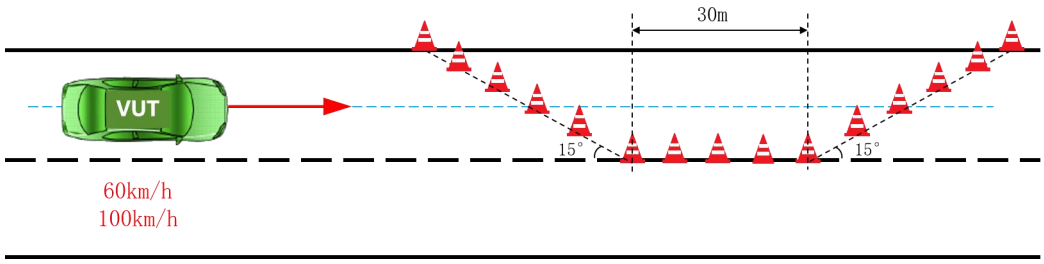

Figure 42 Roadworks-zone navigation

4.6.4.2 Test Procedure

a) the roadworks traffic cones shall be positioned as shown in Figure 42, with a longitudinal spacing of 5 m between adjacent cones;
b) with the DCAS activated, the VUT shall travel in the lane towards the roadworks zone at the specified speed;
c) the VUT shall reach the specified speed at least 200 m before the first traffic cone.

Table 26 Roadworks-zone navigation test conditions

No.	VUT speed (km/h)
1	60
2	100

4.6.4.3 Test Termination Conditions

The test run shall end when the VUT either avoids or collides with a traffic cone.