EURO NCAP

#FORSAFERVANS

Version 1.0
June 2025

Crash Avoidance
Frontal Collisions

Protocol

Implementation January 2026

PREFACE

During the test preparation, vehicle manufacturers are encouraged to liaise with the laboratory and to check that they are satisfied with the way cars are set up for testing. Where a manufacturer feels that a particular item should be altered, they should ask the laboratory staff to make any necessary changes. Manufacturers are forbidden from making changes to any parameter that will influence the test, such as dummy positioning, vehicle setting, laboratory environment etc.

It is the responsibility of the test laboratory to ensure that any requested changes satisfy the requirements of Euro NCAP. Where a disagreement exists between the laboratory and manufacturer, the Euro NCAP secretariat should be informed immediately to pass final judgment. Where the laboratory staff suspect that a manufacturer has interfered with any of the set up, the manufacturer's representative should be warned that they are not allowed to do so themselves. They should also be informed that if another incident occurs, they will be asked to leave the test site.

Where there is a recurrence of the problem, the manufacturer's representative will be told to leave the test site and the Secretary General should be immediately informed. Any such incident may be reported by the Secretary General to the manufacturer and the person concerned may not be allowed to attend further Euro NCAP tests.

DISCLAIMER: Euro NCAP has taken all reasonable care to ensure that the information published in this protocol is accurate and reflects the technical decisions taken by the organisation. In the unlikely event that this protocol contains a typographical error or any other inaccuracy, Euro NCAP reserves the right to make corrections and determine the assessment and subsequent result of the affected requirement(s).

CONTENTS

DEFINITIONS

Throughout this protocol the following terms are used:

Peak Braking Coefficient (PBC) – the measure of tyre to road surface friction based on the maximum deceleration of a rolling tyre, measured using the method as specified in UNECE R13-H.

Vehicle under test (VUT) – means the vehicle tested according to this protocol with a pre-crash collision mitigation or avoidance system on board.

Global Vehicle Target (GVT) – means the vehicle target used in this protocol as defined in ISO 19206-3:2021

Secondary Other Vehicle (SOV) – means the vehicle being overtaken by VUT in VCFhol scenario. This vehicle can either be a GVT or a real vehicle.

Euro NCAP Pedestrian Target (EPTa) – means the articulated adult pedestrian target used in this protocol as specified in ISO 19206-2:2018

Euro NCAP Bicyclist Target (EBTa) – means the adult bicyclist and bike target used in this protocol as specified in ISO 19206-4:2020

Euro NCAP Child Target (EPTc) – means the articulated child pedestrian target used in this protocol as specified in ISO 19206-2:2018

Euro NCAP Motorcyclist Target (EMT) – means the Motorcyclist target used in this protocol as specified in ISO 19206-5.

Real Motorcycle – Means a motorcyclist target that can be used in the Blind-Spot Monitoring Tests of this protocol, as an alternative to the EMT. The Real Motorcycle shall be a type approved two-wheeled motorcycle, with a maximum speed of at least 80km/h by design, without front fairing or windshield. It shall closely resemble the EMT (as specified in section 2.1 of deliverable D2.1 of the MUSE project), thus staying within the mean dimensions of the most registered middleweight naked motorcycles in Europe (i.e. wheelbase >1405mm. and <1445mm.).

Autonomous Emergency Braking (AEB) – braking that is applied automatically by the vehicle in response to the detection of a likely collision to reduce the vehicle speed and potentially avoid the collision.

Forward Collision Warning (FCW) – an audio-visual warning that is provided automatically by the vehicle in response to the detection of a likely collision to alert the driver.

Autonomous Emergency Steering (AES) – steering that is applied automatically by the vehicle in response to the detection of a likely collision to steer the vehicle and potentially avoid the collision.

Emergency Steering Support (ESS) – a system that supports the driver steering input in response to the detection of a likely collision to alter the vehicle path and potentially avoid a collision.

Vehicle width – the widest point of the vehicle ignoring the rear-view mirrors, side marker lamps, tyre pressure indicators, direction indicator lamps, position lamps, flexible mud-guards and the deflected part of the tyre side-walls immediately above the point of contact with the ground.

Van-to-Pedestrian – a collision between a vehicle and an adult or child pedestrian in its path, when no braking and/or steering action is applied.

Van-to-Bicyclist – a collision between a vehicle and an adult bicyclist in its path, when no braking and/or steering is applied.

Van-to-Motorcyclist – a collision between a vehicle and a Motorcyclist in its path, when no braking and/or steering is applied.

T_{AEB} – means the time where the AEB system activates. Activation time is determined by identifying the last data point where the filtered acceleration signal is below -3 m/s^2, and then going back to the point in time where the acceleration first crossed -1 m/s^2

T_{FCW} – means the time where the audible warning of the FCW starts. The starting point is determined by audible recognition.

V_{impact} – means the speed at which the profiled line around the front or rear end of the VUT coincides with the virtual box around the test targets (platform not included in the virtual box) EPTa, EPTc, EBTa and EMT as shown in the right part of the figures below, as illustrated in Figure 0-1 and Figure 0-22.

V_{rel_test} – means the relative speed between the VUT and the test target (GVT, EPT, EBT or EMT) by subtracting the longitudinal velocity of the test target from that of the VUT at the start of test.

V_{rel_impact} – means the relative speed at which the VUT hits the test target (GVT, EPT, EBT or EMT) by subtracting the longitudinal velocity of the test target from V_{impact} at the time of collision.

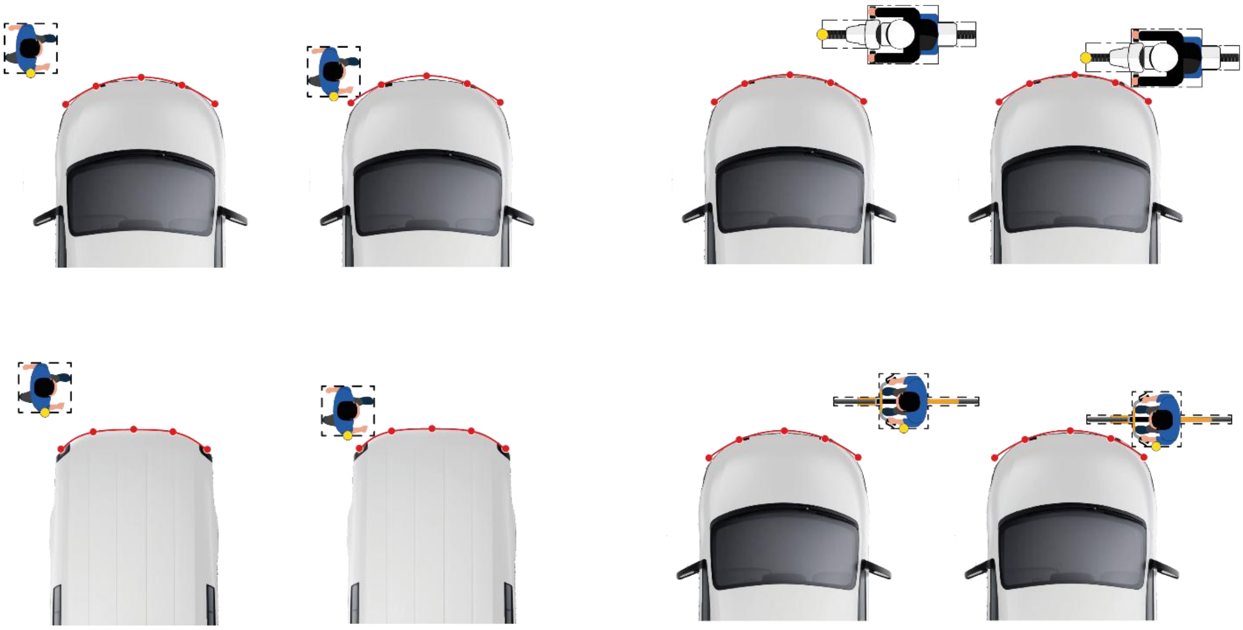


Figure 0-1 :Front end profile vs EPT, EMT, and EBT targets, and rear end profile vs EPT target.

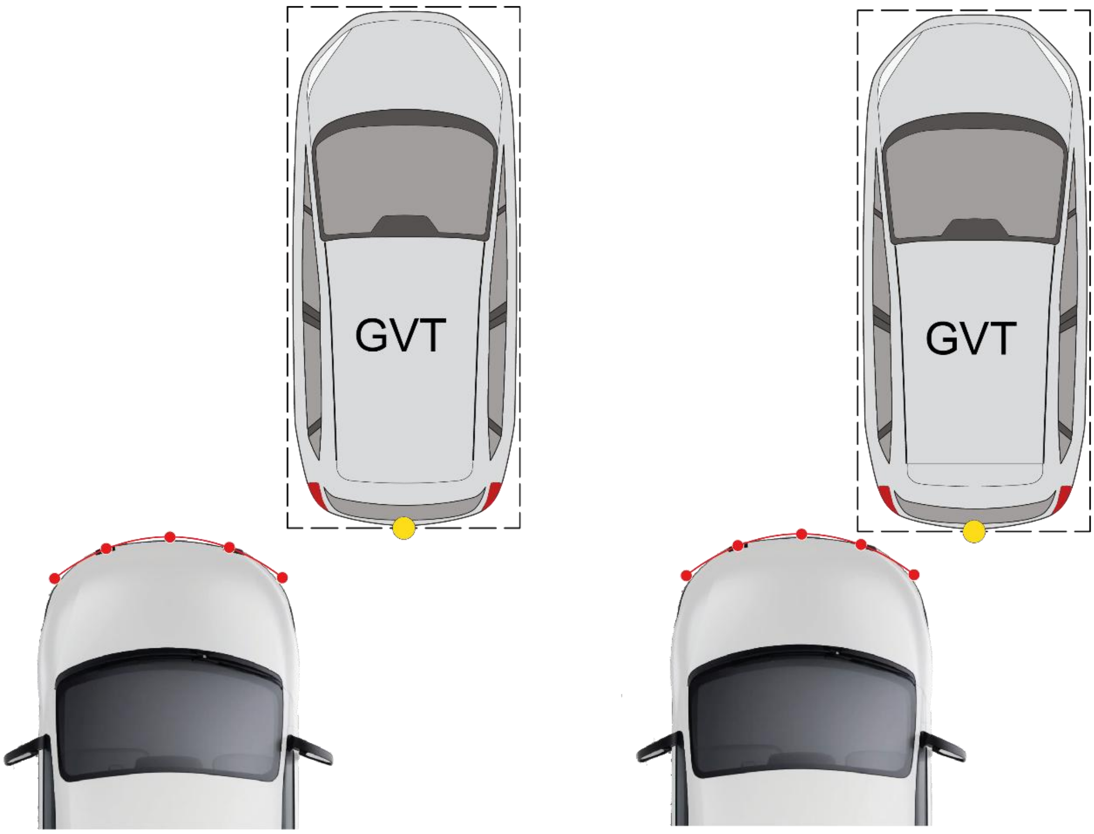


Figure 0-2 Front end profile and GVT

Test Scenarios

Van-to-Pedestrian Farside Adult (VPFA) – a collision in which a vehicle travels forwards towards an adult pedestrian crossing its path running from the farside and the frontal structure of the vehicle strikes the pedestrian when no braking action is applied.

Van-to-Pedestrian Nearside Adult (VPNA) – a collision in which a vehicle travels forwards towards an adult pedestrian crossing its path walking from the nearside and the frontal structure of the vehicle strikes the pedestrian when no braking action is applied.

Van-to-Pedestrian Nearside Child Obstructed (VPNCO) – a collision in which a vehicle travels forwards towards a child pedestrian crossing its path running from behind and obstruction from the nearside and the frontal structure of the vehicle strikes the pedestrian when no braking action is applied.

Van-to-Pedestrian Longitudinal Adult (VPLA) – a collision in which a vehicle travels forwards towards an adult pedestrian walking in the same direction in front of the vehicle where the vehicle strikes the pedestrian when no braking action is applied or an evasive steering action is initiated after an FCW.

Van-to-Pedestrian Longitudinal Adult (VPLA) – a collision in which a vehicle travels forwards towards an adult pedestrian walking in the same direction in front of the vehicle where the vehicle strikes the pedestrian when no braking action is applied.

Van-to-Pedestrian Turning Adult (VPTA) – a collision in which a vehicle turns towards an adult pedestrian crossing its path, walking across a junction (in either the same and opposite direction as the VUT, before the VUT made the turn) and the frontal structure of the vehicle strikes the pedestrian at 50% of the vehicle's width when no braking action is applied.

Van-to-Bicyclist Nearside Adult (VBNA) – a collision in which a vehicle travels forwards towards a bicyclist crossing its path cycling from the nearside and the frontal structure of the vehicle strikes the bicyclist when no braking action is applied.

Van-to-Bicyclist Nearside Adult Obstructed (VBNAO) – a collision in which a vehicle travels forwards towards a bicyclist crossing its path cycling from the nearside from behind an obstruction and the frontal structure of the vehicle strikes the bicyclist when no braking action is applied.

Van-to-Bicyclist Farside Adult (VBFA) – a collision in which a vehicle travels forwards towards a bicyclist crossing its path cycling from the farside and the frontal structure of the vehicle strikes the bicyclist when no braking action is applied.

Van-to-Bicyclist Longitudinal Adult (VBLA) – a collision in which a vehicle travels forwards towards a bicyclist cycling in the same direction in front of the vehicle where the vehicle would strike the cyclist when no braking action is applied or an evasive steering action is initiated after an FCW.

Van-to-Bicyclist Turning Adult (VBTA) – a collision in which a vehicle turns towards a bicyclist crossing its path, cycling in the opposite direction across a junction and the frontal structure of the vehicle strikes the cyclist when no braking action is applied.

Van-to-Motorcyclist Rear Stationary (VMRs) – a collision in which a vehicle travels forwards towards a motorcyclist and the front structure of the vehicle strikes the rear of the motorcycle.

Van-to-Motorcyclist Rear Braking (VMRb) – a collision in which a vehicle travels forwards towards a motorcyclist that is travelling at constant speed and then decelerates, and the frontal structure of the vehicle strikes the rear of the motorcycle.

Van-to-Motorcyclist Front Turn Across Path (VMFtap) – a collision in which a vehicle turns across the path of an oncoming motorcyclist travelling at a constant speed, and the frontal structure of the vehicle strikes the front of the motorcycle.

Van-to-Car Rear Stationary (VCRs) – a collision in which a vehicle travels forwards towards another stationary vehicle and the frontal structure of the vehicle strikes the rear structure of the other.

Van-to-Car Rear Moving (VCRm) – a collision in which a vehicle travels forwards towards another vehicle that is travelling at constant speed and the frontal structure of the vehicle strikes the rear structure of the other.

Van-to-Car Rear Braking (VCRb) – a collision in which a vehicle travels forwards towards another vehicle that is travelling at constant speed and then decelerates, and the frontal structure of the vehicle strikes the rear structure of the other.

Van-to-Car Front Turn-Across-Path (VCFtap) – a collision in which a vehicle turns across the path of an oncoming vehicle travelling at constant speed, and the frontal structure of the vehicle strikes the front structure of the other.

Van-to-Car Crossing Straight Crossing Path (VCCscp) – a collision in which a vehicle travels forwards along a straight path across a junction, towards a vehicle crossing the junction on a perpendicular path. The frontal structure of the vehicle under test strikes the side of the other vehicle.

Van-to-Car Front Head-On Straight (VCFhos) – a collision where a vehicle is travelling along a straight path within its defined lane and strikes another vehicle travelling in the opposite direction, which has drifted into the same lane as the original vehicle. The frontal structure of the vehicle strikes the frontal structure of the other.

Van-to-Car Front Head-On Lane change (VCFhol) – a collision where a vehicle is travelling along a straight path within its defined lane and strikes another vehicle travelling in the opposite direction which has intentionally moved into the lane of the original vehicle to attempt an overtake. The frontal structure of the vehicle strikes the frontal structure of the other.

1 MEASURING EQUIPMENT

1.1 Reference system

Use the convention specified in ISO 8855:2011, with the origin at the most forward point on the centreline of the VUT for dynamic data measurements as shown in Figure 1-1. This reference system should be used for both left- and right-hand drive vehicles. In Figure 1-1 nearside and far-side are shown for a left-hand drive vehicle. For a right-hand drive vehicle, nearside and far-side are swapped.

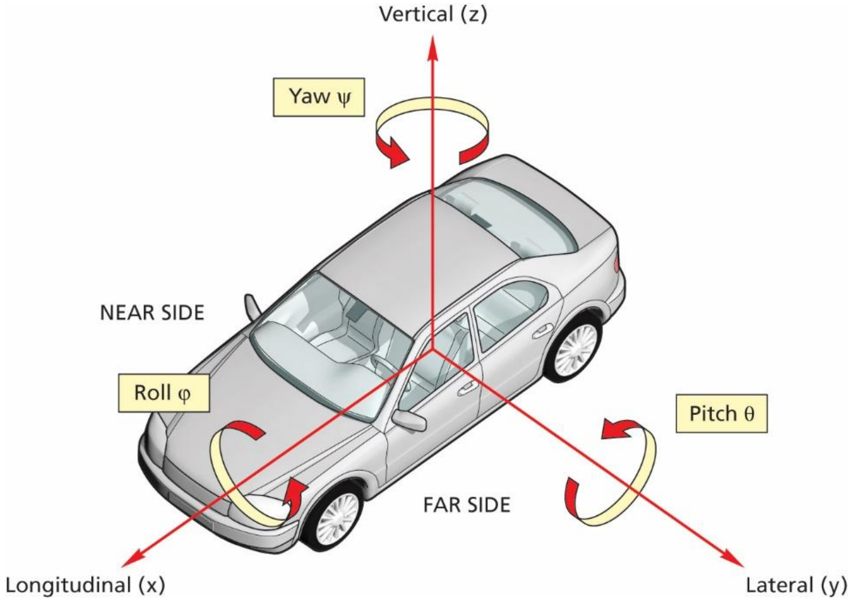


Figure 1-1 Coordinate system and notation

1.2 VUT longitudinal path error

1.2.1 Van-to-Car

The VUT longitudinal path error is determined as the difference between the desired position and the actual position of the front of the VUT when measured at a single defined “stable” position of the front of the GVT during the test.

$$\text{VUT longitudinal path error} = X_{VUT,\ desired} - X_{VUT,\ actual}\ (@X_{GVT})$$

For VCFtap, when the origin of the reference system is at the intended collision point, the values shown in the table below shall be used to determine the VUT longitudinal path error.

VUT speed	Target speed	$X_{VUT,\ desired}$	X_{GVT}
10 km/h	30 km/h		29.17 m
	45 km/h	-9.57 m	43.75 m
	60 km/h		58.33 m
	30 km/h		29.17 m
15 km/h	45 km/h	-14.53 m	43.75 m
	60 km/h		58.33 m
	30 km/h		29.17 m
20 km/h	45 km/h	-19.47 m	43.75 m
	60 km/h		58.33 m

1.2.2 Van-to-Motorcycle

For VMFtap scenario, the VUT longitudinal path error is determined as the difference between the desired position and the actual position of the front of the VUT when measured at a single defined “stable” position of the front of the EMT during the test.

$$\text{VUT longitudinal path error} = X_{VUT,\ desired} - X_{VUT,\ actual}\ (@X_{EMT})$$

When the origin of the reference system is at the intended collision point, the values shown in the table below shall be used to determine the VUT longitudinal path error.

VUT speed	Target speed	$X_{VUT,\ desired}$	X_{EMT}
10 km/h	30 km/h		33.33 m
	45 km/h	-10.66 m	50.00 m
	60 km/h		66.66 m

VUT speed	Target speed	$X_{VUT, desired}$	X_{EMT}
15 km/h	30 km/h 45 km/h 60 km/h	-16.39 m	33.33 m 50.00 m 66.66 m
20 km/h	30 km/h 45 km/h 60 km/h	-22.02 m	33.33 m 50.00 m 66.66 m

1.3 VUT Lateral Path Error

The lateral offset (Y_{VUT}-error) is determined as the lateral distance between the centre of the front axle of the VUT when measured in parallel to the intended path as shown in Figure 1-2 VUT Lateral Path Error.

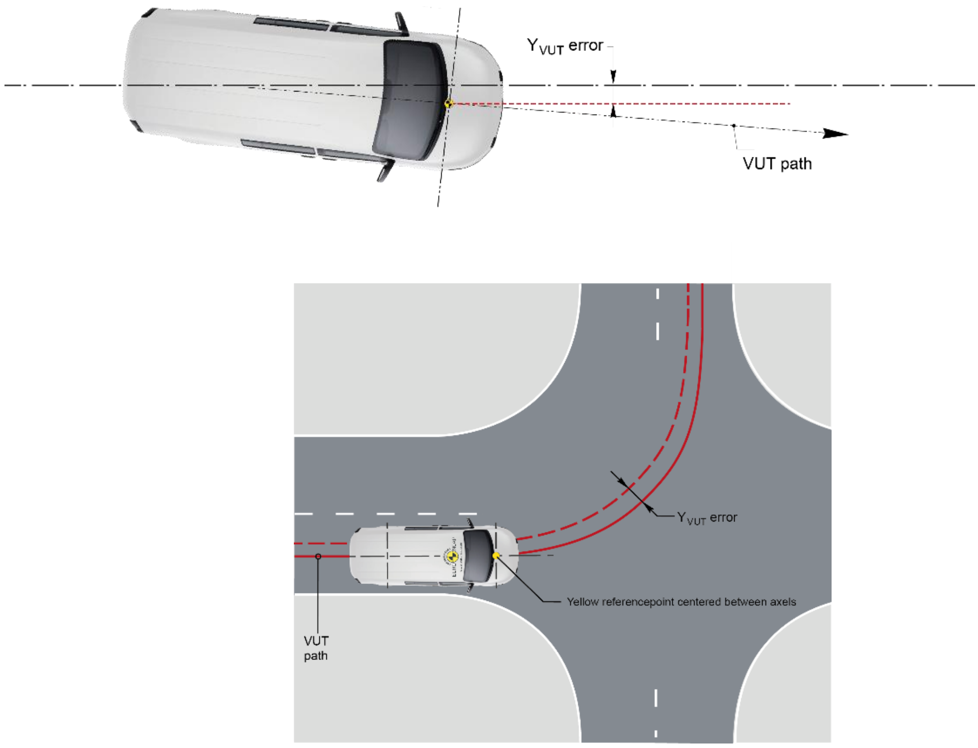
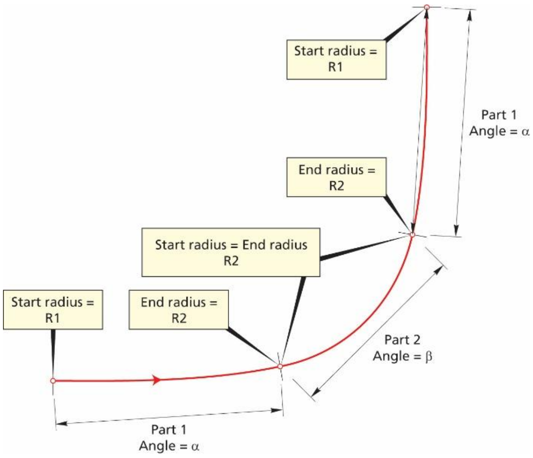


Figure 1-2 VUT Lateral Path Error

1.4 Test paths for turning scenarios

For VPTA, VBTA, VCFtap and VMFtap, the following parameters should be used to create the test paths.

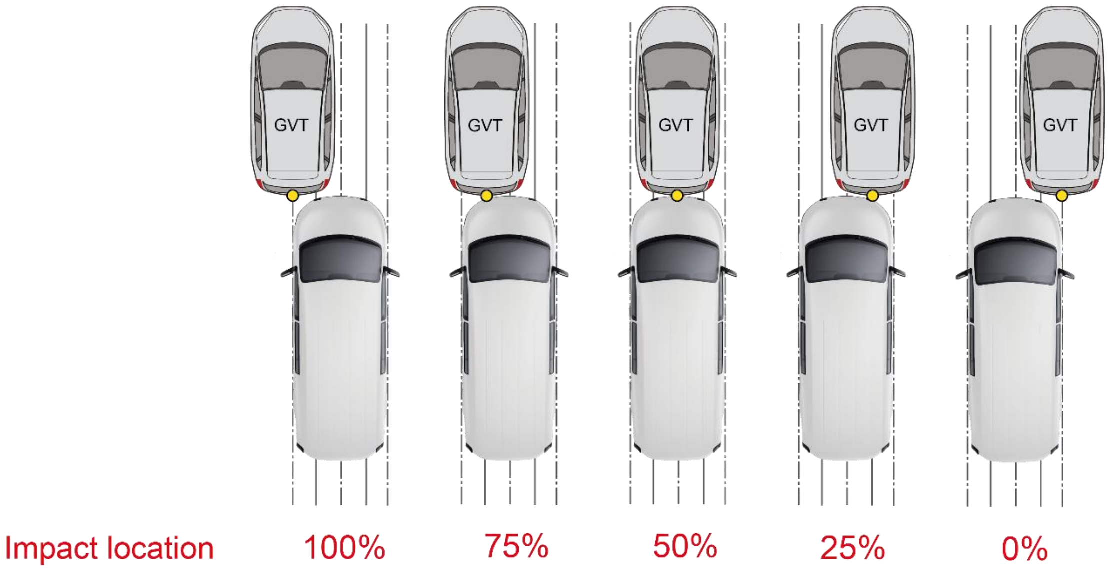


Test Speed	Part 1 (Clothoid)			Part 2 (constant radius)			Part 3 (Clothoid)		
	Start Radius R1 [m]	End Radius R2 [m]	Angle α [deg]	Start Radius R1 [m]	End Radius R2 [m]	Angle β [deg]	Start Radius R2 [m]	End Radius R1 [m]	Angle α [deg]
10 km/h to Farside	1500	9.00	20.62	9.00	9.00	48.75	9.00	1500	20.62
15 km/h to Farside	1500	11.75	20.93	11.75	11.75	48.14	11.75	1500	20.93
20 km/h to Farside	1500	14.75	21.79	14.75	14.75	46.42	14.75	1500	21.79
10 km/h to Nearside	1500	8.00	22.85	8.00	8.00	44.30	8.00	1500	22.85

1.5 Impact location

Impact location is defined as where the reference point of the target coincides with the %-age of the VUT width.

1.5.1 Van-to-Car Rear

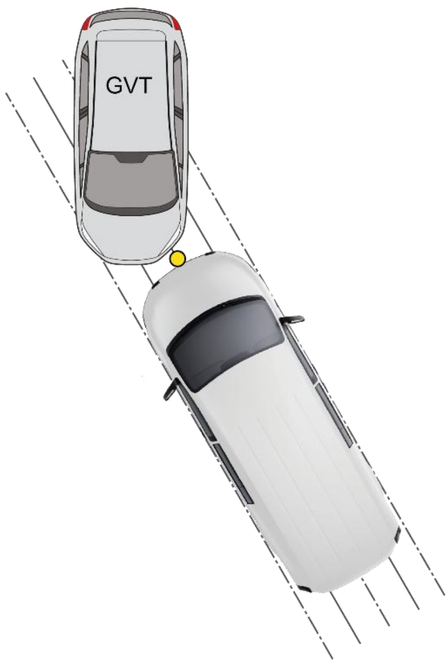


1.5.2 Van-to-Car Front

1.5.3 Van-to-Car Crossing

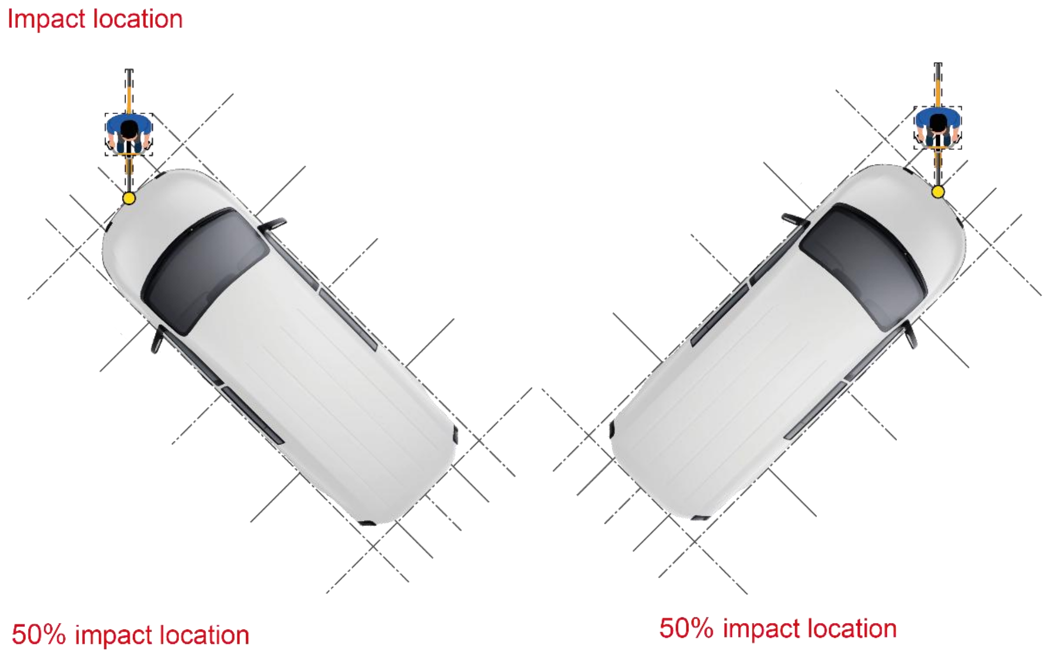
Impact location 50%

1.5.4 Van-to-Car Turn Across Path



Impact location 50%

1.5.5 Van-to-Bicyclist Turning



1.6 Targets

Only equipment listed in the current version of TB029 - Suppliers List may be used for testing. The current version can be found on the Euro NCAP website.

1.6.1 Virtual Boxes

For each test target, a virtual box defined will be used to determine the impact speed. The dimensions of these virtual boxes are shown in the figures below, along with impact reference points related to each test target.

Impact location descriptions in 0 and scenario descriptions in 3 illustrate which of the reference points is to be utilised for each specific scenario.

1.6.1.1 VUT

A virtual profiled line is defined around both the front end and the rear end of the VUT, as well as around the right and left side of the VUT. These lines are defined by straight line segments connecting seven points that are equally distributed over the vehicle width minus 50mm on each side, and over the vehicle length minus 50mm on each side. The theoretical x,y coordinates are provided by the OEMs and verified by the test laboratory.

Figure 1-3 Virtual profiled line around the front end, rear end of the VUT

1.6.1.2 EPTa and EPTc

The dimensions of this virtual box are shown in the figure below, with reference points on the hip and a virtual point where the centreline of the dummy crosses the virtual box.

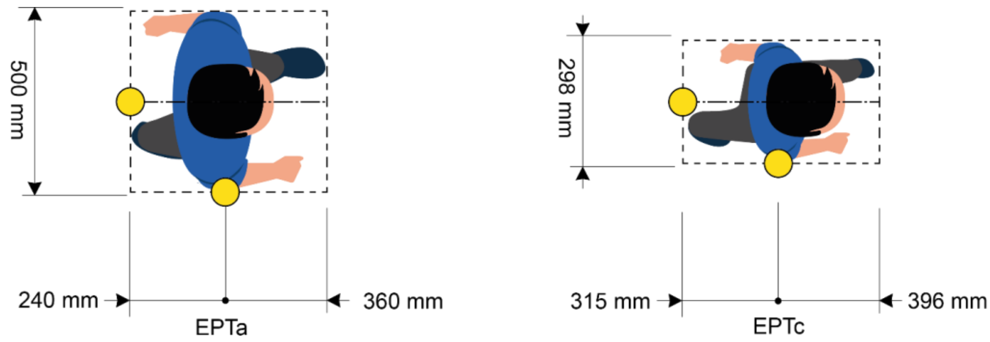


Figure 1.2.1: Virtual box dimensions around EPTa and EPTc

1.6.1.3 EBT

The dimensions of this virtual box are shown in the figure below, with reference points on the crank shaft (applicable to crossing scenarios), most forward point on the front wheel (applicable to turning scenarios) and most rearward point on the rear wheel (applicable to longitudinal scenarios).

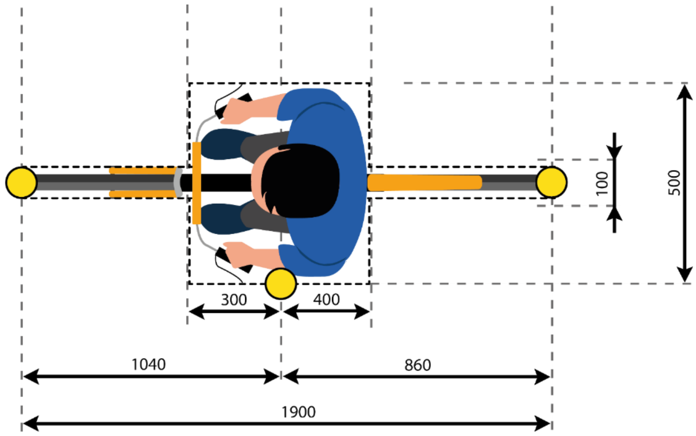


Figure 1.2.2: Virtual box dimensions around EBT

1.6.1.4 EMT

The dimensions of this virtual box are shown in the figure below with reference points on the most forward point on the front wheel (applicable to turning scenarios) and most rearward point on the rear wheel (applicable to longitudinal-rear scenarios).

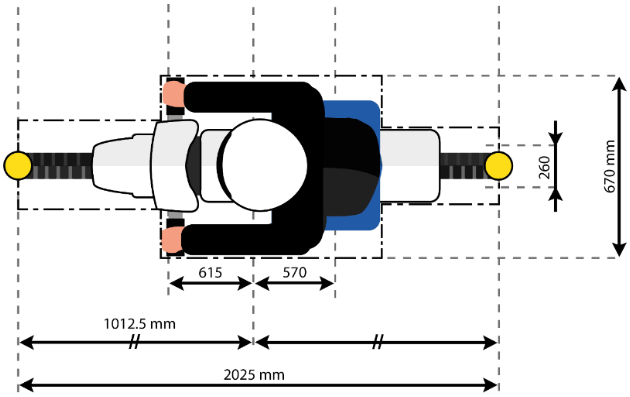


Figure 1.2.3: Virtual box dimensions around EMT

1.6.1.5 GVT

The virtual box of the GVT is shown in the figure below, with reference points on: the most forward point on the front profile (1 in the centre and 1 in the intersection of the front profile and each of the side profiles), the most rearward point on the rear profile (in the centre), and at 75% along the length of each side of the GVT.

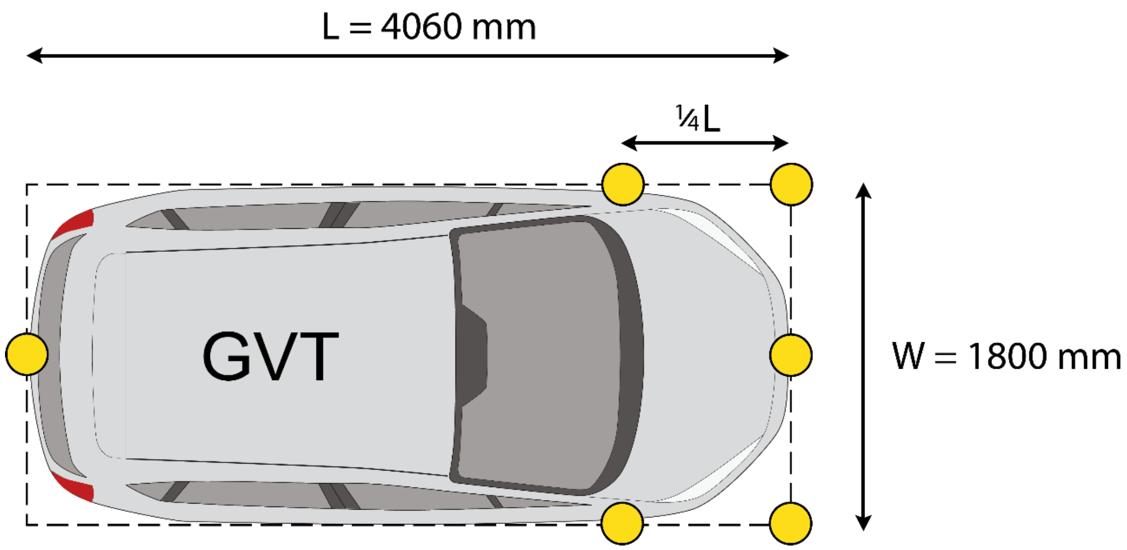


Figure 1.2.4: Virtual box dimensions around the GVT

1.7 Measurements and variables

Sample and record all dynamic data at a frequency of at least 100Hz. Synchronise using the DGPS time stamp the target data with that of the VUT.

1.7.1 Variables

Variable	Description
T	Time
T_0	Time of test start T_0 = TTC 4s, unless stated otherwise - Turning scenarios: $T_0 = T_{steer}$ -1s - Braking scenarios: $T_0 = T_{Target\_deceleration\_start}$ -1s - Crossing scenarios: T_0 = 0.5s after target acceleration phase
T_{AEB}	Time where AEB activates
T_{FCW}	Time where FCW activates
T_{impact}	Time where the VUT impacts the target
T_{steer}	Time where the VUT enters in curve segment
$T_{Target\_deceleration\_start}$	Time where the target starts decelerating
V_{impact}	Speed when the VUT impacts the target
V_{rel_impact}	Relative speed when the VUT impacts the target
X_{VUT}, Y_{VUT}	Position of the VUT during the entire test
V_{VUT}	Speed of the VUT during the entire test
A_{VUT}	Acceleration of the VUT during the entire test
$\dot{\Psi}_{VUT}$	Yaw velocity of the VUT during the entire test
Ω_{VUT}	Steering wheel velocity of the VUT during the entire test
X_{target}, Y_{target}	Position of the target during the entire test
V_{target}	Speed of the target during the entire test
A_{target}	Acceleration of the target during the entire test
$\dot{\Psi}_{target}$	Yaw velocity of the target during the entire test

1.7.2 Measurements

Equip the VUT and GVT with data measurement and acquisition equipment to sample and record data with an accuracy of at least:

- VUT and target speed to 0.1km/h
- VUT and target lateral and longitudinal position to 0.03m
- VUT heading angle to 0.1°
- VUT and target yaw rate to 0.1°/s
- VUT and target longitudinal acceleration to $0.1 m/s^2$
- VUT steering wheel velocity to 1.0 °/s

1.7.3 Data Filtering

Filter the measured data as follows:

- Position and speed are not filtered and are used in their raw state.
- Acceleration, yaw rate, steering wheel velocity and force are filtered with a 12-pole phase less Butterworth filter with a cut off frequency of 10Hz.

2 TEST CONDITIONS

2.1 Test track

Conduct tests on a dry (no visible moisture on the surface), uniform, solid paved surface with a maximum longitudinal slope of ±1% and a maximum lateral slope of ±3%. The test surface shall have a minimal peak braking coefficient (PBC) of 0.9.

The test track surface must be paved and may not contain irregularities (e.g. large dips or cracks, manhole covers or reflective studs) that may give rise to abnormal sensor measurements within a lateral distance of 5.0m to either side of the test path, and with a longitudinal distance of 20m ahead of the VUT when the test ends.

Unless otherwise specified, conduct testing such that, between T_0 and the test end, there are no other vehicles, infrastructure (except lighting columns during the low ambient lighting condition tests), obstructions, other objects or persons which may give rise to abnormal sensor measurements within the visual axis of the VUT and test target, and 20m ahead of the VUT at test end.

The general view ahead and to either side of the test area shall not comprise of any highly reflective surfaces or contain any silhouettes similar in shape to the test target.

2.1.1 Lane Markings

The presence of lane markings is allowed for AEB tests. However, testing may only be conducted in an area where typical road markings depicting a driving lane may not be parallel to the test path within 3.0m either side. Lines or markings may cross the test path but may not be present in the area where AEB activation and/or braking after FCW is expected.

Some scenarios described in this document require the use of a junction, where this is the case the scenario description will illustrate the scenario on a junction as in Figure 4.2. The main approach lane where the VUT path starts, (horizontal lanes in Figure 4.2) will have a width of 3.5m. The side lane (vertical lanes in Figure 4.2) will have a width of 3.25 to 3.5m. The lane markings on these lanes need to conform to one of the lane markings as defined in UNECE Regulation 130:

- Dashed line starting at the same point where the radius transitions into a straight line with a width between 0.10 and 0.15m
- Solid line with a width between 0.10 and 0.25m
- Junction without any central markings

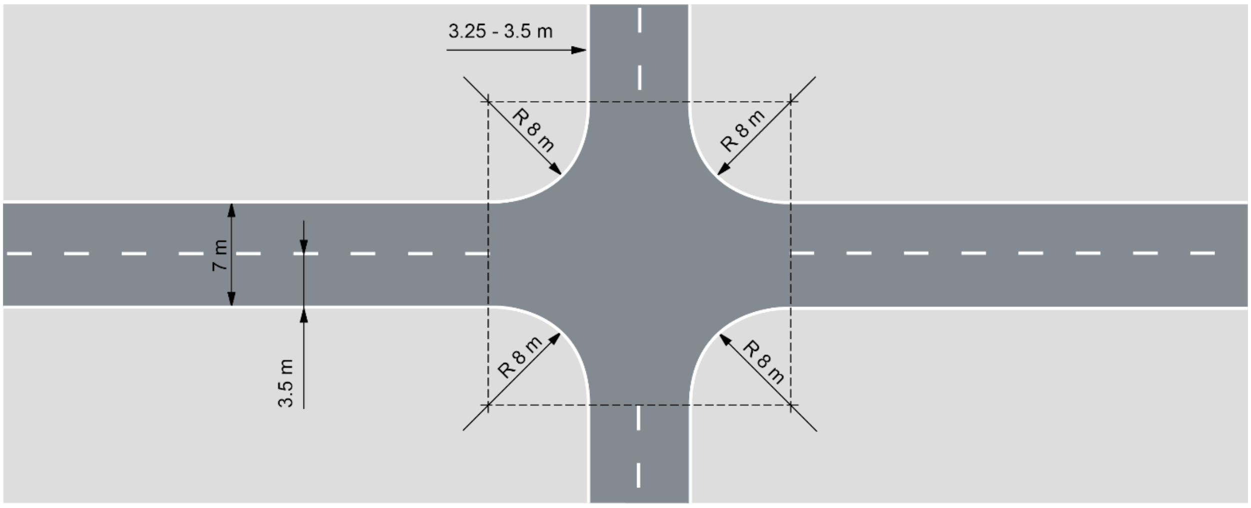


Figure 4.2: Layout of junction and the connecting lanes

2.2 Weather Conditions

Conduct tests in dry conditions with ambient temperature above 5°C and below 40°C.

No precipitation shall be falling and horizontal visibility at ground level shall be greater than 1km. Wind speeds shall be below 10m/s to minimise Target and VUT disturbance.

Natural ambient illumination must be homogenous in the test area and in excess of 2000 lux for daylight testing with no strong shadows cast across the test area other than those caused by the VUT or Target. Ensure testing is not performed driving towards, or away from the sun when there is direct sunlight.

Measure and record the following parameters preferably at the commencement of every single test or at least every 30 minutes:

- Ambient temperature in °C
- Track Temperature in °C
- Wind speed and direction in m/s
- Ambient illumination in Lux

2.3 Surroundings

Conduct testing such that there are no other vehicles, highway infrastructure (except lighting columns during the low ambient lighting condition tests), obstructions, other objects or persons protruding above the test surface, that may give rise to abnormal sensor measurements during the full duration of the test starting at T0 and within a longitudinal distance 20m ahead of the VUT when the test ends, within:

- 5m either side of the VUT test path,
- a circle around the GVT, and
- The visual axis between the geometric centre of the VUT and the circle surrounding the GVT.
- For VCCscp only, the above applies from TTC =3.5s (instead of T0).

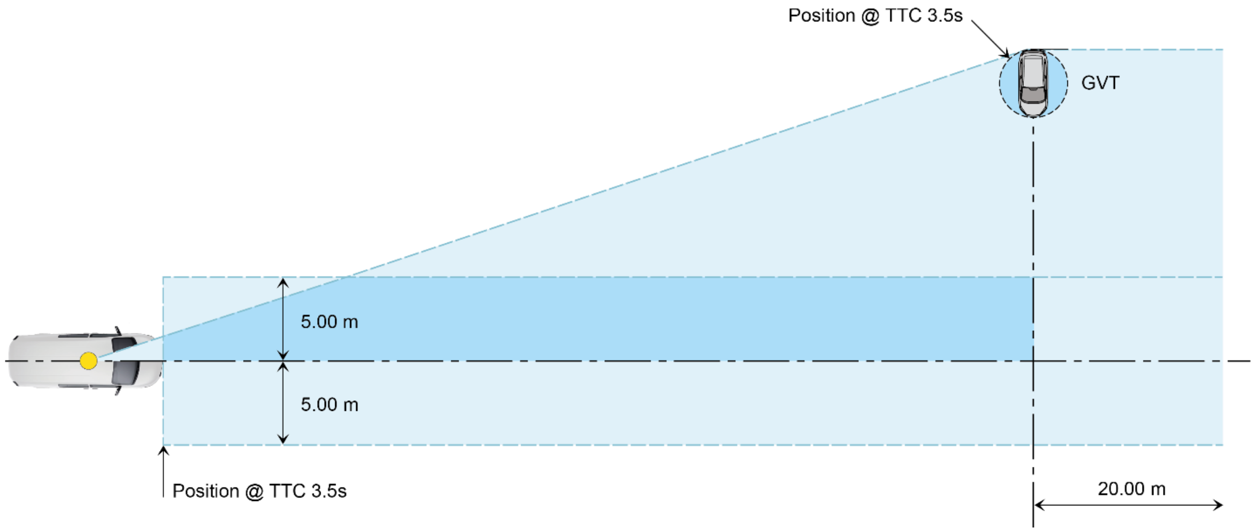


Figure 2-1 Free space requirements – VCCscp Farside Test

Test areas where the VUT needs to pass under overhead signs, bridges, gantries or other significant structures are not permitted.

The general view ahead and to either side of the test area shall comprise of a wholly plain man made or natural environment (e.g. further test surface, plain coloured fencing or hoardings, natural vegetation or sky etc.) and must not comprise any highly reflective surfaces or contain any vehicle-like silhouettes that may give rise to abnormal sensor measurements.

2.4 VUT Preparation

2.4.1 System Settings

Set any driver configurable elements of the AEB and/or FCW system (e.g. the timing of the collision warning or the braking application if present) to the middle setting or midpoint and then next latest setting similar to the examples shown in Figure 4.4.

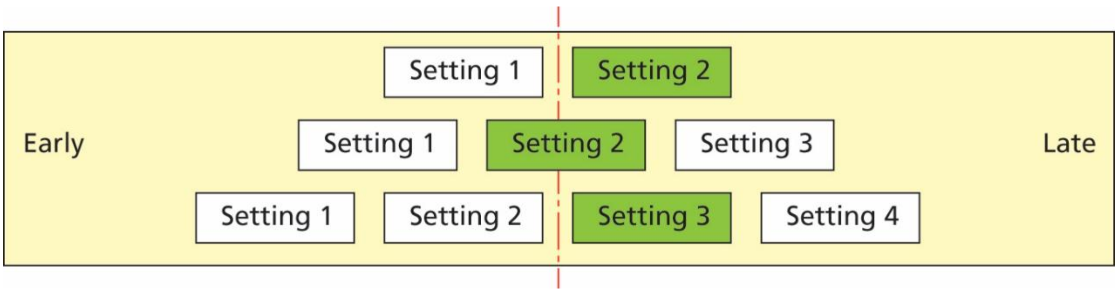


Figure 4.4: AEB and/or FCW system setting for testing

When the vehicle is equipped with a Driver State Monitoring (DSM) which alters the AEB and/or FCW sensitivity according to the driver's state (e.g. distracted / attentive), this system shall be deactivated before the testing commences.

When the vehicle is equipped with a deployable pedestrian/VRU protection system, this system shall be deactivated before the testing commences.

2.4.2 Tyres

Perform the testing with new original fitment tyres of the make, model, size, speed and load rating as specified by the vehicle manufacturer. It is permitted to change the tyres which are supplied by the manufacturer or acquired at an official dealer representing the manufacturer if those tyres are identical make, model, size, speed and load rating to the original fitment. Inflate the tyres to the vehicle manufacturer's recommended cold tyre inflation pressure(s). Use inflation pressures corresponding to least loading normal condition.

Run-in tyres according to the tyre conditioning procedure. After running-in maintain the run-in tyres in the same position on the vehicle for the duration of the testing.

2.4.3 Wheel Alignment Measurement

The vehicle should be subject to a vehicle (in-line) geometry check to record the wheel alignment set by the OEM. This should be done with the vehicle in kerb weight.

2.4.4 Vehicle loading

Complete testing with the vehicle half laden to represent typical N1 operation, with 'as tested' mass as follows:

$$As\ tested\ mass\ =\ Test\ ready\ mass\ +\ ((GVW - Test\ ready\ mass)/2)$$

With 'test ready' mass being:

$$Test\ ready\ mass\ =\ Unladen\ kerb\ mass\ +\ Interior\ load$$

And with 'interior load' being:

$$Interior\ load\ =\ 200kg\ =\ Driver\ +\ test\ equipment\ +\ additional\ required\ ballast$$

The procedure to prepare the van for the load requirements will be followed according to below steps:

a. Fill up the tank with fuel to at least 90% of the tank's capacity of fuel.
b. Check the oil level and top up to its maximum level if necessary. Similarly, top up the levels of all other fluids to their maximum levels if necessary.
c. Ensure that the vehicle has its spare wheel on board, if fitted, along with any tools supplied with the vehicle. Nothing else should be in the van.
d. Ensure that all tyres are inflated according to the manufacturer's instructions for the appropriate loading condition.
e. Measure the front and rear axle masses and determine the total mass of the vehicle. The total mass is the 'unladen kerb mass' of the vehicle. Record this mass in the test details.

f. Fit the test equipment in the vehicle (i.e. on-board test equipment and instrumentation , associated cables, cabling boxes and power sources).
g. With the driver and test equipment in the vehicle, weigh the vehicle. Record the driver + test equipment mass by subtracting the new measured mass to the initially measured unladen kerb mass.
h. Calculate the 'additional required ballast' by subtracting the mass of the driver and test equipment from the required 200kg interior load.
i. If applicable, place weights with a mass of the 'additional required ballast'. Any items added should be securely attached to the interior of the vehicle.
j. Compare these loads with the 'unladen kerb mass'.
k. Add additional ballast in the cargo space to increase the 'test ready' mass to 'as tested' mass, with an overall tolerance of ±1%. Locate the centre of mass of the ballast centrally within the cargo space (longitudinally, laterally and vertically) as far as is as practically possible. If the vertical limit of the cargo space is undefined (e.g. in the case of a flatbed or tipping body) locate the centre of mass of the ballast [0.6]m above the load bed. Ballast must be securely attached to the VUT. If water is used as ballast, it should be used in full containers to prevent the movement under acceleration.
l. Note the 'as tested' front/rear axle load distribution may not necessarily remain within 5% of the front/rear axle load distribution of the original 'unladen kerb mass', which is acceptable for this testing.

Care needs to be taken when adding or removing weight in order to approximate the original vehicle inertial properties as close as possible. Record the final axle loads in the test details. Record the axle weights of the VUT in the 'as tested' condition.

3 TEST PROCEDURE

Each scenario in this assessment consists of a matrix combining vehicle longitudinal speeds, and ranges of impact locations or target longitudinal speeds. Each combination in a matrix is referred to as grid cell. The total scenario scores and number of grid cells per scenario is indicated in the chapters below. T

3.1 Car & PTW Scenarios

Car & PTW Scenarios	Points	Total 40
Longitudinal		**20.0**
Van-to-Car Rear	10.0	
Van-to-Car Front	5.0	
Van-to-Motorcycle Rear	5.0	
Turning		**10.0**
Van-to-Car Turn Across Path	5.0	
Van-to-Motorcycle Turn Across Path	5.0	
Crossing		**10.0**
Van-to-Car Crossing	10.0	

3.1.1 Longitudinal

Longitudinal	Points	Total 20
Van-to-Car-Rear		**10.0**
VCRs	2.5	
VCRm	4.5	
VCRb	3.0	
Van-to-Car-Front		**5.0**
VCFhos	2.5	
VCFhol	2.5	
Van-to-Motorcycle Rear		**5.0**
VMRs	2.5	
VMRb	2.5	

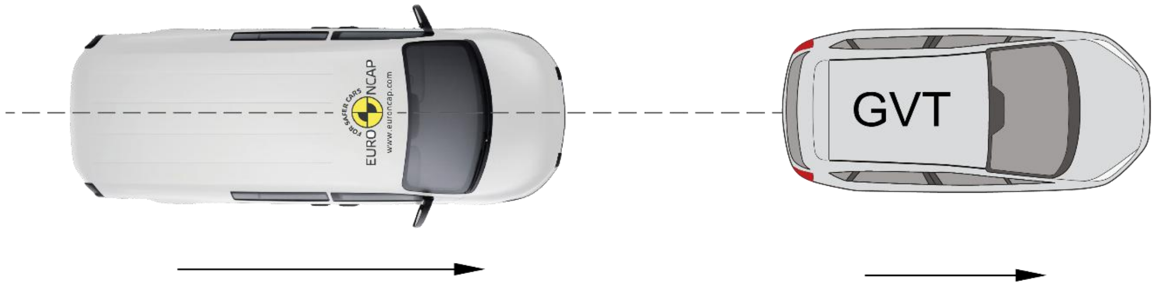
3.1.1.1 Van-to-Car Rear

The Vehicle Manufacturer shall inform Euro NCAP whether the FCW cases are to be verified with FCW or AEB. Where the AEB system is able to avoid the collision in the FCW cases, the points are automatically awarded for the corresponding FCW test.

VCRs	GVT speed	Function	Impact Location				
			100%	75%	50%	25%	0%
10 km/h	0 km/h	AEB					
15 km/h	0 km/h	AEB					
20 km/h	0 km/h	AEB					
25 km/h	0 km/h	AEB					
30 km/h	0 km/h	AEB					
35 km/h	0 km/h	AEB					
40 km/h	0 km/h	AEB					
45 km/h	0 km/h	AEB					
50 km/h	0 km/h	AEB					
55 km/h	0 km/h	FCW					
60 km/h	0 km/h	FCW					
65 km/h	0 km/h	FCW					
70 km/h	0 km/h	FCW					
75 km/h	0 km/h	FCW					
80 km/h	0 km/h	FCW					

VCRm	GVT speed	Function	Impact Location				
			100%	75%	50%	25%	0%
30 km/h	20 km/h	AEB					
35 km/h	20 km/h	AEB					
40 km/h	20 km/h	AEB					
45 km/h	20 km/h	AEB					
50 km/h	20 km/h	AEB					
55 km/h	20 km/h	AEB					
60 km/h	20 km/h	AEB					
65 km/h	20 km/h	AEB					
70 km/h	20 km/h	AEB					
75 km/h	20 km/h	AEB					
80 km/h	20 km/h	AEB					

VCRb	GVT speed	Function	Headway	Acceleration	Impact Location
					50%
50 km/h	50 km/h	AEB	12	-2m/s²	
50 km/h	50 km/h	AEB	12	-6 m/s²	
50 km/h	50 km/h	AEB	40	-2m/s²	
50 km/h	50 km/h	AEB	40	-6 m/s²	



The desired deceleration of the GVT shall be reached within 1.0 second (T_0 + 2.0s) which after the GVT shall remain within ± 0.5 km/h of the reference speed profile, derived from the desired deceleration, until the vehicle speed equals 2km/h.

3.1.1.2 Van-to-Car Front

VCFhos	GVT speed	Impact Location
		50%
50 km/h	50 km/h	
70 km/h	70 km/h	

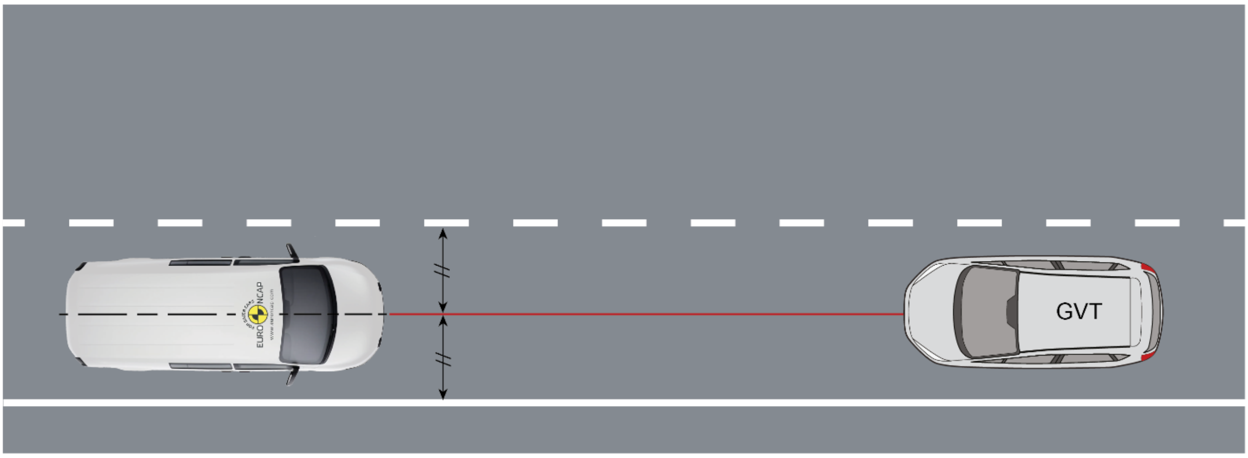


Figure 3-1 VCFhos

VCFhol	GVT speed	Impact Location
		50%
50 km/h	50 km/h	
70 km/h	70 km/h	

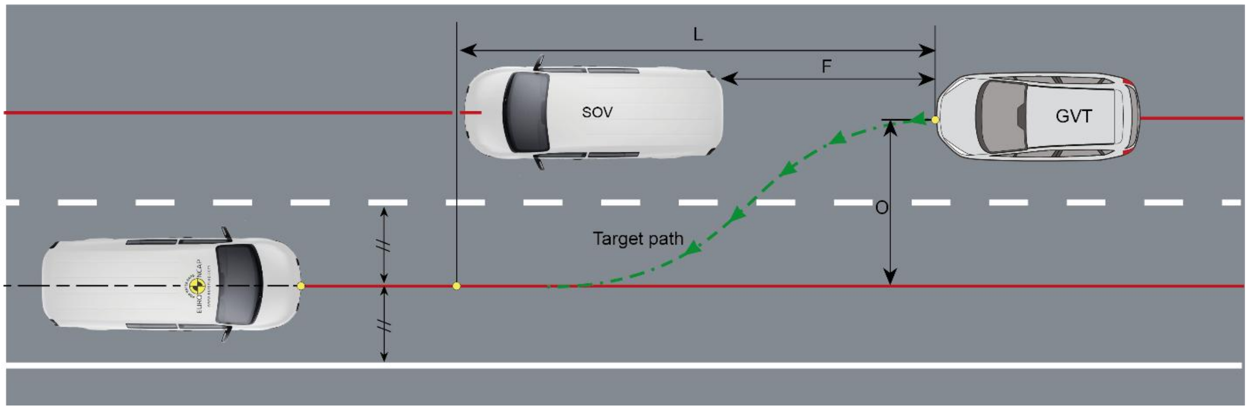


Figure 3-2 VCFhol

Below table indicates the parameters of the VCFhol test cases.

GVT & SOV speed	Lane change offset (O)	Curvature (1/m)	Lane change length (L)	Following Distance (F)	TTC at end of lane change	Max Lateral acceleration
50 km/h	3.5 m	0.0076	44 m	[13.9] m	[1.5] s	1.50 m/s²
70 km/h	3.5 m	0.0039	60 m	[19.4] m	[1.5] s	1.50 m/s²

3.1.1.3 Van-to-Motorcyclist Rear

The Vehicle Manufacturer shall inform Euro NCAP whether the FCW cases are to be verified with FCW or AEB. Where the AEB system is able to avoid the collision in the FCW cases, the points are automatically awarded for the corresponding FCW test. If AEB avoids impact, FCW points are awarded automatically.

VMRs	EMT speed	Function	Impact Location
			50%
10 km/h	0 km/h	AEB	
15 km/h	0 km/h	AEB	
20 km/h	0 km/h	AEB	
25 km/h	0 km/h	AEB	
30 km/h	0 km/h	AEB	
35 km/h	0 km/h	AEB	
40 km/h	0 km/h	AEB	
45 km/h	0 km/h	AEB	
50 km/h	0 km/h	AEB	
55 km/h	0 km/h	AEB	
60 km/h	0 km/h	AEB	
30 km/h	0 km/h	FCW	
35 km/h	0 km/h	FCW	
40 km/h	0 km/h	FCW	
45 km/h	0 km/h	FCW	
50 km/h	0 km/h	FCW	
55 km/h	0 km/h	FCW	
60 km/h	0 km/h	FCW	

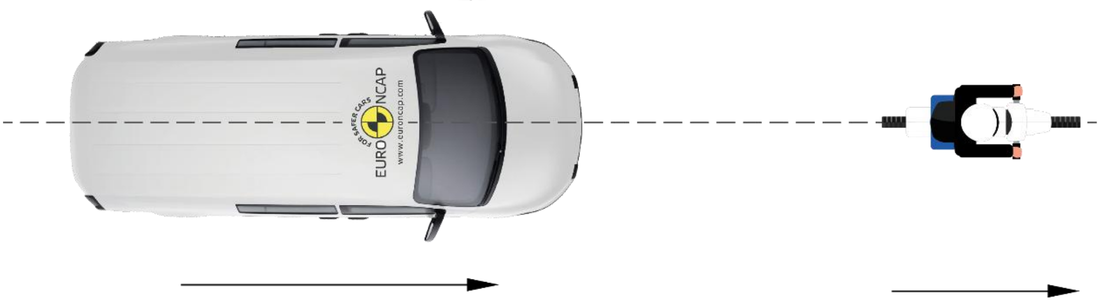


Figure 3-3 VMRs scenario

VMRb	GVT speed	Function	Headway	Acceleration	Impact Location
					25%
50 km/h	50 km/h	AEB	12	-4 m/s²	
50 km/h	50 km/h	AEB	40	-4 m/s²	
50 km/h	50 km/h	FCW	12	-4 m/s²	
50 km/h	50 km/h	FCW	40	-4 m/s²	

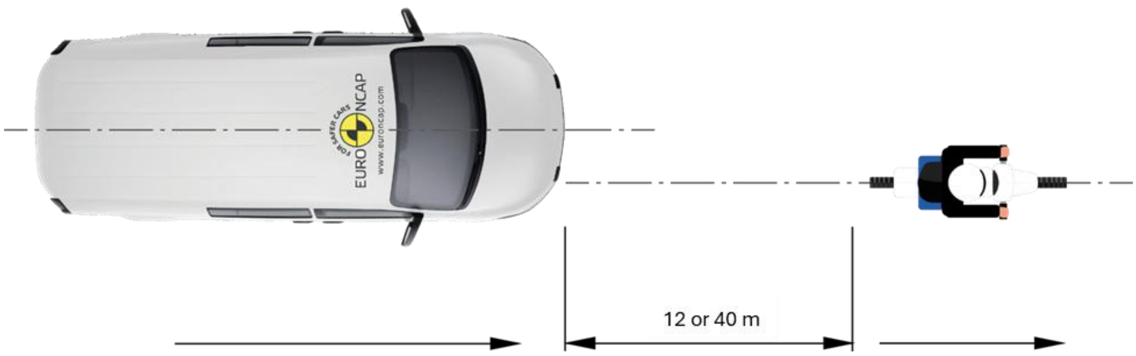


Figure 3-4 VMRb scenario, representing the 25% impact location

The desired deceleration of the EMT shall be reached within 1.0 second (T0 + 2.0s) which after the EMT shall remain within ± 0.5 km/h of the reference speed profile, derived from the desired deceleration, until the vehicle speed equals 2km/h.

3.1.2 Turning

Turning	Points	Total
Van-to-Car Front TAP	5.0	**5.0**
Van-to-Motorcycle Front TAP	5.0	**5.0**

3.1.2.1 Van-to-Car Front Turn Across Path

VCFtap	GVT speed		
	30 km/h	45 km/h	60 km/h
10 km/h			
15 km/h			
20 km/h			

For the VCFtap scenario, for the VUT assume an initial straight-line path followed by a turn (clothoid, fixed radius and clothoid as specified in section 0), followed again by a straight line, hereby known as the test path. The direction indicator is applied at 1.0s ± 0.5s before T_{steer}.

The GVT will follow a straight-line path in the lane adjacent to the VUT's initial position, in the opposite direction to the VUT. The straight-line path of the VUT and GVT will be 1.75m from the centre of the centre dashed lane marking of the VUT lane.

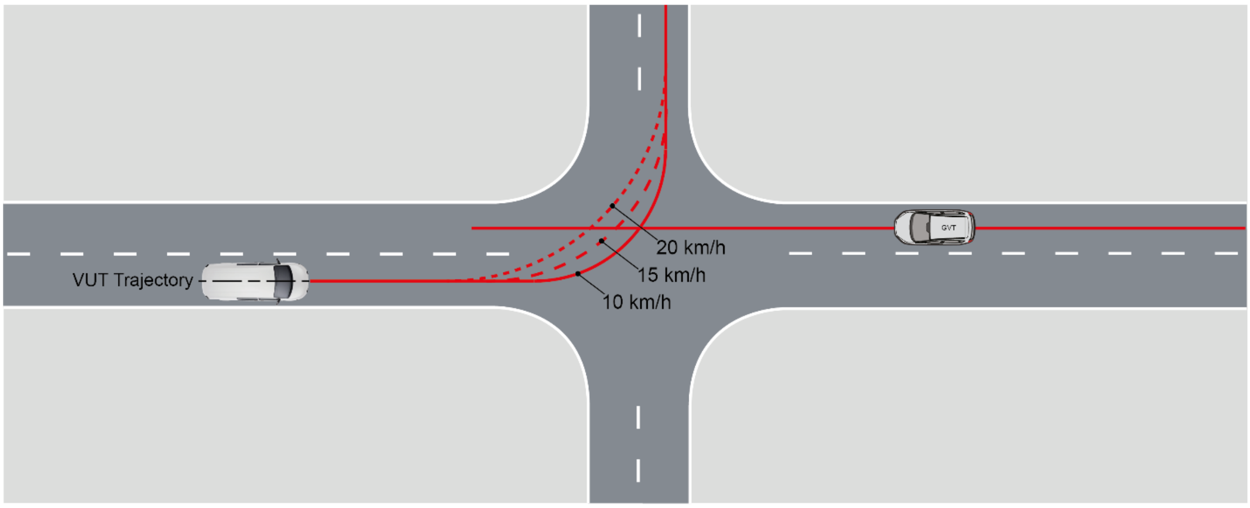


Figure 3-5 VCFtap scenario VUT and GVT paths

The paths of the VUT and target vehicle will be synchronised so that the front edges of the target meets the 50% impact location (assuming no system reaction) of the width of the VUT. The VUT longitudinal path error shall be within ± [0.5] m when determined in accordance with section 0.

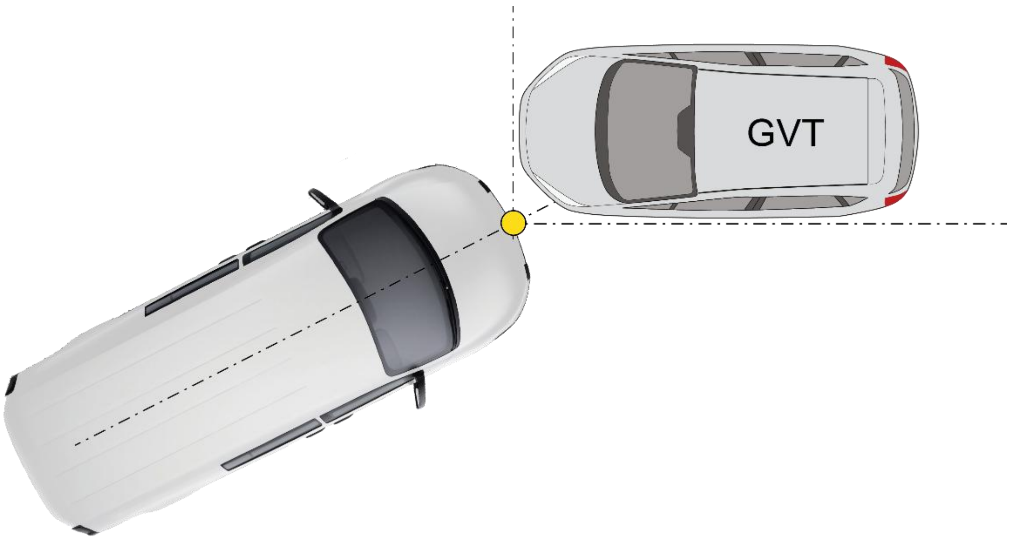


Figure 3-6 VCFtap impact location definition

3.1.2.2 Van-to-Motorcyclist Front Turn Across Path

VMFtap	GVT speed		
	30 km/h	45 km/h	60 km/h
10 km/h			
15 km/h			
20 km/h			

For the VMFtap scenario, for the VUT assume an initial straight-line path followed by a turn (clothoid, fixed radius and clothoid as specified in section 0), followed again by a straight line, hereby known as the test path. The direction indicator is applied at 1.0s ± 0.5s before T_{steer}.

The EMT will follow a straight-line path in the lane adjacent to the VUT's initial position, in the opposite direction to the VUT. The straight-line path of the VUT and target will be 1.75m from the centre of the centre dashed lane marking of the VUT lane.

The paths of the VUT and EMT will be synchronised so that the front wheel of the target meets the 50% impact location (assuming no system reaction) of the width of the VUT. The VUT longitudinal path error shall be within ± [0.5] m when determined in accordance with section 0

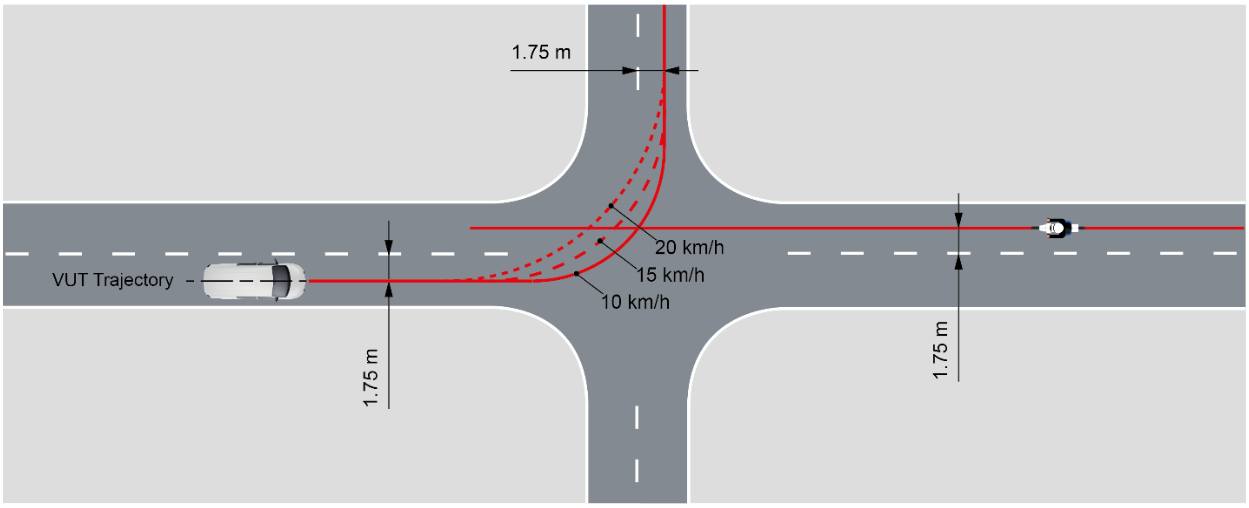


Figure 3-7 VMFtap scenario VUT and EMT paths

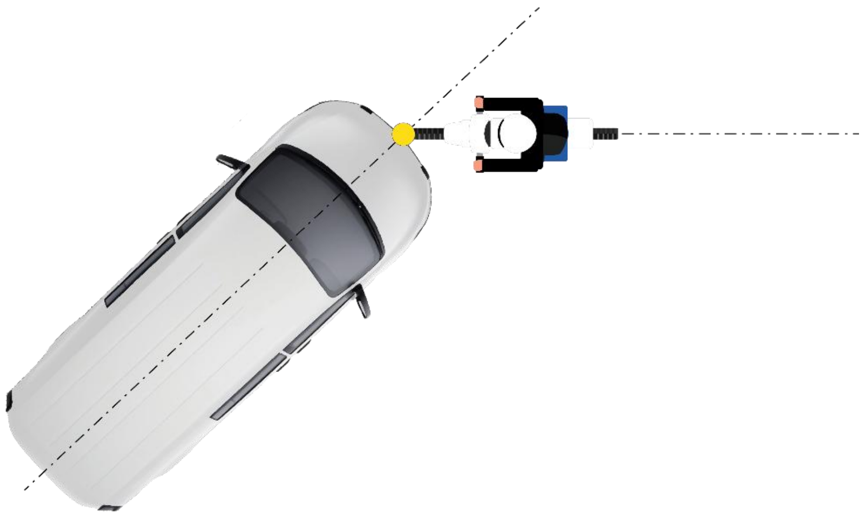


Figure 3-8 VMFtap impact location definition

3.1.3 Crossing

Crossing	Points	Total
Van-to-Car	10.0	**10.0**

3.1.3.1 Van-to-Car Crossing

VCCscp	Function	GVT speed				
		20 km/h	30 km/h	40 km/h	50 km/h	60 km/h
20 km/h	AEB					
30 km/h	AEB					
40 km/h	AEB/FCW					
50 km/h	AEB/FCW					
60 km/h	AEB/FCW					

For the VUT assume a straight-line path equivalent to the centre line of the driving lane, approaching and continuing straight ahead across a junction.

For the GVT assume a straight-line path equivalent to the centre line of the driving lane, perpendicular to that of the VUT, travelling across the junction from either the nearside or farside direction, randomly selected by the test laboratory.

To achieve the correct GVT speed, the GVT must be accelerated at a rate >1m/s^2 during the acceleration phase. This is followed by a 0.5s stabilization phase, after which steady state conditions must be met as soon as the GVT has arrived in the field of vision of the VUT, corresponding to [3.5]s TTC.

The paths will be synchronised to that (assuming no system reaction) the reference point of the GVT collides with 50% impact location of the VUT, as indicated in Figure 3-10. The boundary condition for synchronization is a VUT Time Error of ±[0.1]s.

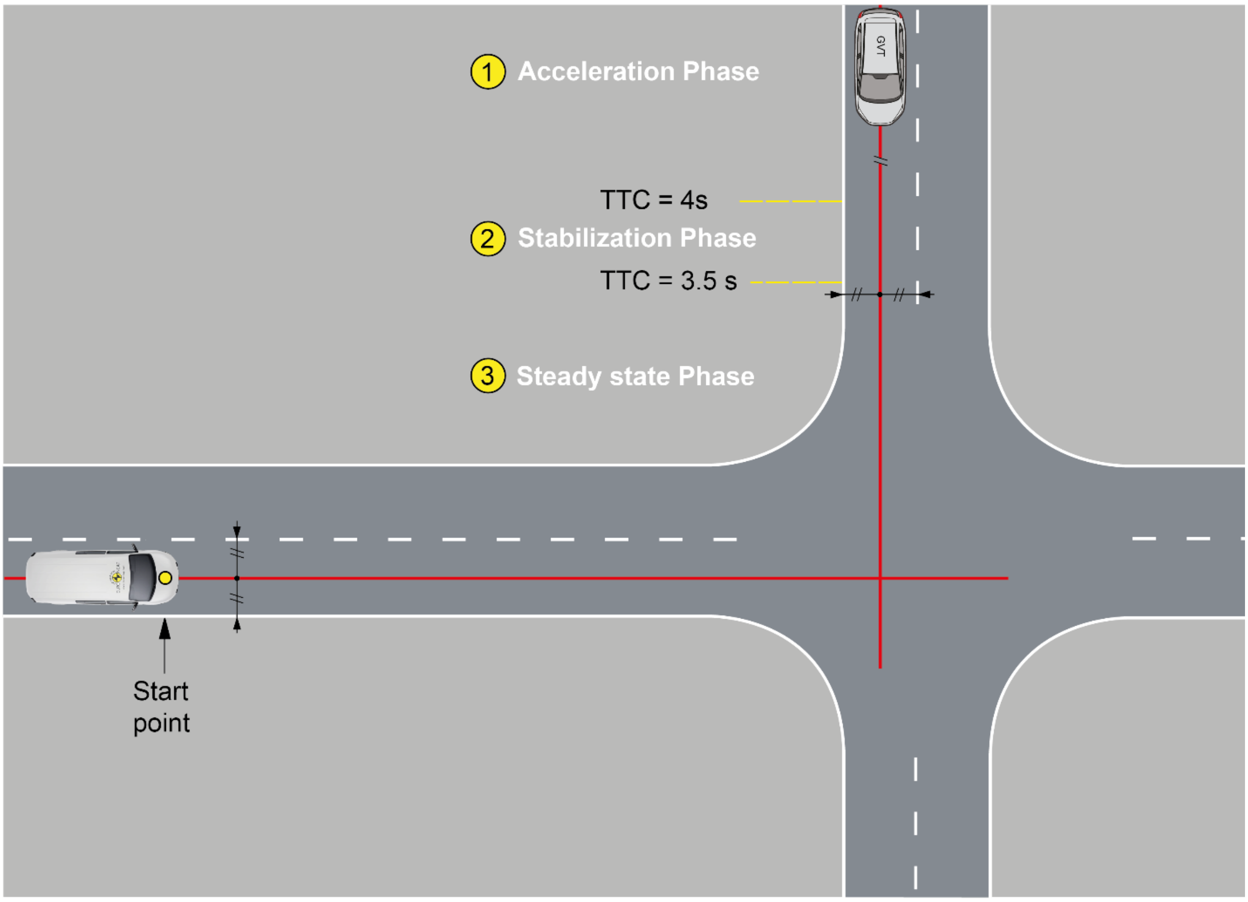


Figure 3-9 VCCscp

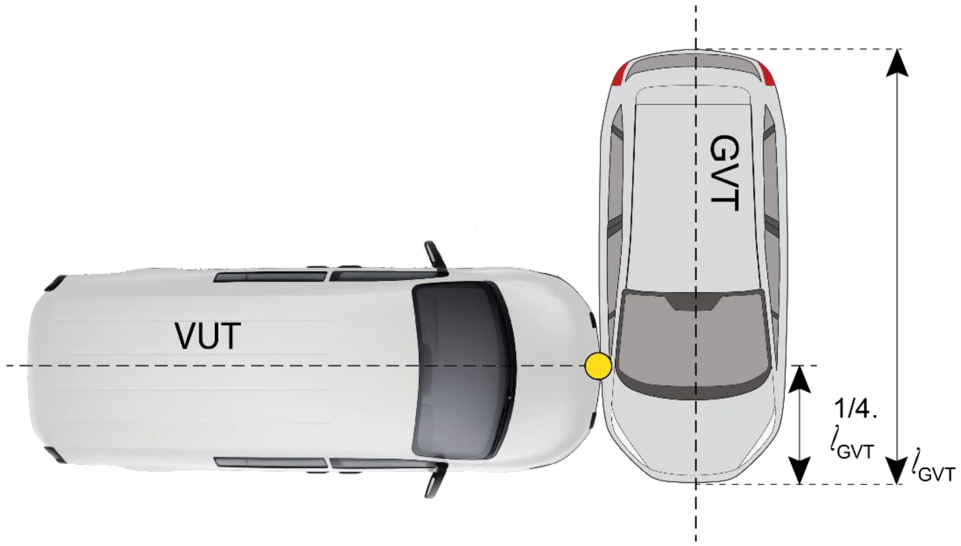


Figure 3-10 Impact location on VCCscp

3.2 Pedestrian & Cyclist Scenarios

Pedestrian & Cyclist	Points	Total
Longitudinal Van-to-Pedestrian Van-to-Bicyclist	 2.5 2.5	**7.5**
Turning Van-to-Pedestrian Van-to-Bicyclist	 2.5 2.5	**7.5**
Crossing Van-to-Pedestrian Van-to-Bicyclist	 7.5 7.5	**15.0**

3.2.1 Longitudinal

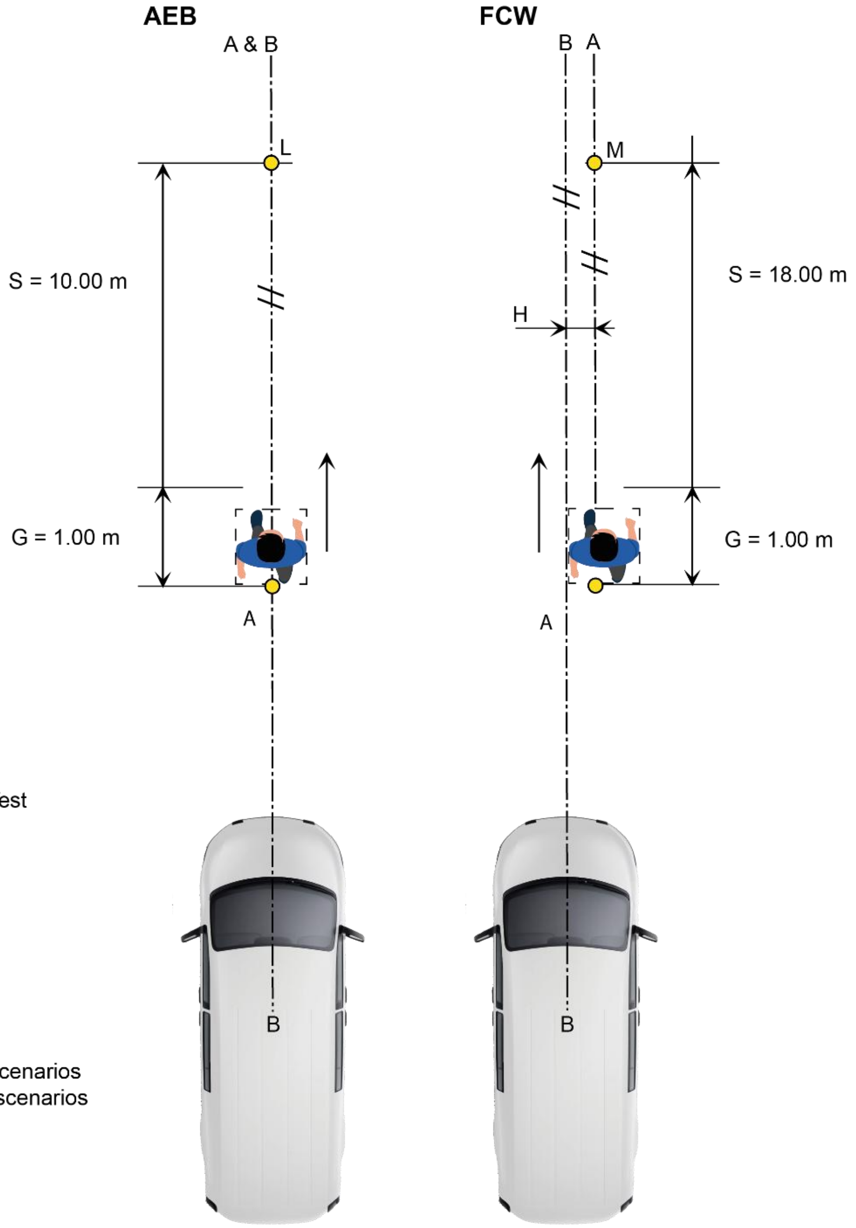
Longitudinal	Points	Total
Van-to-Pedestrian	2.5	**2.5**
Van-to-Bicyclist	2.5	**2.5**

3.2.1.1 Van-to-Pedestrian Longitudinal

VPLA	EPT speed	Function	☀/☾	Impact Location	
				25%	50%
20 km/h	5 km/h	AEB	☀		
25 km/h	5 km/h	AEB	☀		
30 km/h	5 km/h	AEB	☀		
35 km/h	5 km/h	AEB	☀		
40 km/h	5 km/h	AEB	☀		
45 km/h	5 km/h	AEB	☀		
50 km/h	5 km/h	AEB	☀		
55 km/h	5 km/h	AEB	☀		
60 km/h	5 km/h	AEB	☀		
50 km/h	5 km/h	FCW	☀		
55 km/h	5 km/h	FCW	☀		
60 km/h	5 km/h	FCW	☀		
65 km/h	5 km/h	FCW	☀		
70 km/h	5 km/h	FCW	☀		
75 km/h	5 km/h	FCW	☀		
80 km/h	5 km/h	FCW	☀		

20 km/h	5 km/h	AEB	☾		
25 km/h	5 km/h	AEB	☾		
30 km/h	5 km/h	AEB	☾		
35 km/h	5 km/h	AEB	☾		
40 km/h	5 km/h	AEB	☾		
45 km/h	5 km/h	AEB	☾		
50 km/h	5 km/h	AEB	☾		
55 km/h	5 km/h	AEB	☾		
60 km/h	5 km/h	AEB	☾		
50 km/h	5 km/h	FCW	☾		
55 km/h	5 km/h	FCW	☾		
60 km/h	5 km/h	FCW	☾		
65 km/h	5 km/h	FCW	☾		
70 km/h	5 km/h	FCW	☾		
75 km/h	5 km/h	FCW	☾		
80 km/h	5 km/h	FCW	☾		

For nighttime tests in VPLA (marked with ☾), illumination conditions shall apply as described in Technical Bulletin CA 101. Furthermore, nighttime tests shall be conducted with high beams.



Axes
AA - Trajectory of pedestrian
BB - Axis of centerline of Vehicle under Test

Distances
G - Dummy acceleration distance
S - Dummy steady state distance
H - Impact point offset for 25%

Points
L - Impact position for 50% longitudinal scenarios
M - Impact position for 25% longitudinal scenarios

Figure 3-11 VPLA scenario, Longitudinal walking Adult

3.2.1.2 Van-to-Bicyclist Longitudinal

VBLA	EBT speed	Function	Impact Location	
			25%	50%
25 km/h	15 km/h	AEB		
30 km/h	15 km/h	AEB		
35 km/h	15 km/h	AEB		
40 km/h	15 km/h	AEB		
45 km/h	15 km/h	AEB		
50 km/h	15 km/h	AEB		
55 km/h	15 km/h	AEB		
60 km/h	15 km/h	AEB		
65 km/h	15 km/h	AEB		
50 km/h	20 km/h	FCW		
60 km/h	20 km/h	FCW		
60 km/h	20 km/h	FCW		
60 km/h	20 km/h	FCW		
60 km/h	20 km/h	FCW		
60 km/h	20 km/h	FCW		
80 km/h	20 km/h	FCW		

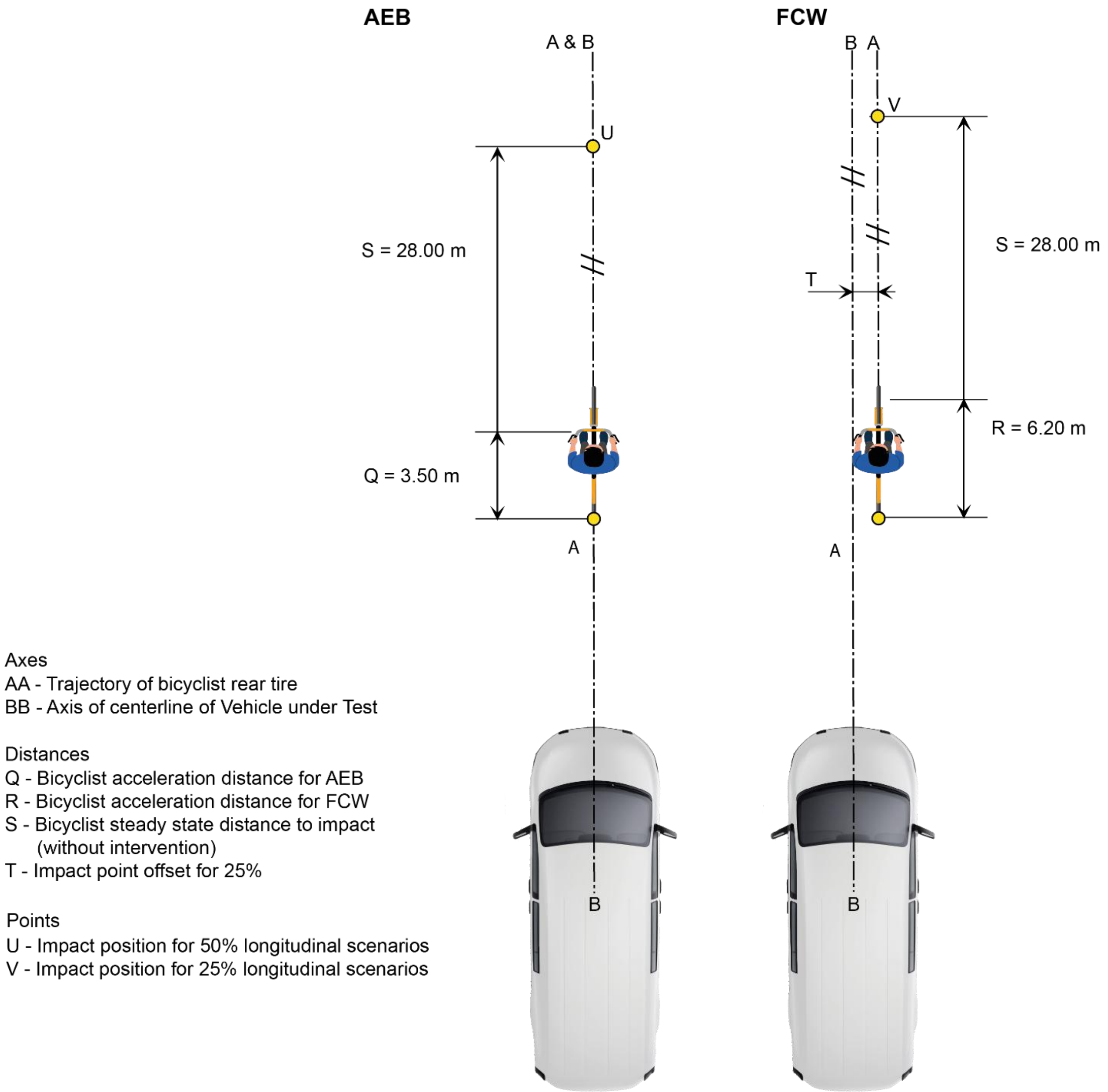


Figure 3-12 VBLA scenarios, Longitudinal Bicyclist (AEB left & FCW right)

***Note**: the reflected acceleration distances Q and R are meant to suit the limited usable length of a belt-driven carrier platform. If a self-propelled carrier platform is used for the execution of VBLA, the acceleration distances Q and R can be increased according to the acceleration capabilities of the platform carrier.*

3.2.2 Turning

Turning	Points	Total
Van-to-Pedestrian	**2.5**	**2.5**
VPTAfs & VPTAns	*1.25*	
VPTAfo & VPTAno	*1.25*	
Van-to-Bicyclist	**2.5**	**2.5**
VBTAfo & VBTAno	*2.5*	

3.2.2.1 Van-to-Pedestrian Turning

The VPTA scenario consists of 4 sub-scenarios

- VPTAfs: Farside turn, target travelling in the same direction
- VPTAfo: Farside turn, target travelling in the opposite direction
- VPTAns: Nearside turn, target travelling in the same direction
- VPTAno: Nearside turn, target travelling in the opposite direction

VPTAfs	Turn	EPT Direction	EPT Speed	Impact Location
				50%
10 km/h	Farside	Same	5 km/h	
15 km/h	Farside	Same	5 km/h	
20 km/h	Farside	Same	5 km/h	

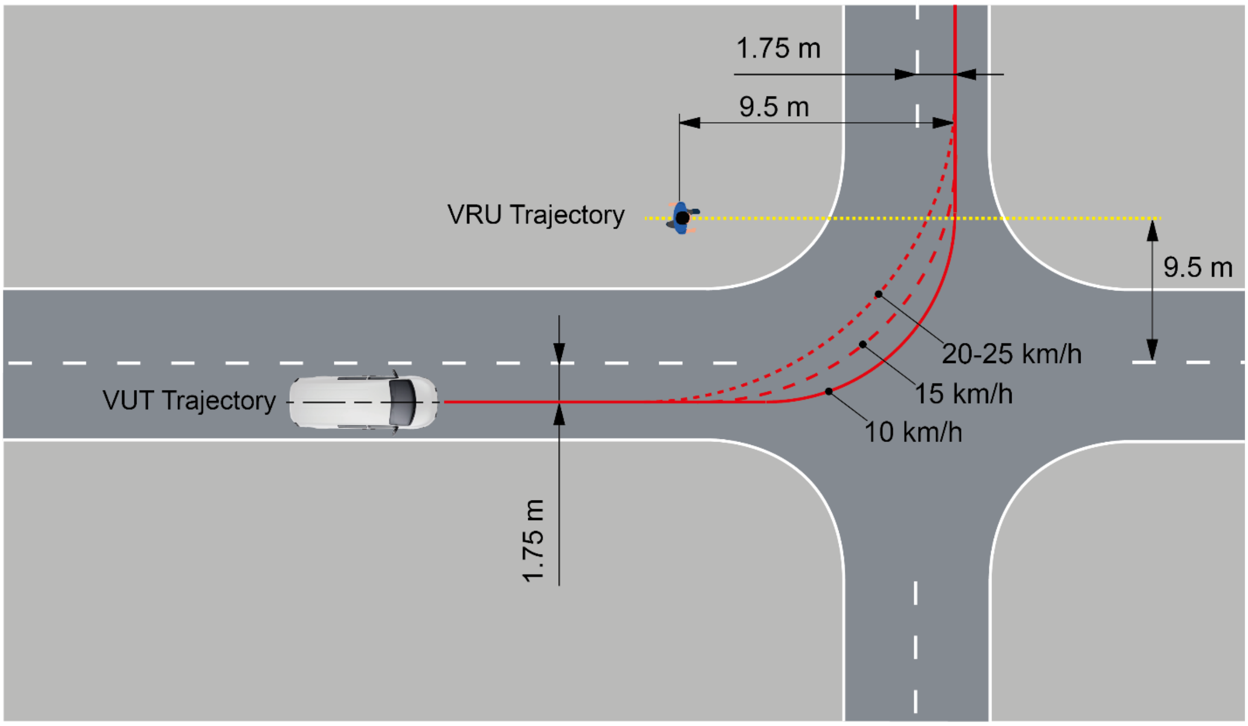


Figure 3-13 VPTAfs scenario – VUT left turn, pedestrian crossing from farside

VPTAfo	Turn	EPT Direction	EPT Speed	Impact Location
				50%
10 km/h	Farside	Opposite	5 km/h	
15 km/h	Farside	Opposite	5 km/h	
20 km/h	Farside	Opposite	5 km/h	

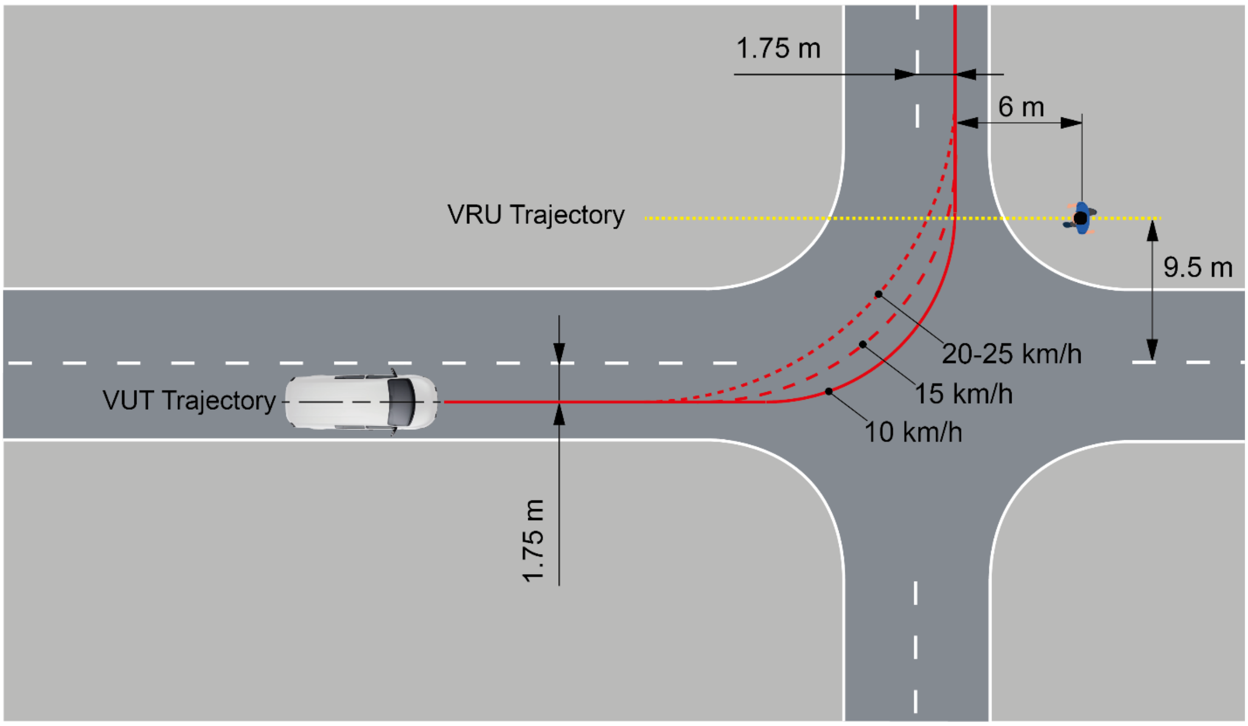


Figure 3-14 VPTAfo scenario – VUT left turn, pedestrian crossing from nearside

VPTAno	Turn	EPT Direction	EPT Speed	Impact Location
				50%
10 km/h	Nearside	Opposite	5 km/h	

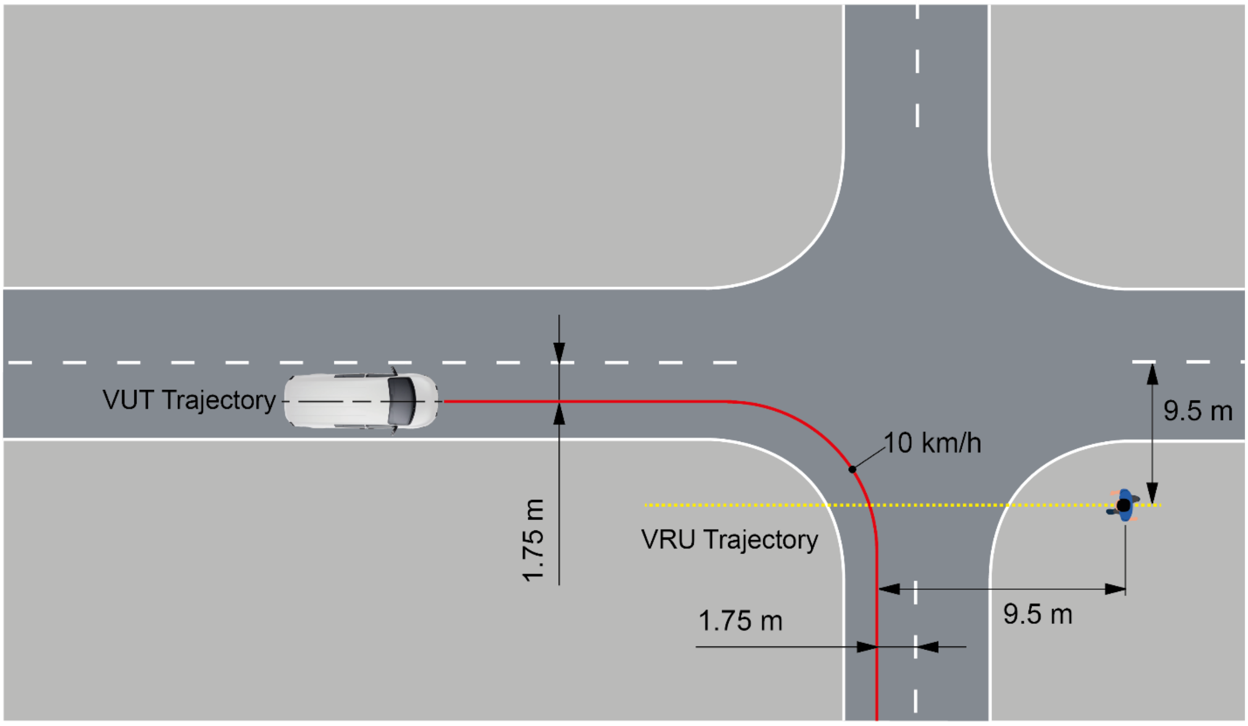


Figure 3-15 VPTAno scenario – VUT right turn, pedestrian crossing from farside

VPTAfs	Turn	EPT Direction	EPT Speed	Impact Location
				50%
10 km/h	Nearside	Same	5 km/h	

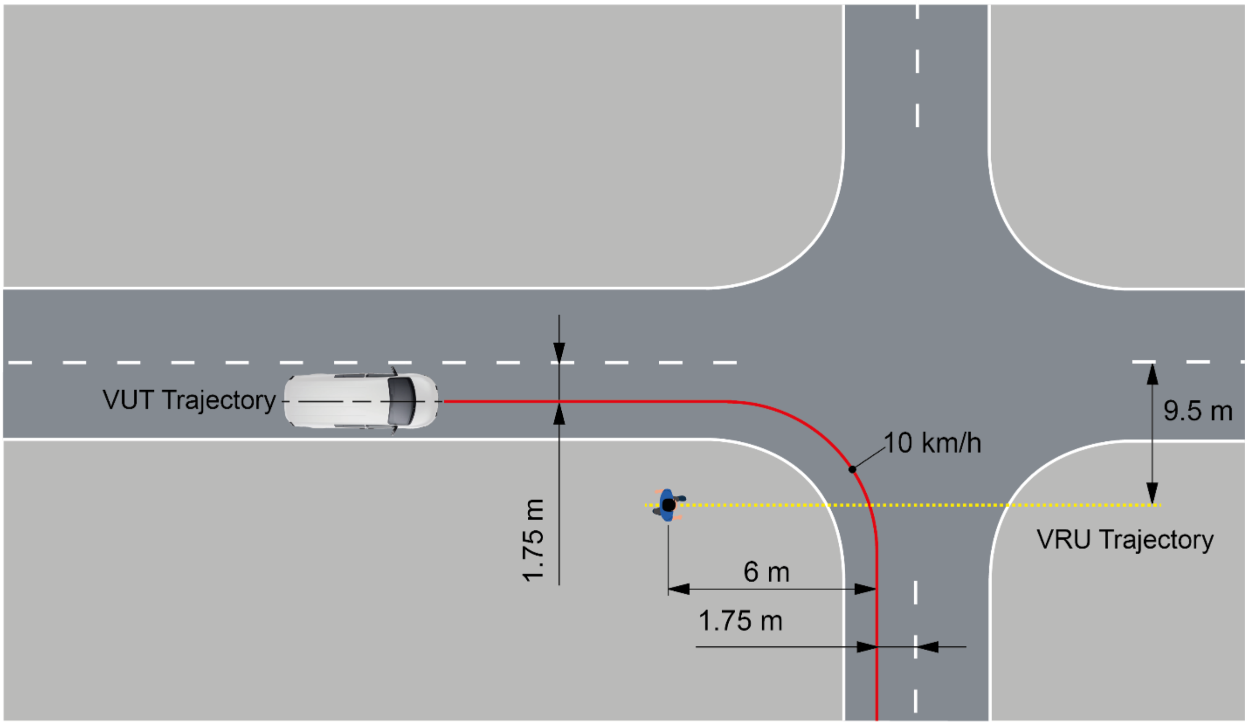


Figure 3-16 VPTAns scenario – VUT right turn, pedestrian crossing from nearside

3.2.2.2 Van-to-Bicyclist Turning

The VBTA scenario consists of 2 sub-scenarios

- VBTAfo: Farside turn, target travelling in the opposite direction
- VBTAno: Nearside turn, target travelling in the opposite direction

In all cases, the target speed is 15 km/h and the target reference point is on the front wheel.

VBTAfo	Turn	EBT Direction	EBT Speed	Impact Location
				50%
10 km/h	Farside	Opposite	15 km/h	
15 km/h	Farside	Opposite	15 km/h	
20 km/h	Farside	Opposite	15 km/h	

VBTAno	Turn	EBT Direction	EBT Speed	Impact Location
				50%
10 km/h	Nearside	Opposite	15 km/h	

For the VBTA scenarios, for the VUT assume an initial straight-line path followed by a turn (clothoid, fixed radius and clothoid as specified in section 0), followed again by a straight line, hereby known as the test path. The direction indicator is applied at 1.0s ± 0.5s before T_{steer}.

The straight-line path of the VUT and GVT will be 1.75m from the centre of the centre dashed lane marking of the VUT lane.

The VUT will follow a straight-line path in the approach lane which will be 1.75m from the centre of the centre dashed lane marking of the VUT lane. The EBT will follow a straight-line path which will be respectively 2.75m (VBTAfo) and 5.00m (VBTAfs, VBTAns, VBTAno) from the centre of the centre dashed lane marking of the VUT lane. Steady state speed of EBT starts at 4sec TTC.

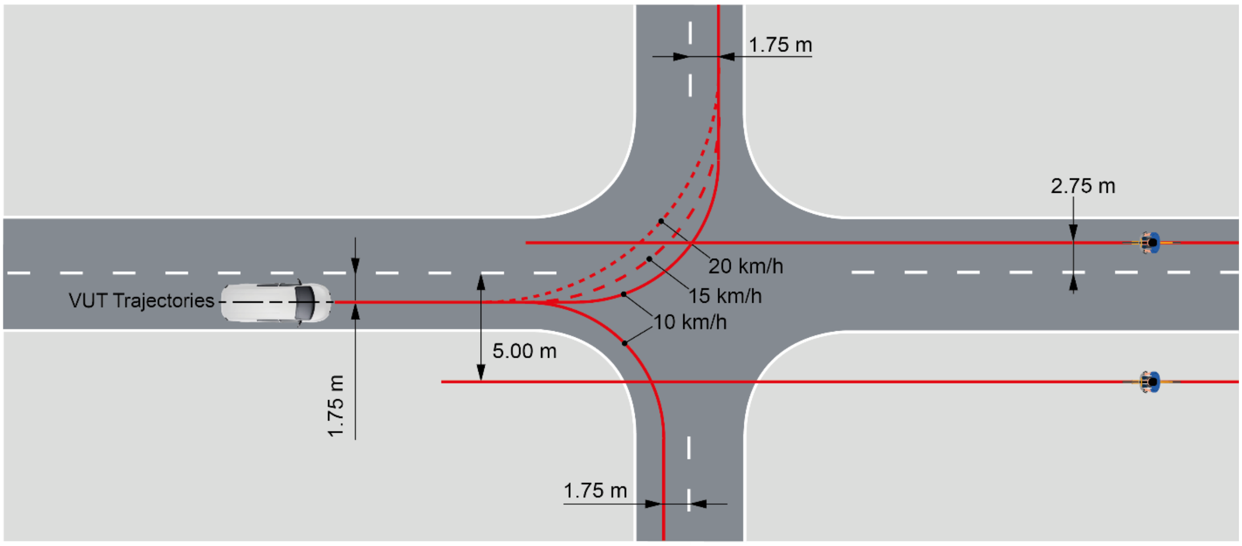


Figure 3-17 VBTA scenario

3.2.3 Crossing

Crossing		Points	Total
Van-to-Pedestrian			**7.5**
	VPNA	1.75	
	VPFA	1.75	
	VPNCO	4.0	
Van-to-Bicyclist			**7.5**
	VBNA	1.75	
	VBFA	1.75	
	VBNAO	4.0	

3.2.3.1 Van-to-Pedestrian Crossing

For all nighttime tests in Van-to-Pedestrian Crossing (marked with ☾), illumination conditions shall apply as described in Technical Bulletin CA 101. Furthermore, nighttime tests shall be conducted with low beams.

VPNA	EPT Speed	☀/☾	Impact Location	
			25%	75%
10 km/h	5 km/h	☀		
15 km/h	5 km/h	☀		
20 km/h	5 km/h	☀		
25 km/h	5 km/h	☀		
30 km/h	5 km/h	☀		
35 km/h	5 km/h	☀		
40 km/h	5 km/h	☀		
45 km/h	5 km/h	☀		
50 km/h	5 km/h	☀		
55 km/h	5 km/h	☀		
60 km/h	5 km/h	☀		
10 km/h	5 km/h	☾		
15 km/h	5 km/h	☾		
20 km/h	5 km/h	☾		
25 km/h	5 km/h	☾		
30 km/h	5 km/h	☾		
35 km/h	5 km/h	☾		
40 km/h	5 km/h	☾		
45 km/h	5 km/h	☾		
50 km/h	5 km/h	☾		
55 km/h	5 km/h	☾		
60 km/h	5 km/h	☾		

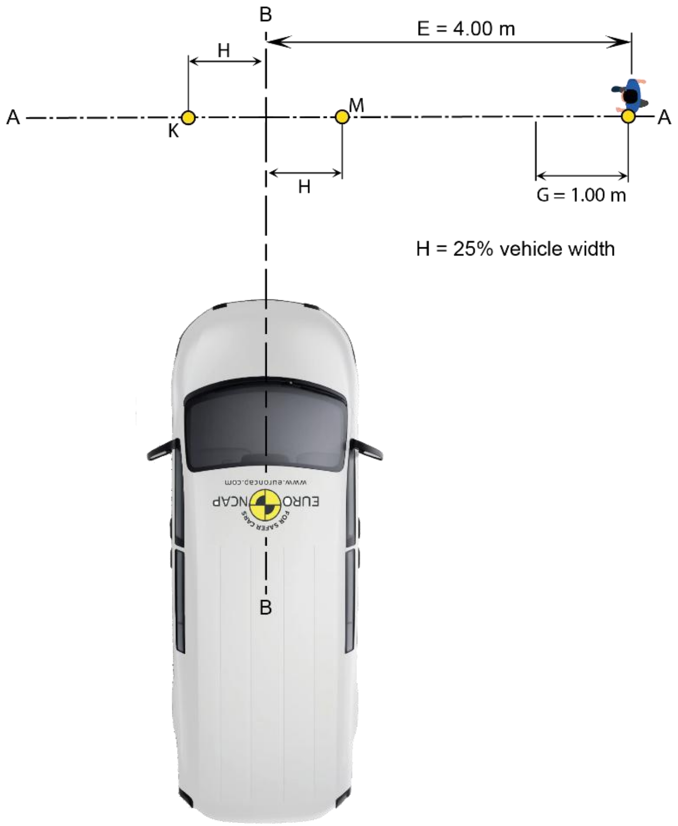


Figure 3-18 VPNA-25 & VPNA-75 scenarios, Walking Adult from Nearside

VPFA	EPT Speed	☀/☾	Impact Location
			50%
10 km/h	8 km/h	☀	
15 km/h	8 km/h	☀	
20 km/h	8 km/h	☀	
25 km/h	8 km/h	☀	
30 km/h	8 km/h	☀	
35 km/h	8 km/h	☀	
40 km/h	8 km/h	☀	
45 km/h	8 km/h	☀	
50 km/h	8 km/h	☀	
55 km/h	8 km/h	☀	
60 km/h	8 km/h	☀	
10 km/h	8 km/h	☾	
15 km/h	8 km/h	☾	
20 km/h	8 km/h	☾	
25 km/h	8 km/h	☾	
30 km/h	8 km/h	☾	

35 km/h	8 km/h	☾	
40 km/h	8 km/h	☾	
45 km/h	8 km/h	☾	
50 km/h	8 km/h	☾	
55 km/h	8 km/h	☾	
60 km/h	8 km/h	☾	

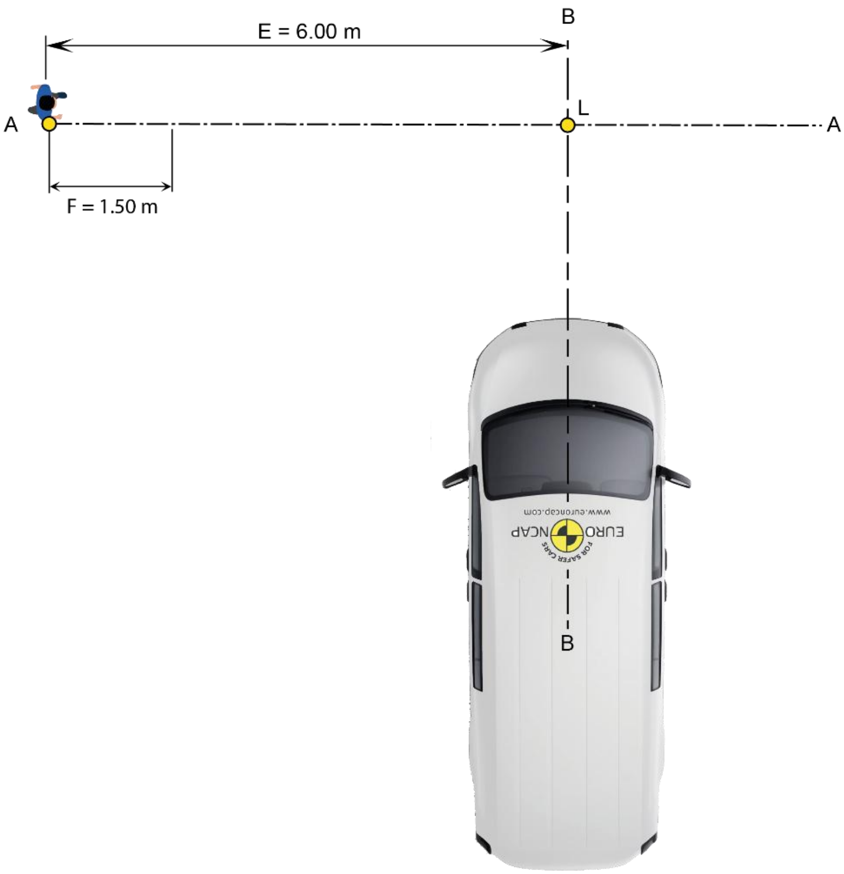


Figure 3-19 VPFA-50 scenario, Adult running from Farside

VPNCO	EPTc Speed	☀/☾	Impact Location
			50%
10 km/h	5 km/h	☀	
15 km/h	5 km/h	☀	
20 km/h	5 km/h	☀	
25 km/h	5 km/h	☀	
30 km/h	5 km/h	☀	
35 km/h	5 km/h	☀	
40 km/h	5 km/h	☀	
45 km/h	5 km/h	☀	
50 km/h	5 km/h	☀	
60 km/h	5 km/h	☀	
10 km/h	5 km/h	☾	
15 km/h	5 km/h	☾	
20 km/h	5 km/h	☾	
25 km/h	5 km/h	☾	
30 km/h	5 km/h	☾	
35 km/h	5 km/h	☾	
40 km/h	5 km/h	☾	
45 km/h	5 km/h	☾	
50 km/h	5 km/h	☾	
60 km/h	5 km/h	☾	
10 km/h	5 km/h	☾	

Axes
AA - Trajectory of pedestrian dummy H-point
BB - Axis of centerline of Vehicle under Test
CC - Axis of centerlines of obstruction vehicles

Distances
G - Dummy acceleration distance (running)
I - Dummy H-point to front of obstruction vehicle
J - Distance between vehicle under test and larger obstruction vehicle

Points
L - Impact position for 50% scenarios

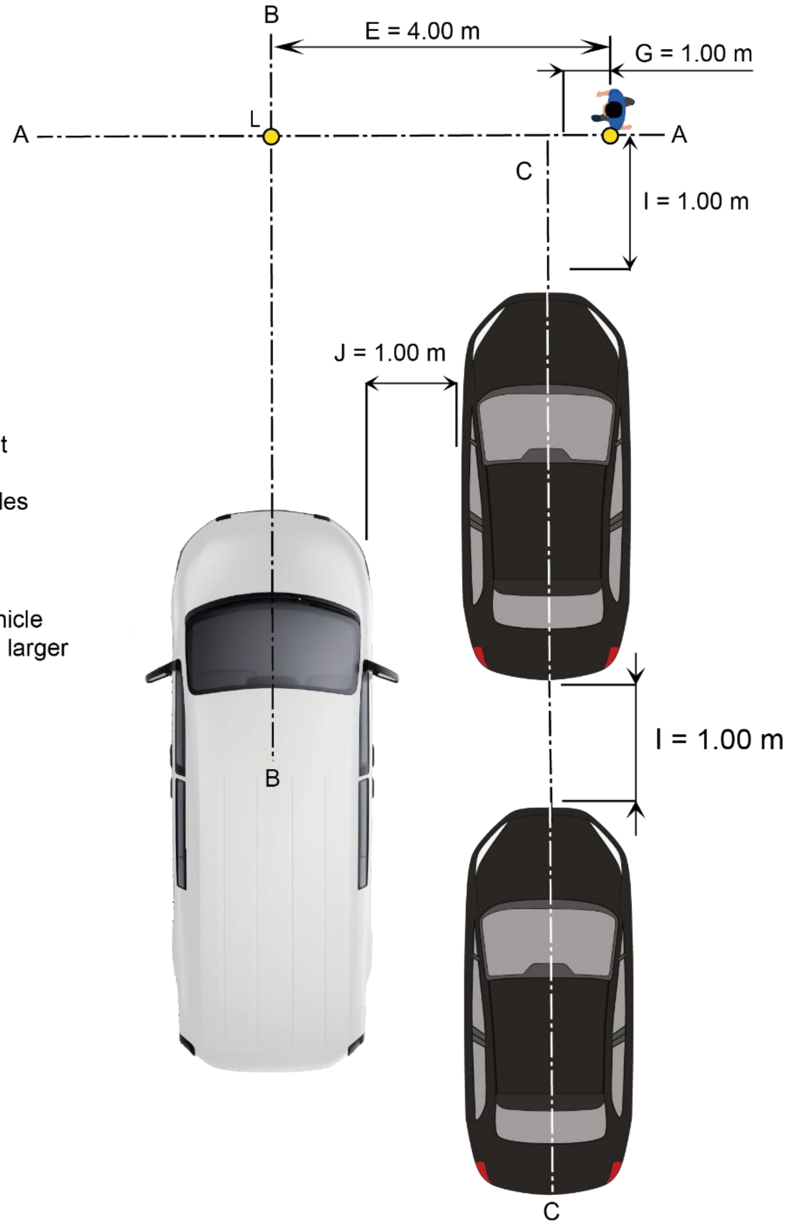


Figure 3-20 VPNCO-50 scenario, Running Child from Nearside from Obstruction

3.2.3.2 Van-to-Bicyclist Crossing

VBNA	EBT Speed	Impact Location
		50%
10 km/h	15 km/h	
15 km/h	15 km/h	
20 km/h	15 km/h	
25 km/h	15 km/h	
30 km/h	15 km/h	
35 km/h	15 km/h	
40 km/h	15 km/h	
45 km/h	15 km/h	
50 km/h	15 km/h	
55 km/h	15 km/h	
60 km/h	15 km/h	

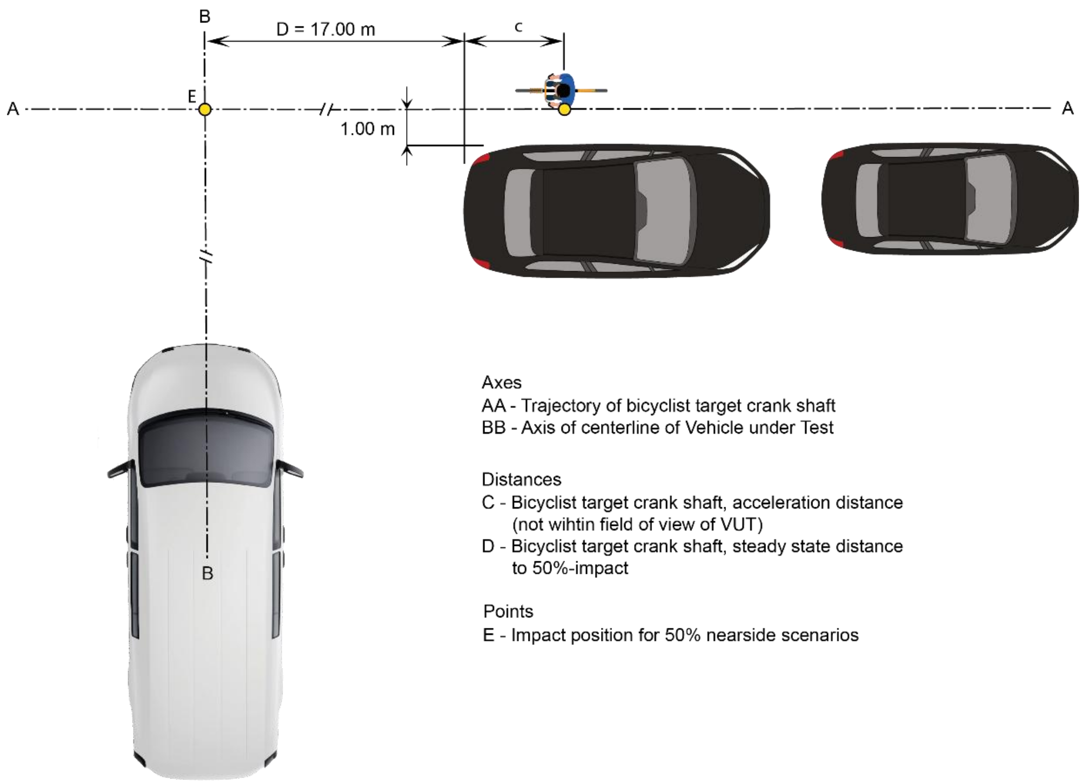


Figure 3-21 VBNA scenario, Bicyclist from Nearside

***Notes**: the gap between the obscuration vehicles should be* [0.1 ~ 0.3] m.

VBNAO	EBT Speed	Impact Location
		50%
10 km/h	10 km/h	
15 km/h	10 km/h	
20 km/h	10 km/h	
25 km/h	10 km/h	
30 km/h	10 km/h	
35 km/h	10 km/h	
40 km/h	10 km/h	
45 km/h	10 km/h	
50 km/h	10 km/h	
55 km/h	10 km/h	
60 km/h	10 km/h	

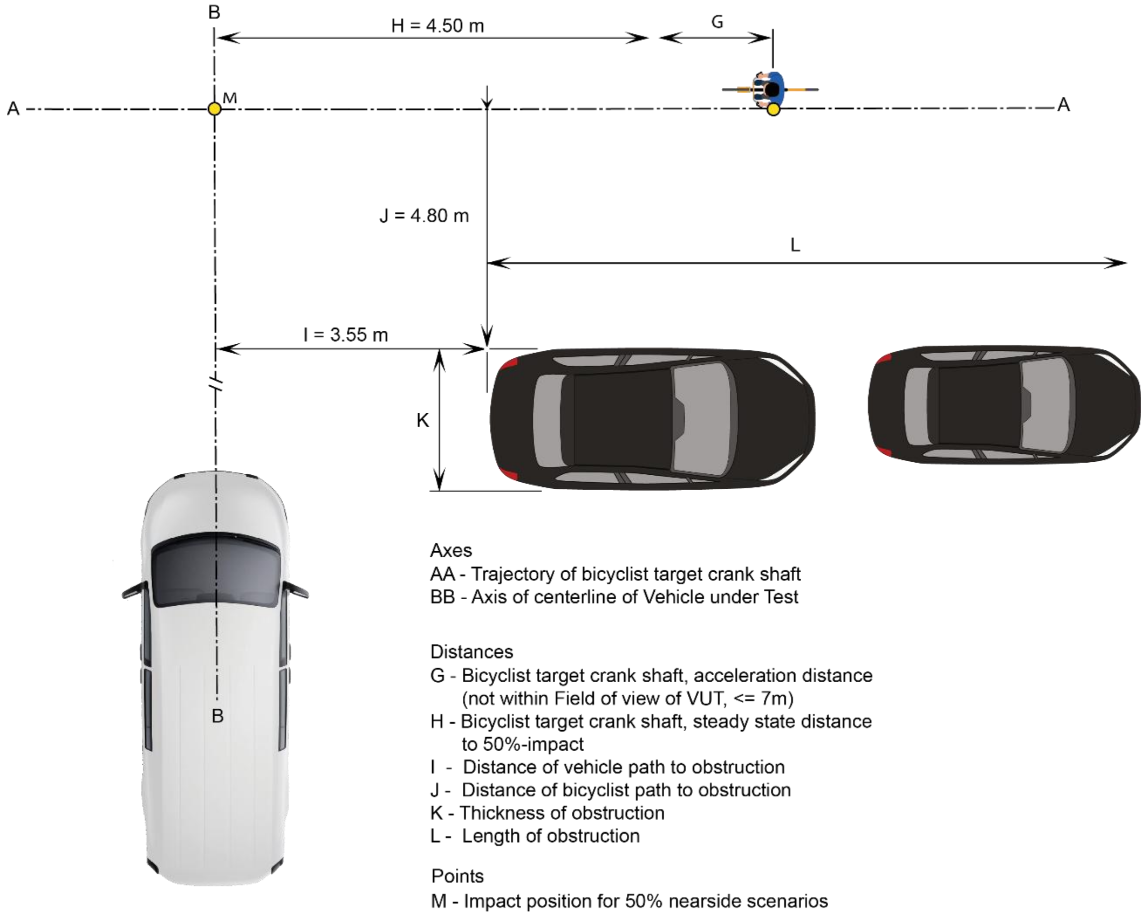


Figure 3-22 VBNAO scenario, Bicyclist from Nearside (obstructed)

***Notes**: the gap between the obscuration vehicles should be* [0.1 ~ 0.3] m.

VBFA	EBT Speed	Impact Location
		50%
10 km/h	20 km/h	
15 km/h	20 km/h	
20 km/h	20 km/h	
25 km/h	20 km/h	
30 km/h	20 km/h	
35 km/h	20 km/h	
40 km/h	20 km/h	
45 km/h	20 km/h	
50 km/h	20 km/h	
55 km/h	20 km/h	
60 km/h	20 km/h	

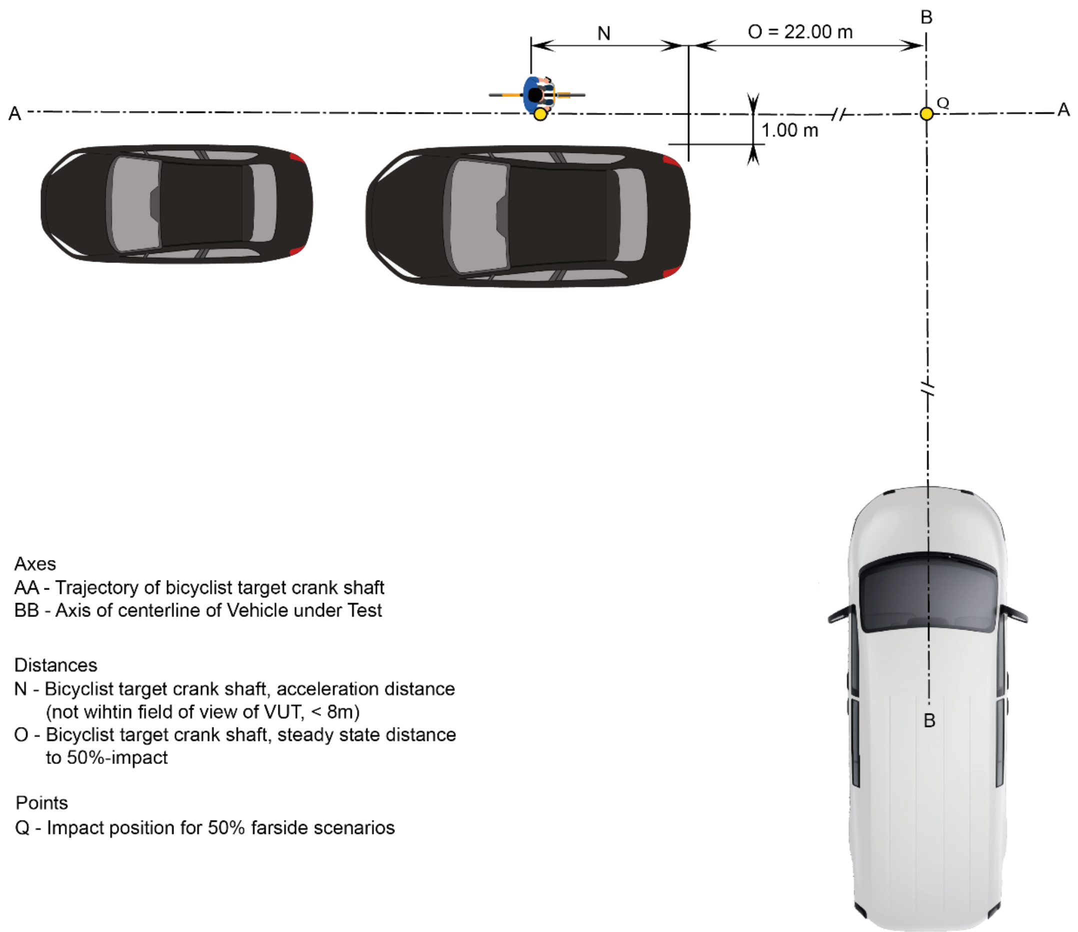


Figure 3-23 VBFA scenario, Bicyclist from Farside

***Notes**: the gap between the obscuration vehicles should be* [0.1 ~ 0.3] m.

4 TEST EXECUTION

4.1 Performance Predictions

4.1.1 Colour data

The vehicle manufacturer is required to provide the Euro NCAP Secretariat with colour data (expected impact speeds are not required) detailing the performance of the vehicle for each grid point across all scenarios, according to the colour scheme detail in chapter 5.2. The prediction is to be done for both AEB and FCW system tests where applicable.

All data must be supplied by the manufacturer before any testing begins, preferably with delivery of the test vehicle(s).

For the Van-to-Car head-on scenarios the vehicle manufacturer must supply a dossier detailing how their vehicle responds in the VCFhol and VCFhos test scenarios. The dossier must, at least, include:

- System performance: The expected performance of the system (TTC of warning – when applicable – , TTC of AEB activation and speed reduction)
- System architecture: Sensor(s) setup used in perception and basic description of sensor fusion and decision-making logic
- System operational conditions/limitations (ODD): system activation speed range, maximum relative speed, overlap range, lighting/environmental conditions, considered vehicle types (passenger car only or motorcycle, truck, etc), required lane width(s), required lane marking, etc.
- System overriding conditions: e.g., accelerator pedal %, brake pedal, steering wheel angle/rate, etc.
- System validation: Evidence of system verification conducted by OEM (physical tests, HiL/SiL/ViL…)
- Real world performance: Evidence from the vehicle manufacturer demonstrating the effectiveness of the head-on function on the field (including false positive likelihood & mitigation strategies)

4.1.2 Absence of colour data

Where predicted colour data is NOT provided by the vehicle manufacturer, ALL grid points are to be tested by the Euro NCAP laboratory, taking into account symmetry.

For VCR AEB and FCW systems tests, when there is complete avoidance, the subsequent test speed for the next test is incremented with 10km/h. When there is contact, first perform a test at a test speed 5km/h less than the test speed where contact occurred. After this test continue to perform the remainder of the tests with speed increments of 5km/h by repeating section **Error! Reference source not found.** to**Error! Reference source not found.**. Stop testing when the speed reduction seen in the test is less than 5 km/h or the (relative) impact speed is more than 50 km/h.

For VCCscp tests should be performed starting with the lowest VUT and GVT speed combination. The next test will use the same VUT test speed and the GVT speed will be incremented by 10km/h. Where the GVT test speed reaches 60km/h, the next test will be the combination of the

VUT speed increased to the next increment, and a GVT speed of 10km/h. Continue this method for all VUT test speeds.

4.1.3 Impact speed tolerance

As test results can be variable between labs and in-house tests and/or simulations, a 2 km/h tolerance to the impact speeds of the verification test is applied. The tolerance is applied in both directions, meaning that when a tested point scores better than predicted, but within tolerance, the predicted result is applied.

The tolerance only applies to verify whether the predicted colour of the tested verification point is correct. When, including tolerance, the colour is not in line with the prediction, the true colour of the test point will be determined by comparing the actual measured impact speed with the colour bands in chapter 5.2, without applying a tolerance to the impact speed.

As an example, the accepted impact speed ranges for the 60km/h VMRs test:

Colour	Impact speed range (km/h)	Accepted Range (km/h)
Green	$v_{impact} = 0$	$v_{impact} < 2$
Yellow	$0 < v_{impact} \leq 10$	$0 < v_{impact} \leq 12$
Orange	$10 < v_{impact} \leq 20$	$8 < v_{impact} \leq 22$
Brown	$20 < v_{impact} \leq 30$	$18 < v_{impact} \leq 32$
Red	$30 < v_{impact}$	

4.2 Verification Tests

4.2.1 Car & PTW

4.2.1.1 Car-to-Car

The performance of the AEB/FCW system is assessed in the VCRs, VCRm, VCRb, VCFtap, VCCscp and VCFhos/VCFhol scenarios.

For VCRs AEB, VCRs FCW and VCRm, the assessment is based on a GRID prediction provided by the OEM. The actual scenarios to be tested to verify the prediction will be chosen randomly, distributed in line with the predicted colour distribution (excluding red points).

The vehicle sponsor will fund 15 verification tests, where applicable. For AEB 10 tests (VCRs and VCRm) and 5 tests for FCW (VCRs). The vehicle manufacturer has the option of sponsoring up to 10 additional verification tests for AEB VCR and 10 for FCW.

For VCRb and VCFtap verification tests are conducted at all test points.

For VCCscp verification tests are conducted at all test points where sufficient performance to score points is predicted.

4.2.1.2 Car-to-PTW

For AEB VMR systems tests, perform tests over the full test speed range per scenario, starting with the lowest test speed. When there is complete avoidance, the subsequent test speed for the next test is incremented with 10km/h. When there is contact, first perform a test at a test speed

5km/h less than the test speed where contact occurred. After this test continue to perform the remainder of the tests with speed increments of 5km/h. Stop testing when the speed reduction seen in the test is less than 5 km/h.

For the VMR FCW system tests, when there is complete avoidance, the subsequent test speed for the next test is incremented by 10km/h. When there is contact, first perform a test at a test speed 5km/h less than the test speed where contact occurred. After this test continue to perform the remainder of the tests with speed increments of 5km/h by repeating the instruction in the paragraph above. In the VMR FCW scenarios, only perform tests at the test speeds where there was no avoidance in the AEB function tests, where applicable. Stop testing when the speed reduction seen in the test is less than 5 km/h.

4.2.2 Pedestrian & Cyclist

For VPFA-50, VPNA-25 and VPNA-75, VPNCO-50, VPLA-50, VBNA-50, VBNAO-50, VBFA-50, and VBLA-50, based on the OEM colour prediction, the highest avoidance (Green) test speeds of each scenario and one randomly selected avoidance (Green) test speed per scenario (where applicable) will be tested according to the following colour scheme detailed in chapter 5.2. If there is an impact in any of these tests, perform a test at the adjacent test speed(s) until the predicted avoidance is confirmed.

Perform all tests where the predicted result is Yellow, Orange or Brown. Test points that are predicted Red are excluded from testing.

For VBNA-50, VBNAO-50 and VBFA-50 the lowest avoidance (Green) test speed will be tested additionally.

In the tests above 40km/h, stop testing when the actual speed reduction measured is less than 15km/h.

For VPLA-25 and VBLA-25 FCW systems tests, based on the OEM prediction, test the highest test speed of each scenario where the FCW is issued at a TTC ≥ 1.7s, plus one randomly selected test speed per scenario where the FCW is issued at a TTC ≥ 1.7s.

If the FCW is not issued at a TTC ≥ 1.7s in any of these tests, perform tests at all remaining test speeds in the scenario in 5km/h increments.

Stop testing when the OEM predicts that the FCW is not issued at a TTC ≥ 1.7s.

4.3 Test Conduct

4.3.1 VUT Pre-test conditioning

If requested by the Vehicle Manufacturer, an initialisation run may be included before every test run. Bring the VUT to a halt and push the brake pedal through the full extent of travel and release.

For vehicles with an automatic transmission select D. For vehicles with a manual transmission select the highest gear where the RPM will be at least 1500 at the test speed.

Perform the first test a minimum of 90s and a maximum of 10 minutes after completing the tyre conditioning (if applicable), and subsequent tests after the same time period. If the time between consecutive tests exceeds 10 minutes perform three brake stops from 72 km/h at approximately 0.3g.

Between tests, manoeuvre the VUT at a maximum speed of 50km/h and avoid riding the brake pedal and harsh acceleration, braking or turning unless strictly necessary to maintain a safe testing environment.

Control the VUT with driver inputs or using alternative control systems that can modulate the vehicle controls as necessary to perform the tests within the boundary for the AEB tests.

4.3.2 AEB tests

Accelerate the VUT and target to the respective test speeds where needed. The test shall start at T_0 and is valid when all boundary conditions are met between T_0 and T_{AEB} and/or T_{FCW}:

	VUT	GVT	EPT	EBT	EMT
Speed	+ 1.0 km/h	± 1.0 km/h	± 0.2 km/h	± 0.5 km/h	± 1.0 km/h
Lateral deviation	0 ± 0.05 m (0 ± 0.1 m for VPTA and VBTA)	0 ± 0.10 m	0 ± 0.05 m for crossing scenarios (incl. junction) 0 ± 0.15 m for longitudinal scenarios		0 ± [0.15] m
Lateral velocity			0 ± 0.15 m/s	0 ± 0.15 m/s	
Relative distance		1.0 sec [+0.1sec] time gap			1.0 sec [+0.1sec] time gap
Yaw velocity (upto T_{STEER})	0 ± 1.0 °/s				
Steering wheel velocity (upto T_{STEER})	0± 15.0 °/s				

The end of a test, where the AEB function is assessed and for VMRs FCW and VMRb FCW, is considered when one of the following occurs:

- V_{VUT} = 0km/h (crossing) or $V_{VUT} = V_{target}$ (longitudinal)
- Contact between VUT and target
- The target has left the VUT path or VUT has left the target path

To avoid contact in the junction scenarios, the test laboratory may include an automated braking action by the robot in case the AEB system fails to intervene (sufficiently). This braking action is applied automatically when:

- The VUT reaches the latest position at which maximum braking applied to the vehicle will prevent the VUT entering the path of the Motorcyclist and no intervention from the AEB system is detected.
- Lateral separation between the VUT and EMT reaches ≤ 0.3m during / after AEB intervention.

It is at the test laboratory's discretion to select and use one of the options above to ensure a safe testing environment. If the Vehicle Manufacturer feels the avoidance action is negatively affecting the performance of their vehicle, they should consult with the test laboratory and Euro NCAP secretariat.

For manual or automatic accelerator control, it needs to be assured that during automatic brake the accelerator pedal does not result in an override of the system. The accelerator pedal needs to be released when the initial test speed is reduced by 5 km/h. There shall be no operation of other driving controls during the test, e.g. clutch or brake pedal.

4.3.3 FCW tests

The VCRs and VMRs FCW system tests should be performed using a braking robot reacting to the warning with a delay time of 1.2 seconds as per C.4 to account for driver reaction time.

Braking will be applied that results in a maximum brake level of -4 m/s^2 - 0.50 m/s^2 when applied in a non-threat situation. The particular brake profile to be applied (pedal application rate applied in 200ms (max. 400mm/s) and pedal force) shall be specified by the manufacturer. When the brake profile provided by the manufacturer results in a higher brake level than allowed, the iteration steps as described in Technical Bulletin CA 102 will be applied to scale the brake level to -4 m/s^2 - 0.50 m/s^2.

If no brake profile is provided, apply default brake profile as described in Technical Bulletin CA 102.

Where the FCW function is assessed, the end of a test is considered when one of the following occurs:

- $V_{VUT} = V_{target}$ (longitudinal)
- T_{FCW}
- TTC ≤ 1.5s , after which an evasive action can be started

It is at the labs discretion to select and use one of the options above to ensure a safe testing environment.

5 ASSESSMENT

5.1 General requirements

To be eligible for scoring points in this assessment, the following conditions shall be met:

- AEB and/or FCW system shall be default ON at the start of every journey and deactivation of the system should not be possible with a momentary single push on a button.
- AEB and/or FCW system shall have a loud and clear audible component of the FCW system (if applicable).
- For AEB Pedestrian, the system shall operate (i.e. warn or brake) from speeds of 10 km/h in the VPNA-75 scenario in both day and night. In addition, the system shall be able to detect pedestrians walking as slow as 3 km/h and reduce speed in the VPNA-75 scenario at 20 km/h, also for both day and night.
- For the AEB VCRs scenario, full avoidance shall be achieved for test speeds up to and including 20 km/h for all impact locations, which is verified by one randomly selected test point.

5.2 Criteria

The following criteria and associated KPIs is used across scenarios to evaluate the performance of the AEB and/or FCW system:

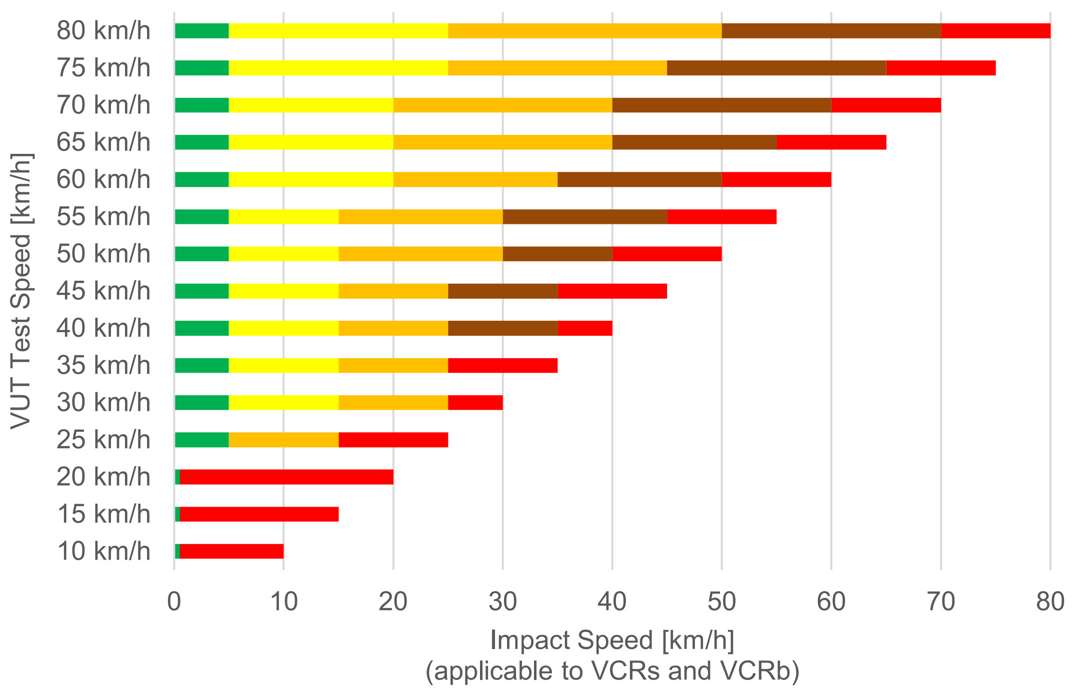
Criteria	KPI	Scenarios	
		Car & PTW	Pedestrian & Cyclist
Mitigation OR avoidance	V_{rel_impact}	VCRm	VPLA-50, VBLA-50
	V_{impact}	VCRs, VCRb VMRs, VMRb VCCscp	VPFA-50, VPNA-25, VPNA-75, VPNCO-50, VBNA-50, VBNAO-50, VBFA-50
Mitigation	$V_{reduction}$	VCFhos, VCFhol	-
Avoidance	V_{impact}	VCFtap, VMFtap	VPTA, VBTA
Warning	FCW TTC	-	VPLA-25, VBLA-25

Where V_{impact},V_{rel_impact} or $V_{reduction}$ is used, a criteria based on a stepped sliding scale using colour bands is applied:

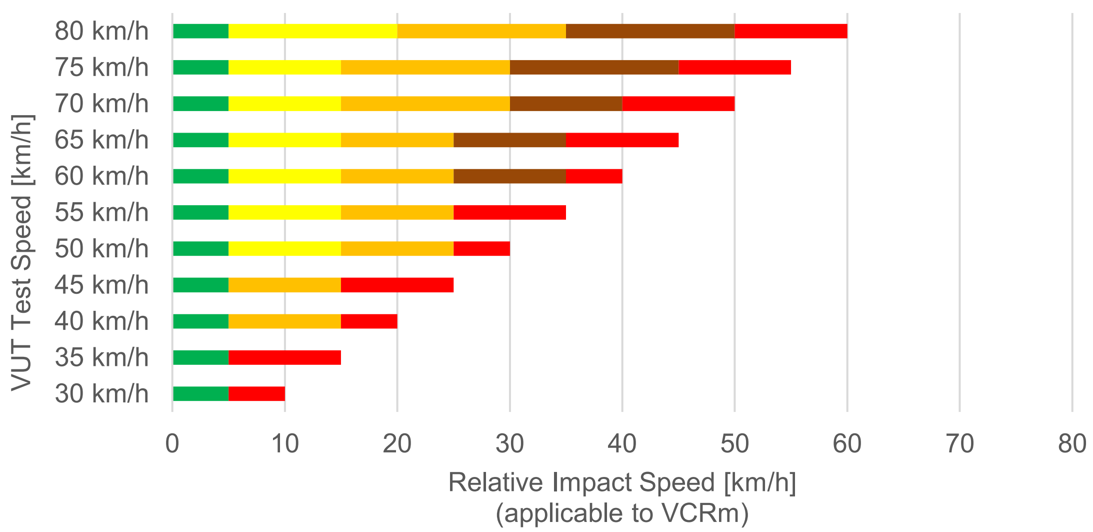
5.2.1 Car & PTW

5.2.1.1 Longitudinal

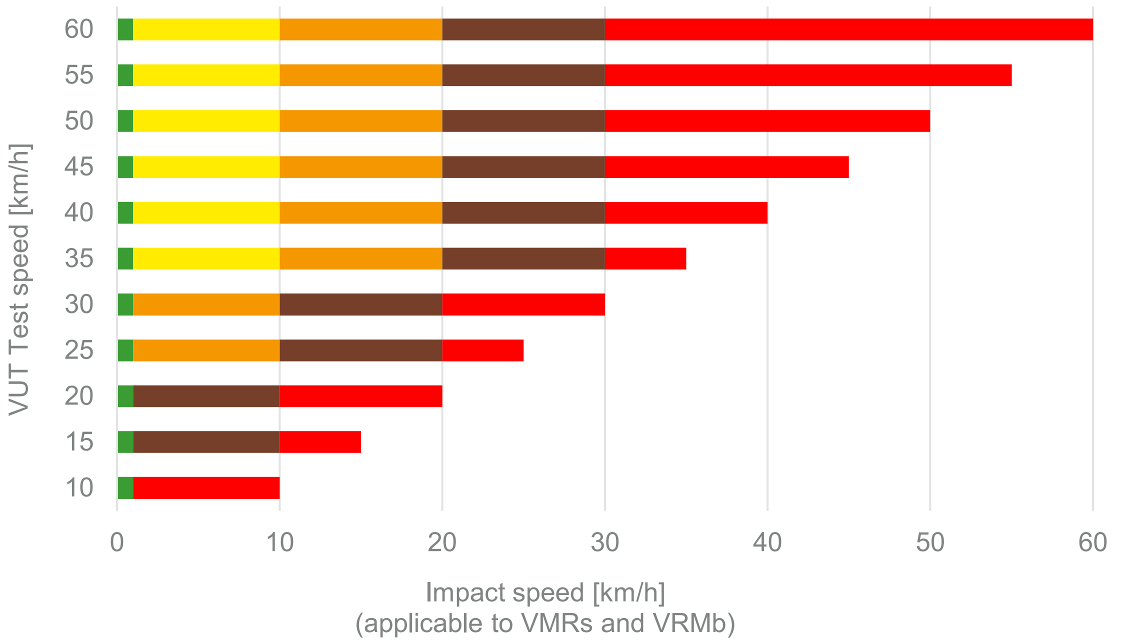
5.2.1.1.1 VCRs, VCRb



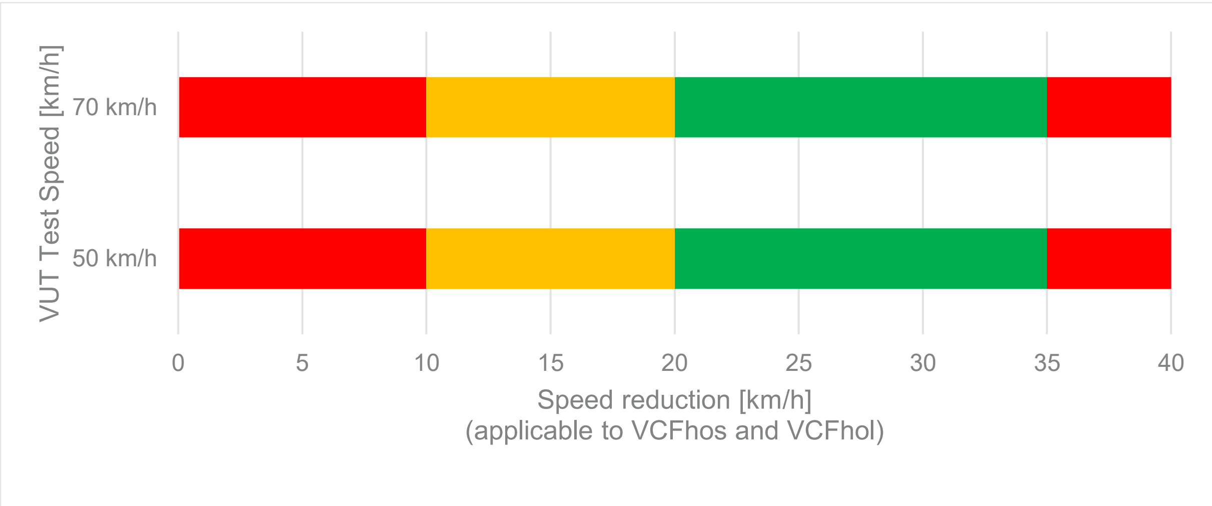
5.2.1.1.2 VCRm



5.2.1.1.3 VMRs, VRMb



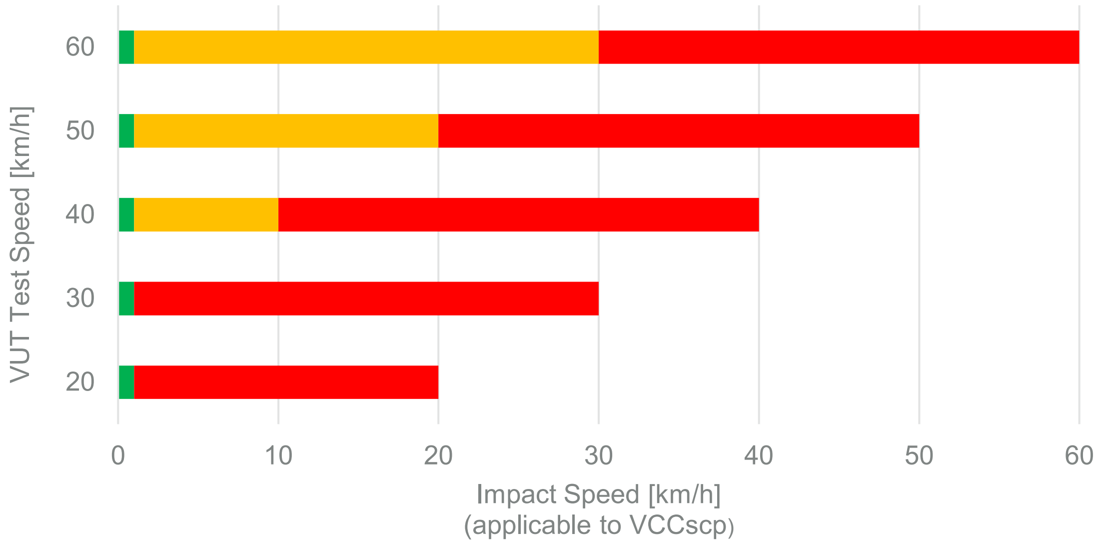
5.2.1.1.4 VCFhos, VCFhol



5.2.1.2 Turning

Colour band	VCFtap, VMFtap
	V_{impact} [km/h]
Green	0
Red	>0

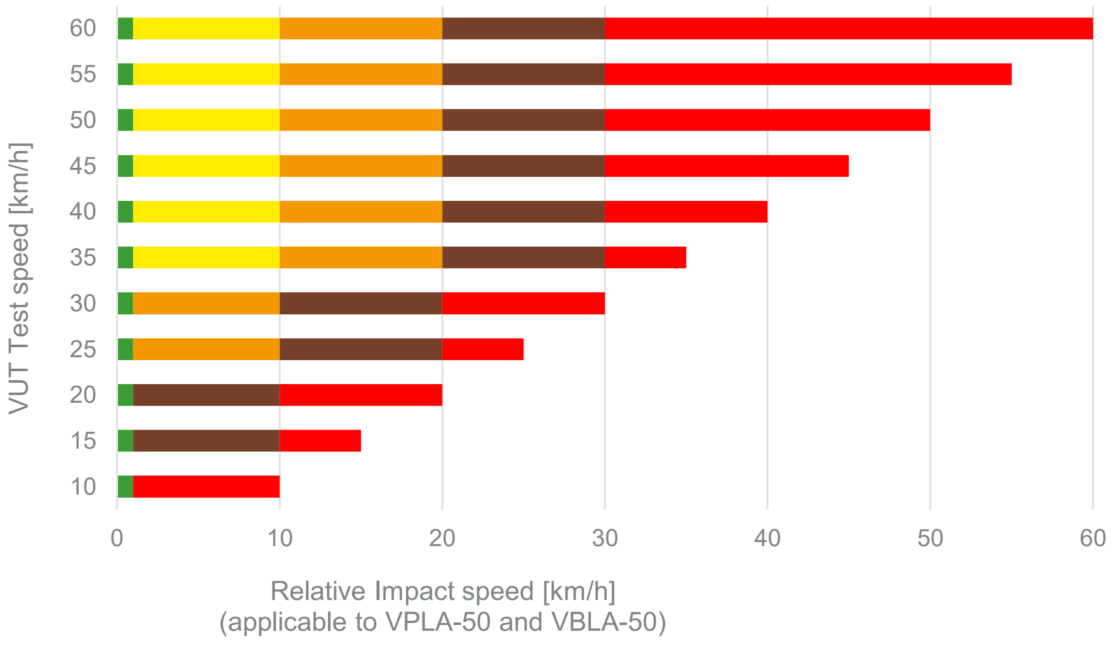
5.2.1.3 Crossing



5.2.2 Pedestrian & Cyclist

5.2.2.1 Longitudinal

5.2.2.1.1 VPLA-50, VBLA-50



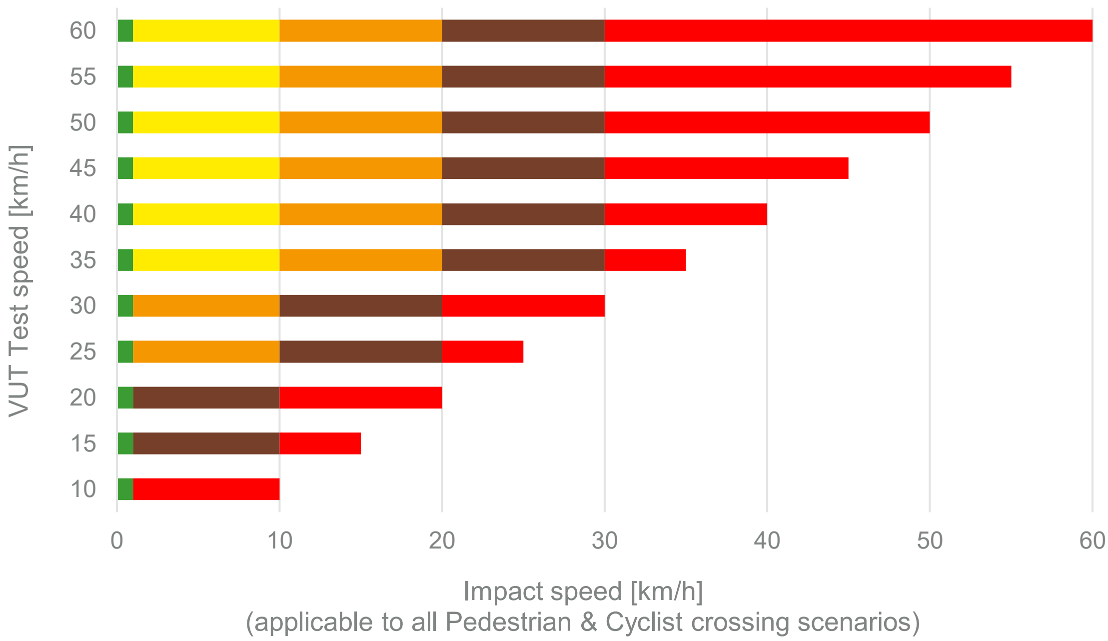
5.2.2.1.2 VPLA-25, VBLA-25

Colour band	VPLA-25, VBLA-25
	FCW TTC [s]
Green	≥1.7
Red	<1.7

5.2.2.2 Turning

Colour band	VPTA, VBTA
	V_{impact} [km/h]
Green	0
Red	>0

5.2.2.3 Crossing



5.3 Scoring

For score calculation of each scenario, first each grid cell is given a sub-score according to the Vehicle Manufacturer colour prediction:

Predicted Colour	Standard Range Sub-score per grid cell
Green	1.00
Yellow	0.75
Orange	0.50
Brown	0.25
Red	0.00

Secondly, the resulting score is calculated by normalizing all the sub-scores to the total score of that scenario (rounded to hundredth):

$$Scenario\ Score\ = \frac{\sum Scenario\ Subscores\ x\ Total\ Scenario\ Score}{Number\ of\ grid\ cells\ in\ the\ scenario}$$

The outcome of the verification tests will dictate the final score of a given scenario.

For VCRs and VCRm only, the data provided by the manufacturer for VCRs and VCRm is scaled using two correction factors, one for AEB and one for FCW/AES, which are calculated based on a number of verification tests performed. The vehicle sponsor will fund 15 verification tests, 10 for AEB and 5 for FCW/AES where applicable. The vehicle manufacturer has the option of sponsoring up to 10 additional verification tests for AEB and 5 for FCW/AES.

The verification points are randomly selected grid points, distributed in line with the predicted colour distribution (excluding red points).

The actual tested total score of the verification test points is divided by the predicted total score of these verification test points. This is called the correction factor, which can be lower or higher than 1.

$$Correction\ Factor = \frac{Actual\ tested\ score}{Predicted\ score}$$

The correction factor is used to calculate the VCRs and VCRm scores for the AEB and FCW/AES function scores. The final VCRs and VCRm scores for AEB and FCW/AES can never exceed 100% regardless of the correction factor.

APPENDIX A OBSTRUCTION DIMENTIONS

B.1 Smaller obstruction vehicle

The smaller obstruction vehicle should be of the category Small Family Car and is positioned closest to the pedestrian path. The smaller obstruction vehicle should be within the following geometrical dimensions and needs to be in a dark colour.

	Vehicle length	**Vehicle width (without mirrors)**	**Vehicle height**	**Bonnet length (till A pillar)**	**BLE height**
Minimum	4100 mm	1700 mm	1300 mm	1100 mm	650 mm
Maximum	4400 mm	1900 mm	1500 mm	1500 mm	800 mm

B.2 Larger obstruction vehicle

The larger obstruction vehicle should be of the category Small SUV and is positioned behind the smaller obstruction vehicle. The larger obstruction vehicle should be within the following geometrical dimensions and needs to be in a dark colour.

	Vehicle length	**Vehicle width (without mirrors)**	**Vehicle height**
Minimum	4300 mm	1750 mm	1500 mm
Maximum	4700 mm	1900 mm	1800 mm