

Crash Avoidance Frontal Collisions

Protocol

Implementation January 2026

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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).

NOTE: All 2026 protocols with a version number 0.9 are under final review of the Working Group and might undergo minor changes

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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.

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.

Car-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.

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

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

Standard range – refers to the most basic and controlled format a test scenario will be tested. Tests within the standard range are deemed the foundational level performance expectations for any given test scenario.

Extended range – refers to test points in which minor levels of complexity are introduced to the standard range tests. Changes for this range are limited to variations in impact position and longitudinal velocity for the VUT and / or test target.

Robustness layer – refers to the introduction of test complexity and variation, designed to challenge vehicle systems and encourage reliable “real-world” performance

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

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

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

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 CCFhol scenario. This vehicle can either be a GVT or a real vehicle.

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.).

Time To Collision (TTC) – means the remaining time before the VUT strikes the test target, assuming that the VUT and test target would continue to travel with the speed it is travelling.

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 -1 m/s^2 , and then going back to the point in time where the acceleration first crossed -0.3 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.

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.

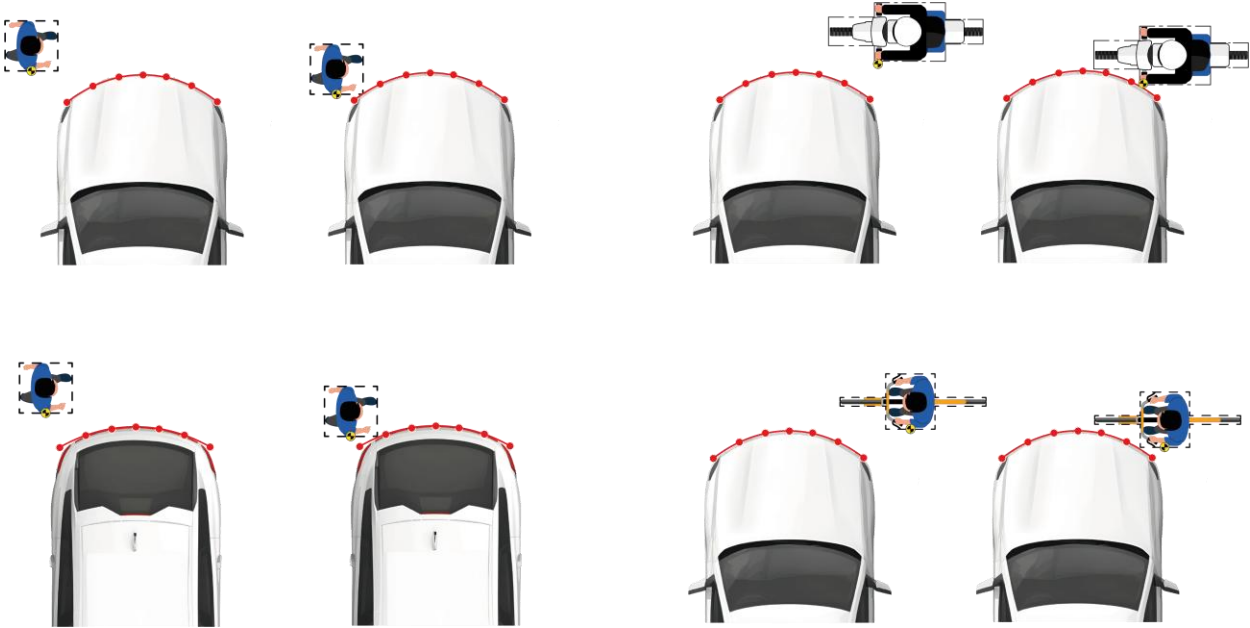


Figure 0-1 :Front end profile vs EPT, EMT, and EBT targets, and rear end profile vs EPT target.

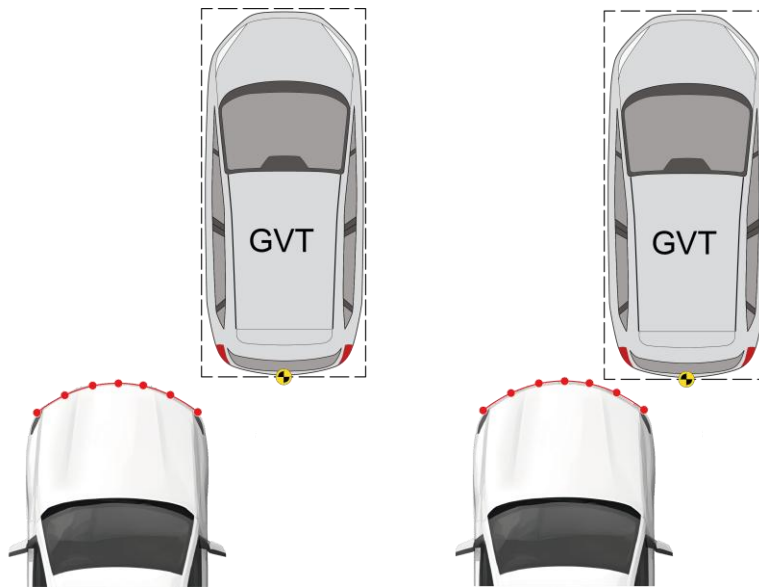


Figure 0-2 Front end profile and GVT

Test Scenarios

Car-to-Pedestrian Farside Adult (CPFA) – 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.

Car-to-Pedestrian Nearside Adult (CPNA) – 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.

Car-to-Pedestrian Nearside Child Obstructed (CPNCO) – 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.

Car-to-Pedestrian Longitudinal Adult (CPLA-25) – 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 at 25% of the vehicle's width when no braking action is applied or an evasive steering action is initiated after an FCW.

Car-to-Pedestrian Longitudinal Adult (CPLA-50) – 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 at 50% of the vehicle's width when no braking action is applied.

Car-to-Pedestrian Turning Adult (CPTA) – 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.

Car-to-Bicyclist Nearside Adult (CBNA) – 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.

Car-to-Bicyclist Nearside Adult Obstructed (CBNAO) – 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.

Car-to-Bicyclist Farside Adult (CBFA) – 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.

Car-to-Bicyclist Longitudinal Adult (CBLA-25) – 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 at 25% of the vehicle's width when no braking action is applied or an evasive steering action is initiated after an FCW.

Car-to-Bicyclist Longitudinal Adult (CBLA-50) – 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 at 50% of the vehicle's width when no braking action is applied.

Car-to-Bicyclist Turning Adult (CBTA) – 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.

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

Car-to-Motorcyclist Rear Braking (CMRb) – 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.

Car-to-Motorcyclist Turn Across Path (CMFtap) – 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.

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

Car-to-Car Rear Stationary (CCRs) – 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.

Car-to-Car Rear Moving (CCRm) – 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.

Car-to-Car Rear Braking (CCRb) – 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.

Car-to-Car Front Turn-Across-Path (CCFtap) – 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.

Car-to-Car Crossing Straight Crossing Path (CCCscp) – 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.

Car-to-Car Front Head-On Straight (CCFhos) – 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.

Car-to-Car Front Head-On Lane change (CCFhol) – 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.

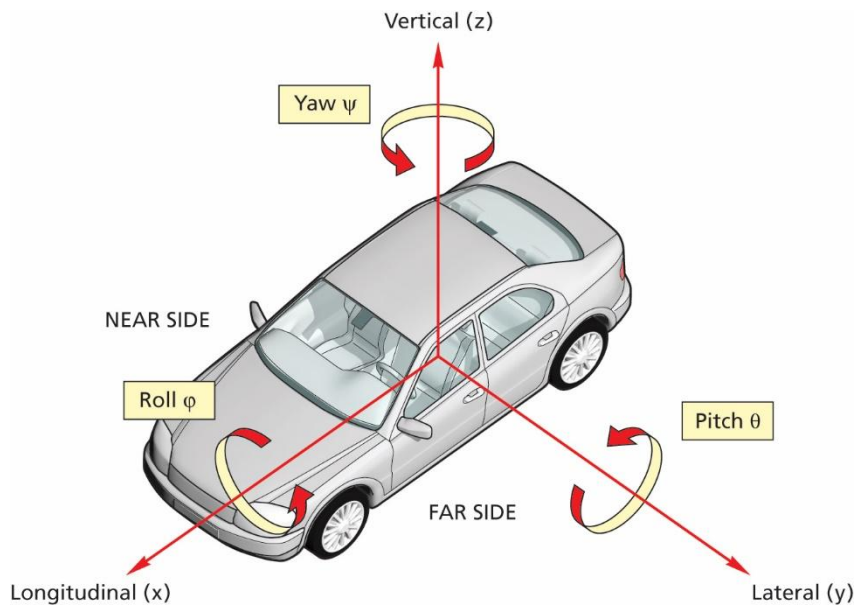


Figure 1-1 Coordinate system and notation

1.1.1 VUT longitudinal path error

1.1.1.1 Car-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.

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

For CCFtap, 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	$X_{VUT, \text{desired}}$	X_{target}
10 km/h	30 km/h		29.17 m
	45 km/h	-9.57 m	43.75 m
	60 km/h		58.33 m
15 km/h	30 km/h		29.17 m
	45 km/h	-14.53 m	43.75 m
	60 km/h		58.33 m
20 km/h	30 km/h		29.17 m
	45 km/h	-19.47 m	43.75 m
	60 km/h		58.33 m
25 km/h	30 km/h		29.17 m
	45 km/h	-24.33 m	43.75 m
	60 km/h		58.33 m

1.1.1.2 Car-to-Motorcycle

For CMFtap 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.

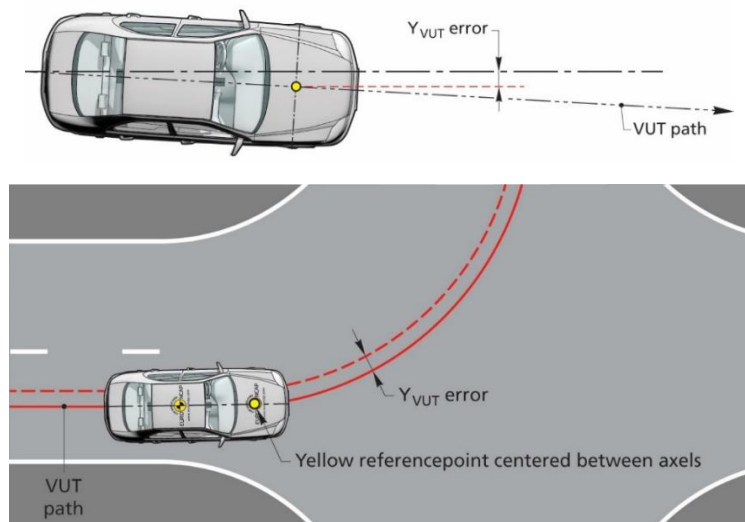
$$\text{VUT longitudinal path error} = X_{VUT, \text{desired}} - X_{VUT, \text{actual}} (@X_{EMT})$$

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	$X_{VUT, \text{desired}}$	X_{target}
10 km/h	30 km/h		33.33 m
	45 km/h	-10.66 m	50.00 m
	60 km/h		66.66 m
15 km/h	30 km/h		33.33 m
	45 km/h	-16.39 m	50.00 m
	60 km/h		66.66 m
20 km/h	30 km/h		33.33 m
	45 km/h	-22.02 m	50.00 m
	60 km/h		66.66 m
25 km/h	30 km/h		33.33 m
	45 km/h	-27.60 m	50.00 m
	60 km/h		66.66 m

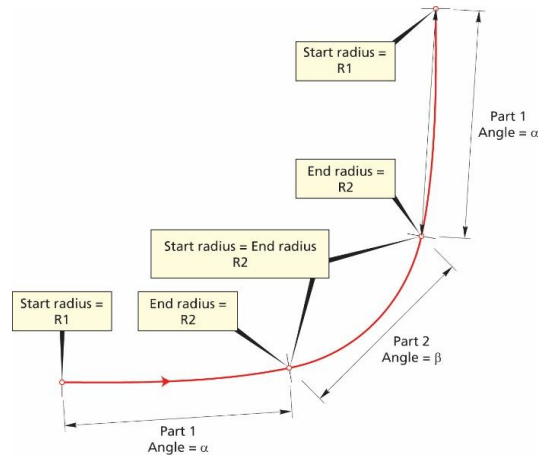
1.1.2 VUT Lateral Path Error

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 **Error! Reference source not found.**



1.1.3 Test paths for turning scenarios

For CPTA, CBTA and CMFtap, the following parameters should be used to create the test paths.



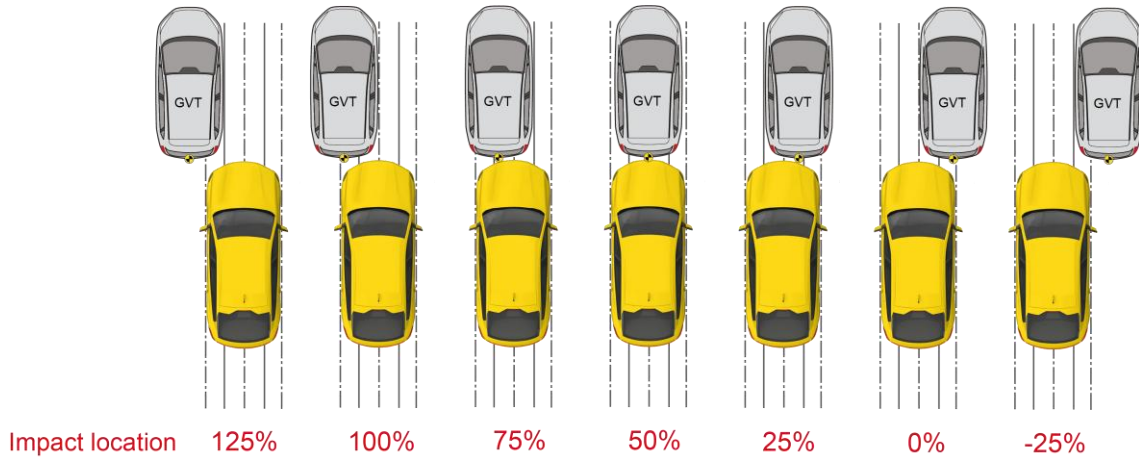
Test speed	Part 1 (clothoid)			Part 2 (constant radius)			Part 3 (clothoid)		
	Start Radius R1 [m]	End Radius R2 [m]	Angle α [deg]	Start Radius R2 [m]	End Radius R2 [m]	Angle β [deg]	Start Radius R2 [m]	End Radius R1 [m]	Angle α [deg]
10 km/h to Farside	1500	9.00	20.62	9.00	9.00	48.76	9.00	1500	20.62
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

* Trajectory for 25 km/h should be the same as the trajectory for 20 km/h

1.1.4 Impact location

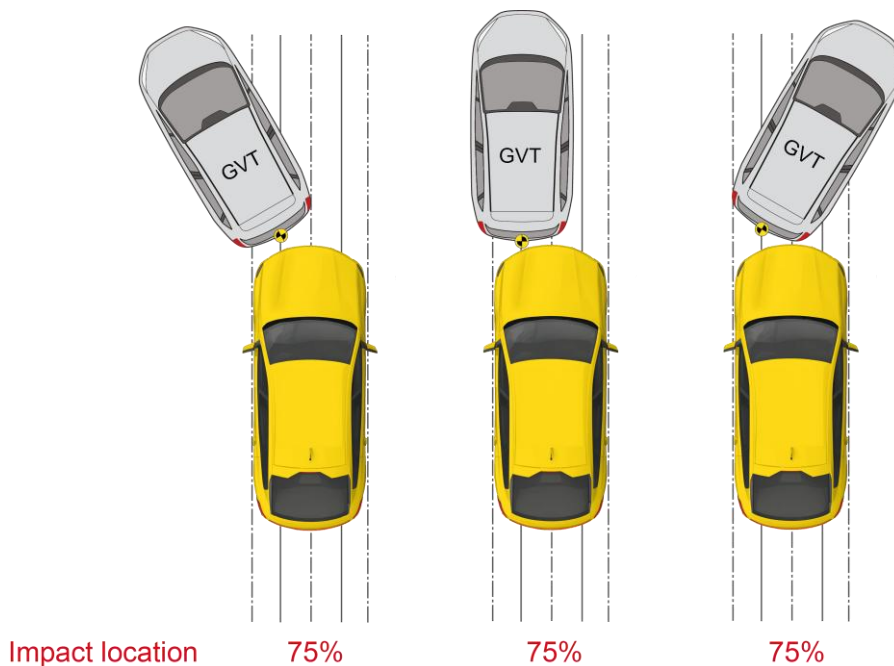
1.1.4.1 Car-to-Car Rear

Impact location related to VUT and Target Reference Point “Mid-Rear-End”:



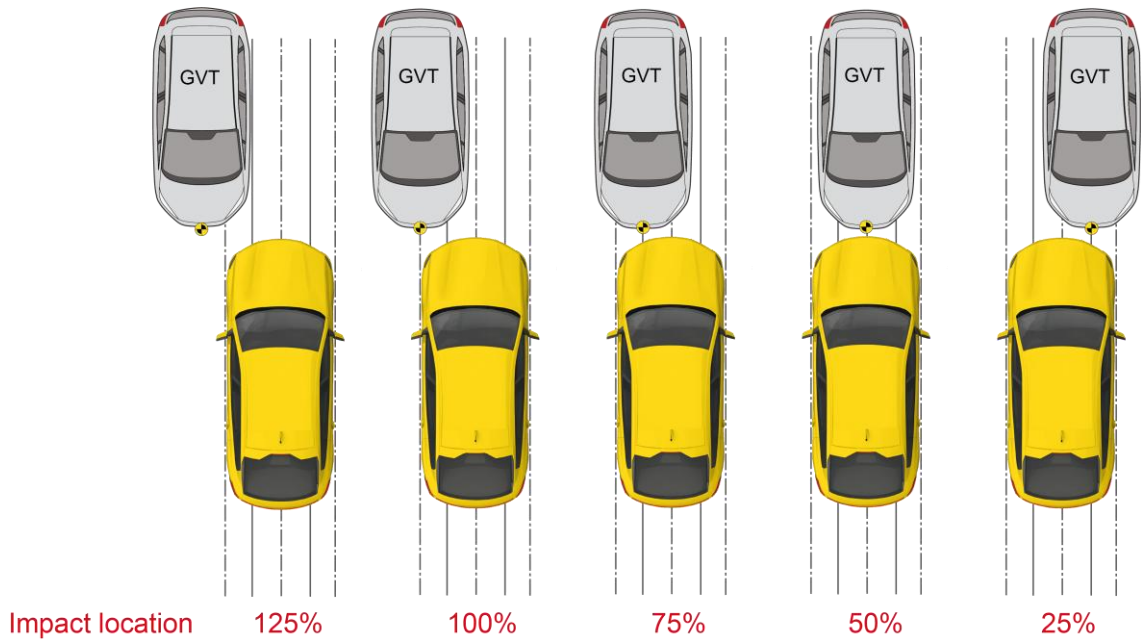
1.1.4.2 Car-to-car Rear + Heading

Rotation by target reference point, dependent on combination of VUT impact location and rotation direction, collision may occur with corner edge before impact location and target reference point contact:



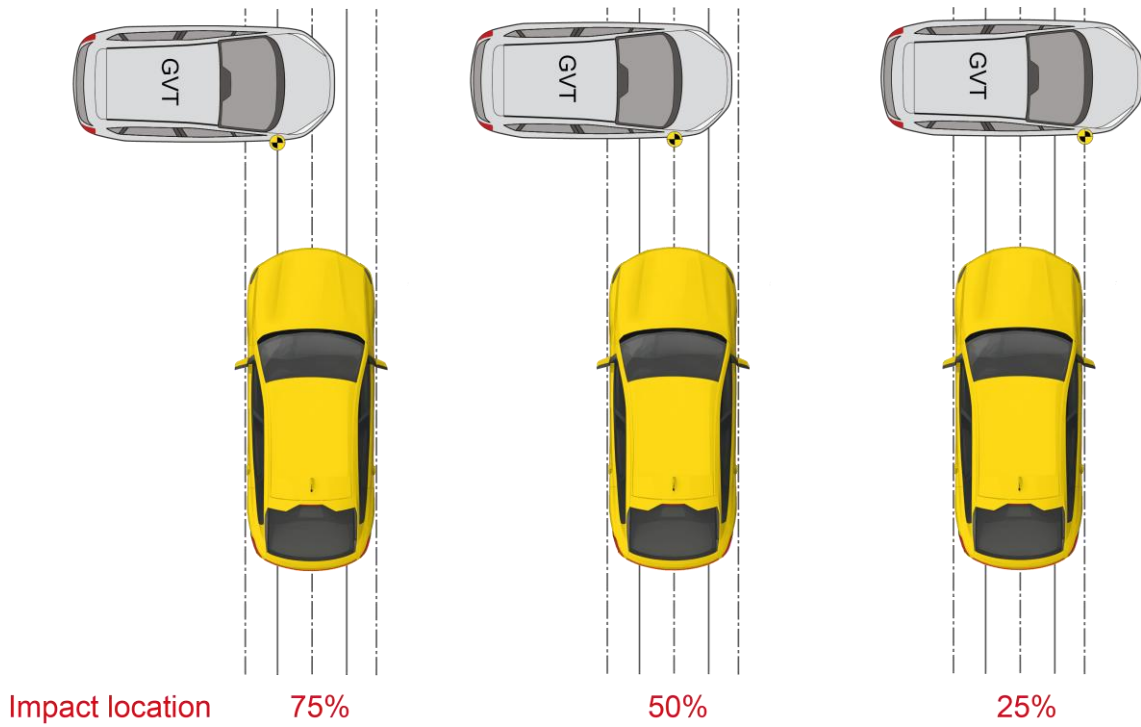
1.1.4.3 Car-to-Car Front

Impact location related to VUT and Target Reference Point “Mid-Front”:

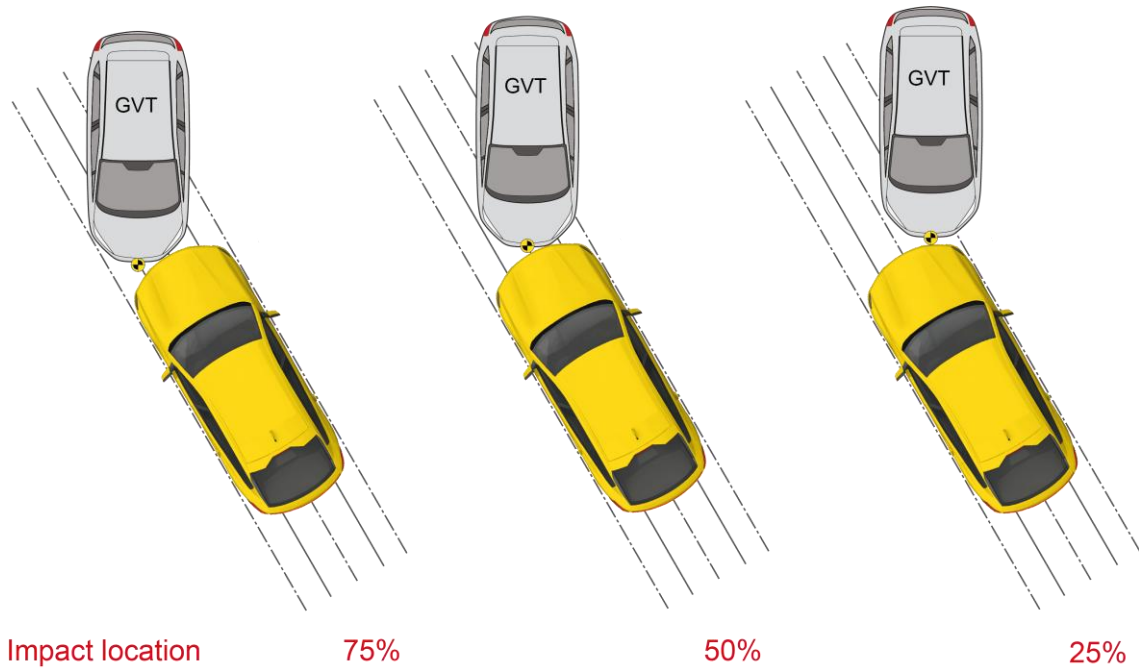


1.1.4.4 Car-to-Car Crossing

Impact location related to VUT and Target Reference Point "Front-Axle center on VUT side":



1.1.4.5 Turn Across Path



1.2 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.

1.2.1 Virtual Boxes

1.2.1.1 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.

1.2.1.2 Impact location descriptions in Chapter 3.1.2 and scenario descriptions in Chapter 5 illustrate which of the reference points is to be utilised for each specific scenario.

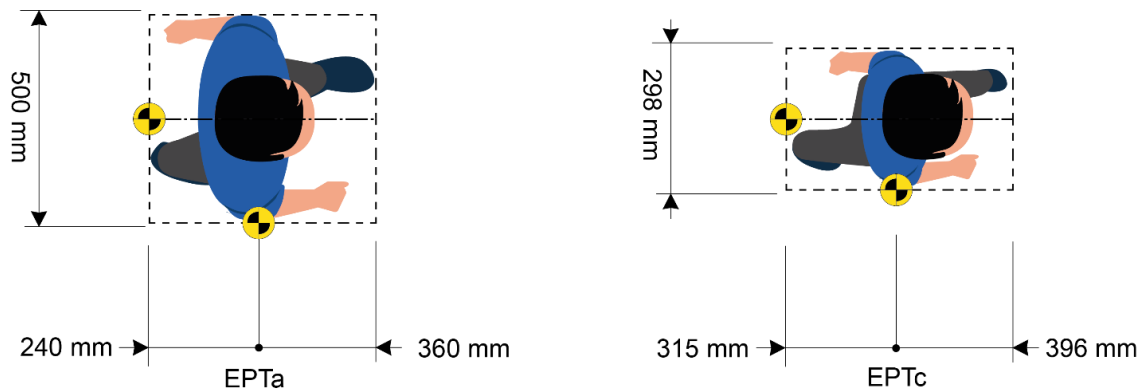


Figure 1.2.1: Virtual box dimensions around EPTa and EPTc

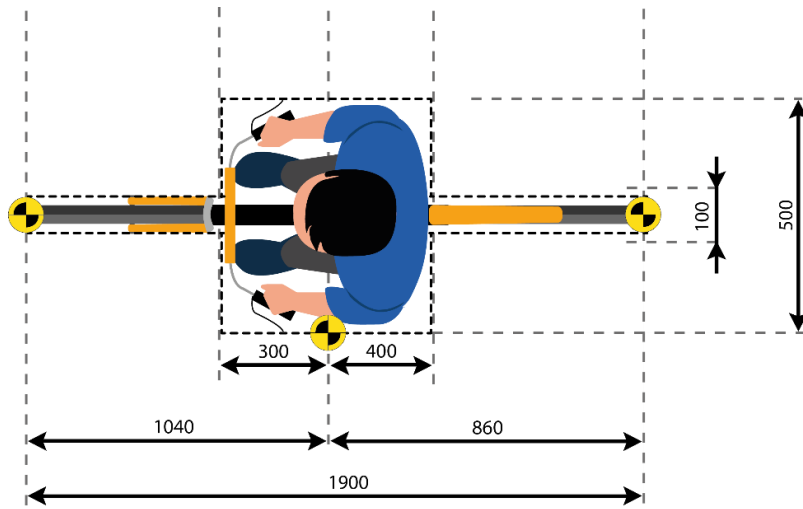


Figure 1.2.2: Virtual box dimensions around EBT

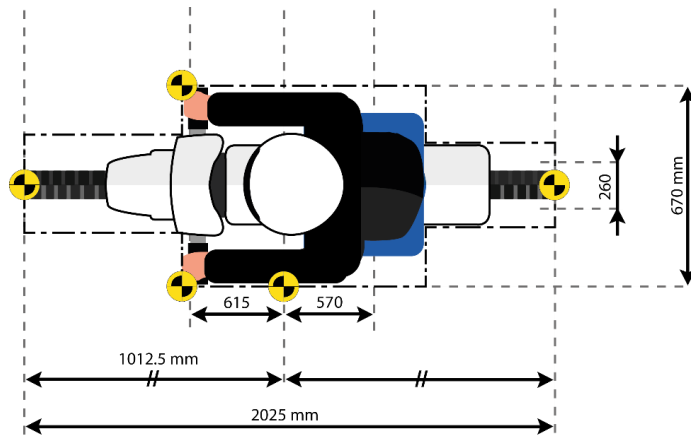


Figure 1.2.3: Virtual box dimensions around EMT

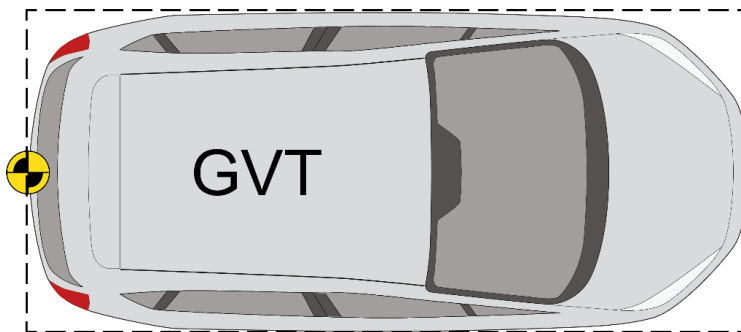


Figure 1.2.4: Virtual box illustration around the GVT, and the rear impact point

1.3 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.

1.3.1 Variables

Time	T
T_0 , time of test start. Unless otherwise stated $T_0 = TTC - 4s$ - Scenarios involving steering: T_0 is 1s. before T_{steer}	T_0
T_{AEB} , time where AEB activates	T_{AEB}
T_{FCW} , time where FCW activates	T_{FCW}
T_{impact} , time where VUT impacts GVT	T_{impact}
T_{steer} , time where VUT enters in curve segment	T_{steer}
$T_{GVT_deceleration_start}$, time where GVT starts decelerating (deceleration to be reached in 1.0 seconds)	$T_{GVT_deceleration_start}$
T_{start} , time where VUT starts moving (in CCCscp start from stop scenario)	T_{start}
T_{End} , time where VUT has travelled 2.9m. from the start position (in CCCscp start from stop scenario)	T_{End}
T_{Avg} , average time value of T_{End} from all the executed trials (in CCCscp start from stop scenario)	T_{Avg}
Position of the VUT during the entire test	X_{VUT}, Y_{VUT}
Position of the GVT during the entire test	X_{GVT}, Y_{GVT}
Position of the EMT during the entire test	X_{EMT}, Y_{EMT}
Speed of the VUT during the entire test	V_{VUT}
V_{impact} , speed when VUT impacts GVT	V_{impact}
V_{rel_impact} , relative speed when VUT impacts GVT	V_{rel_impact}
Speed of the target during the entire test	V_{target}
Yaw velocity of the VUT during the entire test	ψ_{VUT}
Yaw velocity of the target during the entire test	ψ_{target}
Acceleration of the VUT during the entire test	A_{VUT}
Acceleration of the target during the entire test	A_{target}
Steering wheel velocity of the VUT during the entire test	Ω_{VUT}

1.3.2 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 0.1m/s²;
- VUT steering wheel velocity to 1.0 °/s

1.3.3 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 $\pm 1\%$ and a maximum lateral slope of $\pm 3\%$. 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.

2.2 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

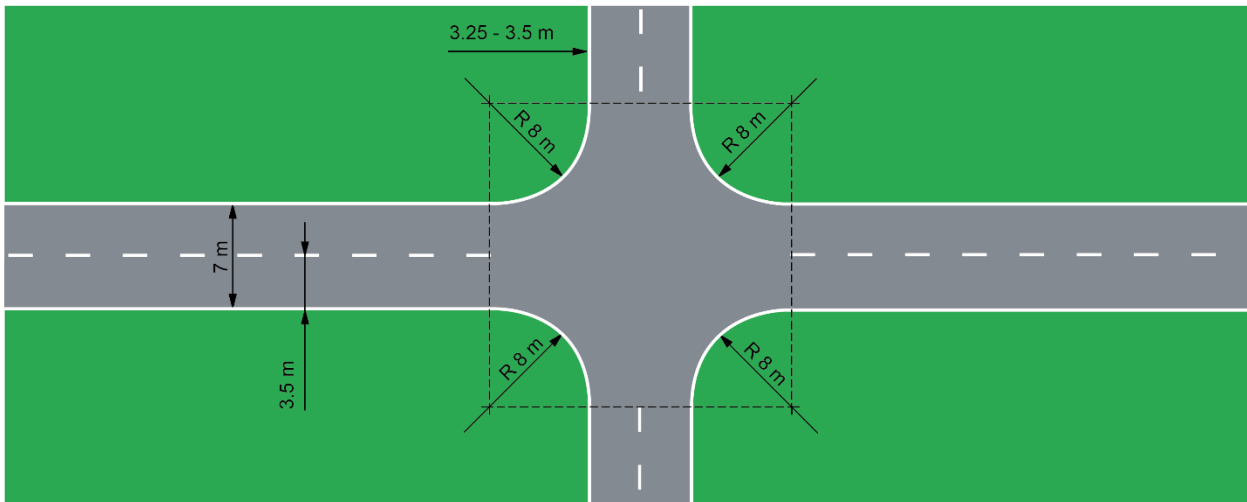


Figure 4.2: Layout of junction and the connecting lanes

2.3 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 GVT 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 GVT. 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.

2.4 VUT Preparation

2.4.1 AEB and FCW 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.

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.

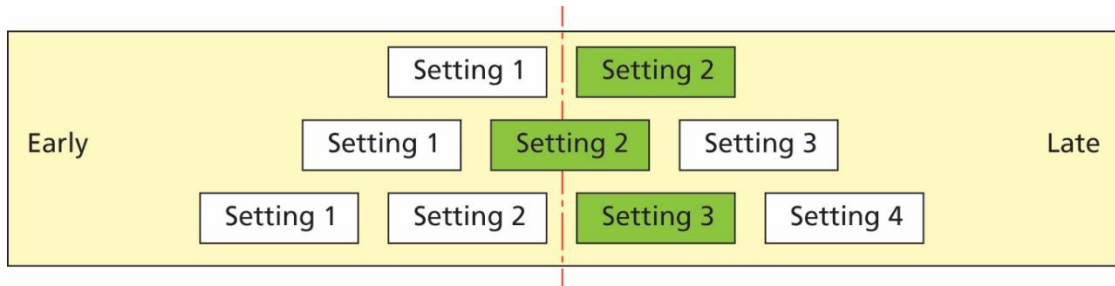


Figure 4.4: AEB and/or FCW system setting for testing

2.4.2 Deployable Pedestrian/VRU Protection Systems

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

2.4.3 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.

2.4.4 Wheel Alignment Measurement and Unladen Kerb Mass

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.

Fill up the tank with fuel to at least 90% of the tank's capacity of fuel.

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.

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 car.

Ensure that all tyres are inflated according to the manufacturer's instructions for the appropriate loading condition.

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.

Calculate the required ballast mass, by subtracting the mass of the test driver and test equipment from the required 200 kg interior load.

2.4.5 Vehicle Preparation

Fit the on-board test equipment and instrumentation in the vehicle. Also fit any associated cables, cabling boxes and power sources and place weights with a mass of the ballast mass. Any items added should be securely attached to the car.

With the driver in the vehicle, weigh the front and rear axle loads of the vehicle and compare these loads with the "unladen kerb mass"

The total vehicle mass shall be within $\pm 1\%$ of the sum of the unladen kerb mass, plus 200kg. The front/rear axle load distribution needs to be within 5% of the front/rear axle load distribution of the original unladen kerb mass plus full fuel load. If the vehicle differs from the requirements given in this paragraph, items may be removed or added to the vehicle which has no influence on its performance. Any items added to increase the vehicle mass should be securely attached to the car.

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

For all scenarios, the assessment is based on a GRID prediction provided by the Vehicle Manufacturer. 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).

3.1 Car & PTW Scenarios

The Standard and Extended Ranges for Car & PTW scenarios are shown below:

3.1.1 Longitudinal

3.1.1.1 Car-to-Car Rear

Three scenarios are considered for CCR: Stationary, Moving and Braking.

The impact locations applicable for CCR are illustrated in 1.1.4.1

CCRs	GVT speed	Function	Impact Location						
			125%	100%	75%	50%	25%	0%	-25%
10 km/h	0 km/h	AEB							
20 km/h	0 km/h	AEB							
30 km/h	0 km/h	AEB							
40 km/h	0 km/h	AEB							
50 km/h	0 km/h	AEB							
60 km/h	0 km/h	FCW							
70 km/h	0 km/h	FCW							
80 km/h	0 km/h	FCW							

 Standard Range
 Extended Range

CCRm	GVT speed	Function	Impact Location						
			125%	100%	75%	50%	25%	0%	-25%
30 km/h	20 km/h	AEB							
40 km/h	20 km/h	AEB							
50 km/h	20 km/h	AEB							
60 km/h	20 km/h	AEB							
70 km/h	20 km/h	AEB							
80 km/h	20 km/h	AEB							
90 km/h	30 km/h	AEB							
100 km/h	40 km/h	AEB							
110 km/h	50 km/h	AEB							
120 km/h	60 km/h	AEB							
130 km/h	70 km/h	AEB							

 Standard Range
 Extended Range

CCRb	GVT speed	Function	Impact Location						
			125%	100%	75%	50%	25%	0%	-25%
30 km/h	30 km/h	AEB							
40 km/h	40 km/h	AEB							
50 km/h	50 km/h	AEB							
60 km/h	60 km/h	AEB							
70 km/h	70 km/h	AEB							
80 km/h	80 km/h	AEB							
90 km/h	90 km/h	AEB							
100 km/h	100 km/h	AEB							
110 km/h	110 km/h	AEB							
120 km/h	120 km/h	AEB							
130 km/h	130 km/h	AEB							

 Standard Range
 Extended Range

For CCRb, the Time Headway = 1.0 s, and the target acceleration = -4m/s^2 for both Standard Range and Extended Range.

3.1.1.2 Car-to-Car Front

The Standard and Extended Ranges for Car-to-Car Front scenarios are shown below:

CCFhos	GVT speed	Impact Location			
		100%	75%	50%	25%
30 km/h	50 km/h	Standard Range	Standard Range	Standard Range	Standard Range
40 km/h	50 km/h	Standard Range	Standard Range	Standard Range	Standard Range
50 km/h	50 km/h	Standard Range	Standard Range	Standard Range	Standard Range
60 km/h	70 km/h	Standard Range	Standard Range	Standard Range	Standard Range
70 km/h	70 km/h	Standard Range	Standard Range	Standard Range	Standard Range
80 km/h	70 km/h	Standard Range	Standard Range	Standard Range	Standard Range
90 km/h	90 km/h	Extended Range	Extended Range	Extended Range	Extended Range
100 km/h	100 km/h	Extended Range	Extended Range	Extended Range	Extended Range

Standard Range
 Extended Range

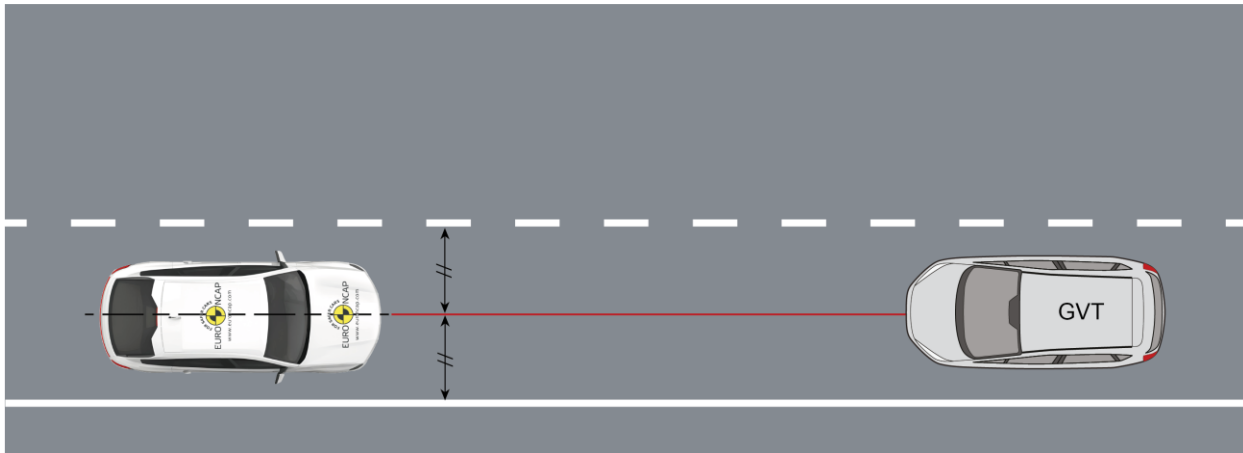


Figure 3-1 CCFhos

CCFhol	GVT speed	Impact Location			
		100%	75%	50%	25%
30 km/h	50 km/h	Standard Range	Standard Range	Standard Range	Standard Range
40 km/h	50 km/h	Standard Range	Standard Range	Standard Range	Standard Range
50 km/h	50 km/h	Standard Range	Standard Range	Standard Range	Standard Range
60 km/h	70 km/h	Standard Range	Standard Range	Standard Range	Standard Range
70 km/h	70 km/h	Standard Range	Standard Range	Standard Range	Standard Range
80 km/h	70 km/h	Standard Range	Standard Range	Standard Range	Standard Range
90 km/h	90 km/h	Extended Range	Extended Range	Extended Range	Extended Range
100 km/h	100 km/h	Extended Range	Extended Range	Extended Range	Extended Range

Standard Range
 Extended Range

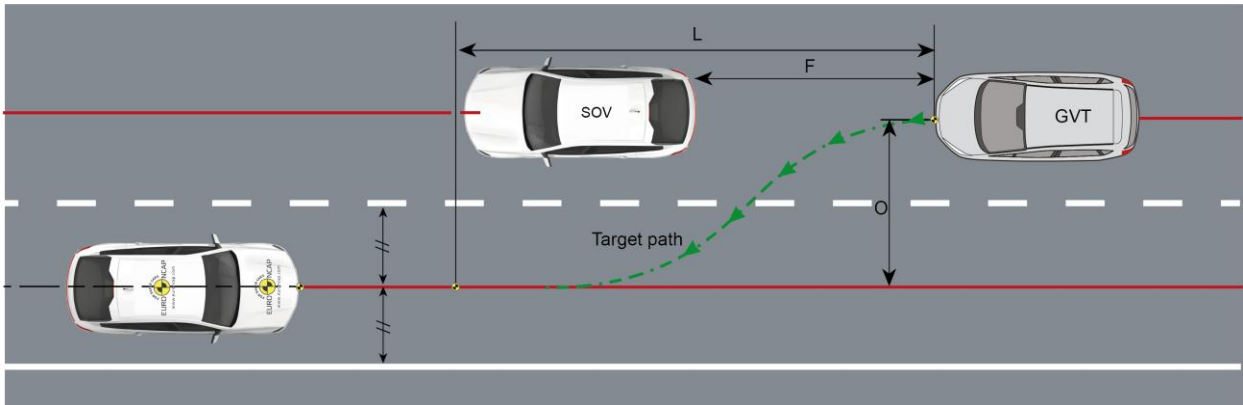


Figure 3-2 CCFhol

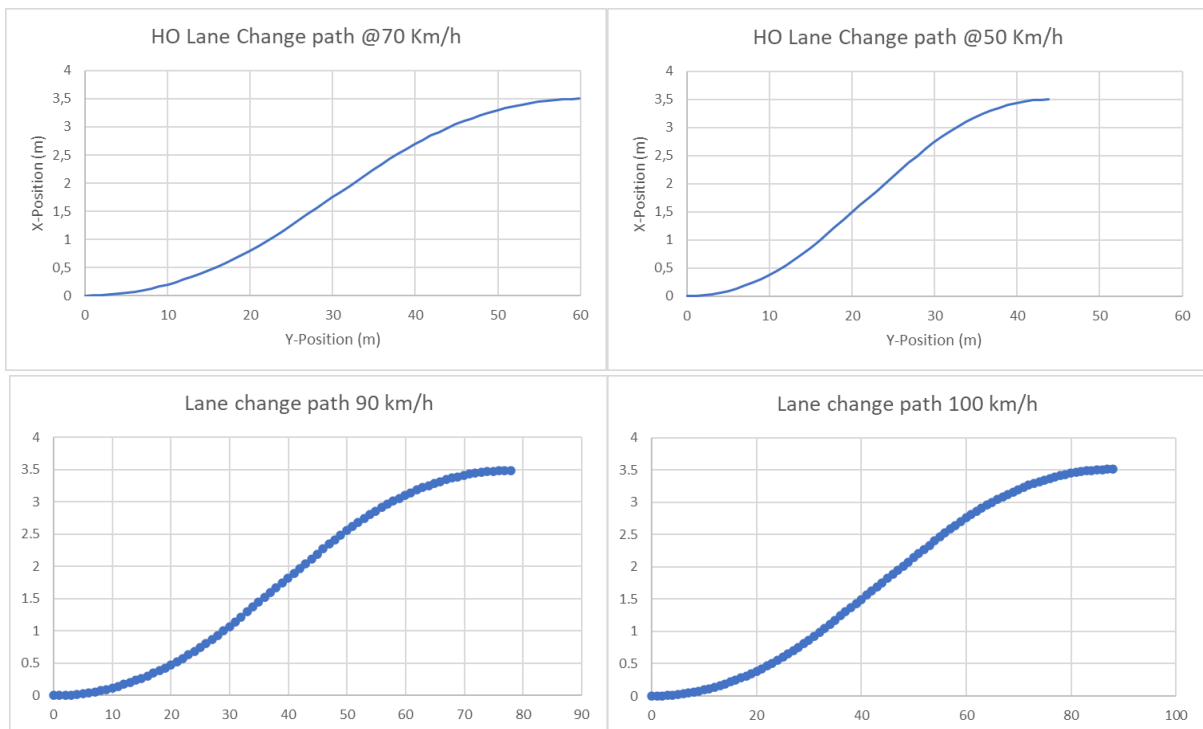


Figure 3-3 CCFhol path at 70, 50, 90 and 100 km/h

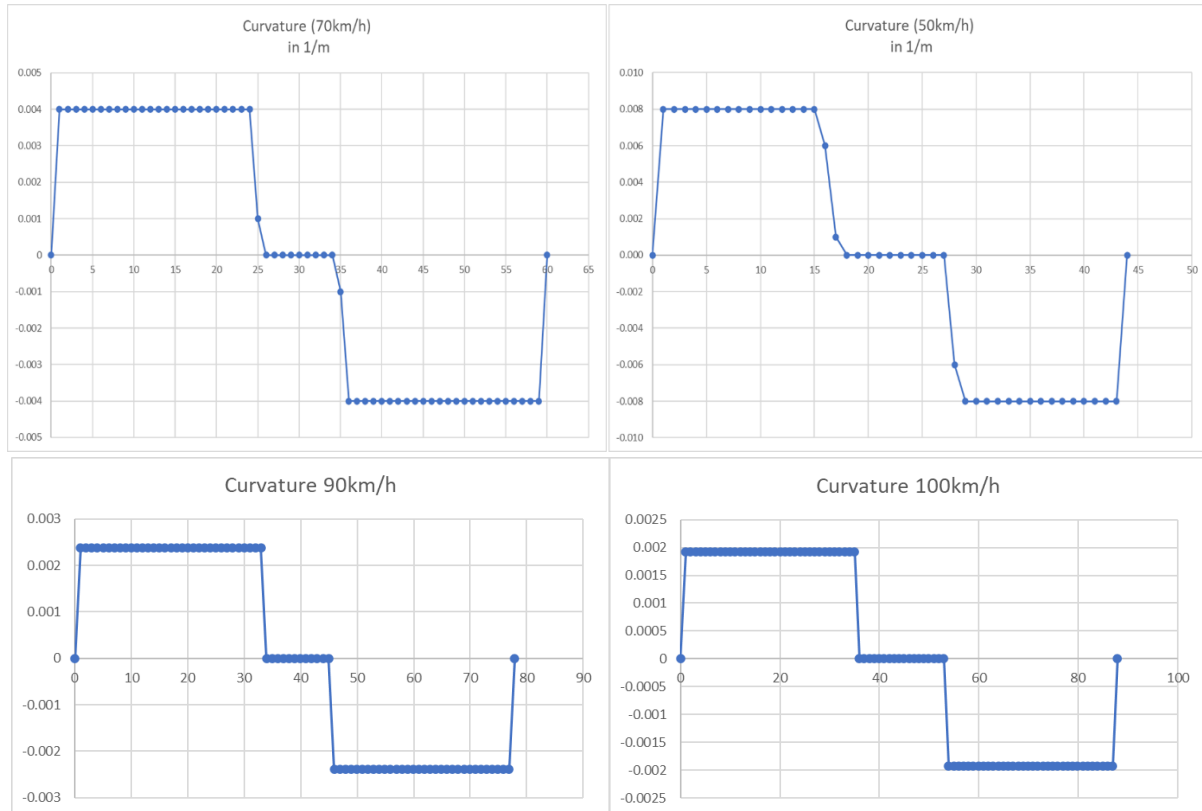


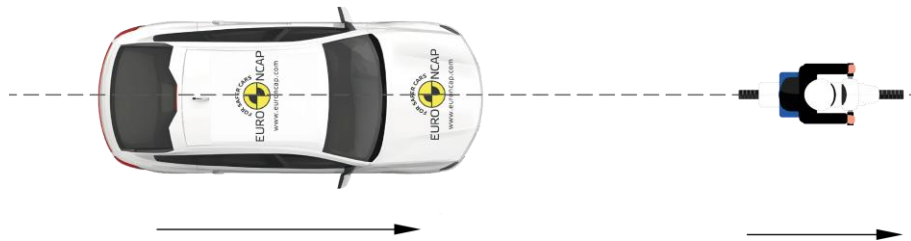
Figure 3-4 CCFhol curvature values at 70 and 50 km/h

GVT 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/s ²
70 km/h	3.5 m	0.0039	60 m	[19.4] m	[1.5] s	1.50 m/s ²
90 km/h	3.5 m	0.0023	78 m	[25.0] m	[1.5] s	1.50 m/s ²
100 km/h	3.5 m	0.0019	88 m	[27.8] m	[1.5] s	1.50 m/s ²

3.1.1.3 Car-to-Motorcyclist Rear

CMRs	EMT speed	Function	Impact Location				
			90%	75%	50%	25%	10%
10 km/h	0 km/h	AEB	Standard Range	Standard Range	Standard Range	Standard Range	Extended Range
20 km/h	0 km/h	AEB	Standard Range	Standard Range	Standard Range	Standard Range	Extended Range
30 km/h	0 km/h	AEB	Standard Range	Standard Range	Standard Range	Standard Range	Extended Range
40 km/h	0 km/h	AEB	Standard Range	Standard Range	Standard Range	Standard Range	Extended Range
50 km/h	0 km/h	AEB	Standard Range	Standard Range	Standard Range	Standard Range	Extended Range
60 km/h	0 km/h	FCW	Standard Range	Standard Range	Standard Range	Standard Range	Extended Range
70 km/h	0 km/h	FCW	Standard Range	Standard Range	Standard Range	Standard Range	Extended Range
80 km/h	0 km/h	FCW	Standard Range	Standard Range	Standard Range	Standard Range	Extended Range

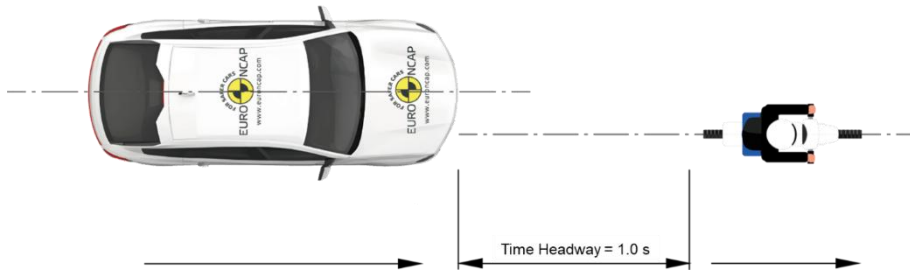
Standard Range
 Extended Range



CMRb	EMT Speed	Function	Impact Location				
			90%	75%	50%	25%	10%
30 km/h	30 km/h	AEB					
40 km/h	40 km/h	AEB					
50 km/h	50 km/h	AEB					
60 km/h	60 km/h	AEB					
70 km/h	70 km/h	AEB					
80 km/h	80 km/h	AEB					
90 km/h	90 km/h	AEB					
100 km/h	100 km/h	AEB					
110 km/h	110 km/h	AEB					
120 km/h	120 km/h	AEB					
130 km/h	130 km/h	AEB					

 Standard Range
 Extended Range

For CMRb, the Time Headway = 1.0 s, and the target acceleration = -4m/s^2 for both Standard Range and Extended range.



3.1.2 Turning

3.1.2.1 Car-to-Car Turn Across Path

CCFtap	GVT speed			
	30 km/h	45 km/h	60 km/h	80 km/h
10 km/h				
15 km/h				
20 km/h				
25 km/h				

Standard Range
 Extended Range

For the CCFtap scenario, for the VUT assume an initial straight-line path followed by a turn (clothoid, fixed radius and clothoid as specified in section 1.1.3 **Error! Reference source not found.**), followed again by a straight line, hereby known as the test path. The direction indicator is applied at $1.0s \pm 0.5s$ 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.

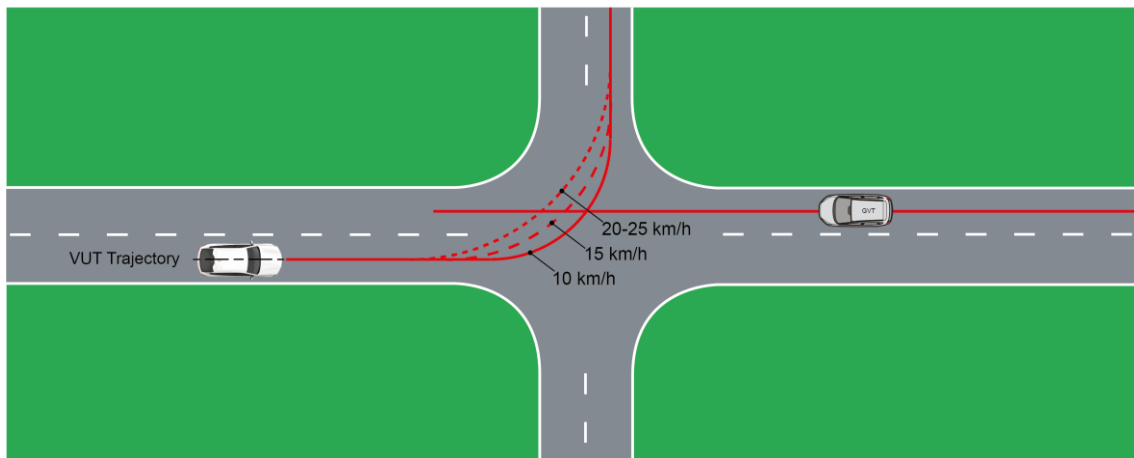


Figure 3-5 CCFtap scenario VUT and GVT paths

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 $\pm [1.0]$ m when determined in accordance with section

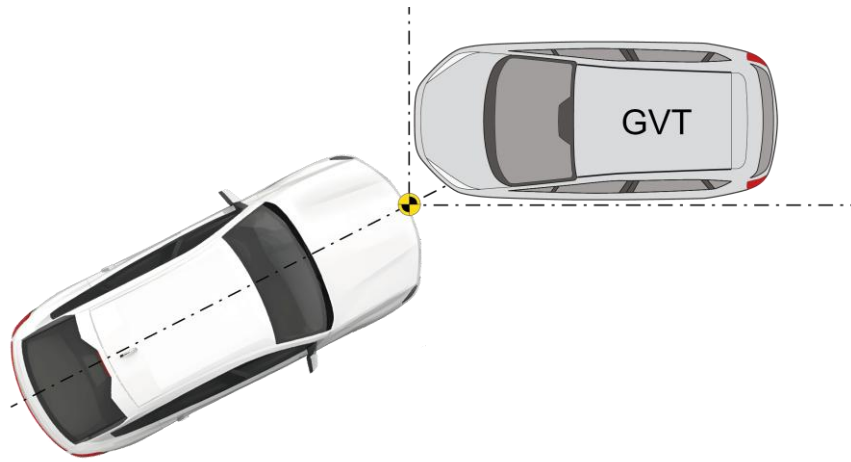


Figure 3-6 CCFtap impact location definition

3.1.2.2 Car-to-Motorcyclist Turn Across Path

CMFtap	EMT speed			
	30 km/h	45 km/h	60 km/h	80 km/h
10 km/h				
15 km/h				
20 km/h				
25 km/h				

Standard Range
 Extended Range

For the CMFtap scenario, for the VUT assume an initial straight-line path followed by a turn (clothoid, fixed radius and clothoid as specified in section 1.1.3), followed again by a straight line, hereby known as the test path. The direction indicator is applied at $1.0s \pm 0.5s$ 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 $\pm [1.0]$ m when determined in accordance with section 1.1.1

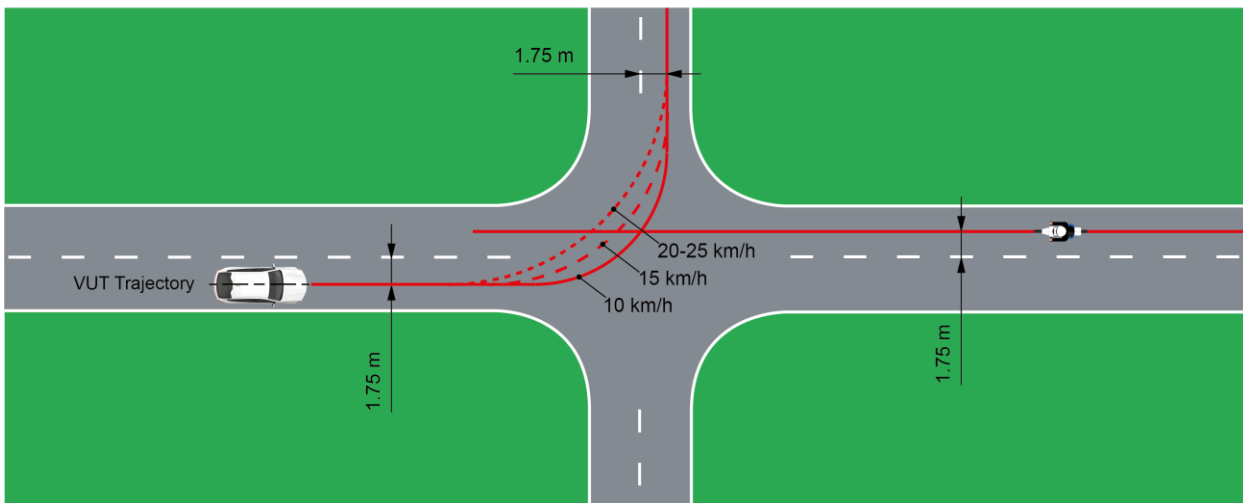


Figure 3-7 CMFtap scenario VUT and EMT paths

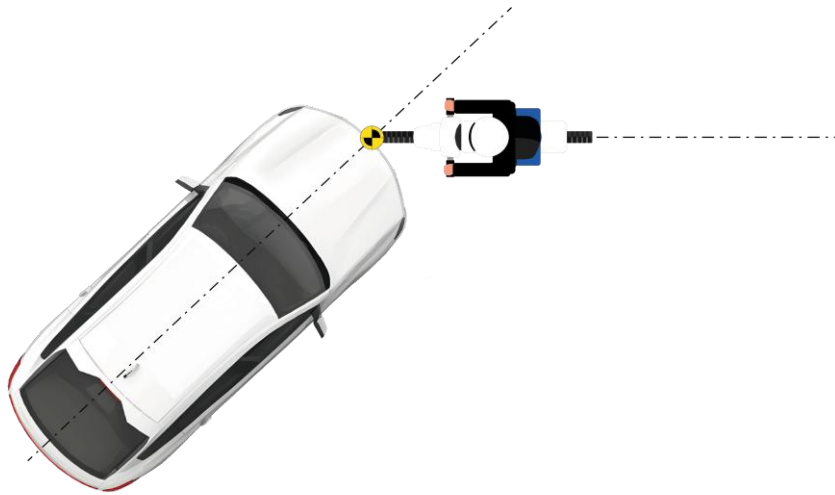


Figure 3-8 CMFtap impact location definition

3.1.3 Crossing

3.1.3.1 Car-to-Car Crossing

CCCscp	Function	GVT speed							
		20 km/h	30 km/h	40 km/h	50 km/h	60 km/h	70 km/h	80 km/h	
20 km/h	AEB								
30 km/h	AEB								
40 km/h	AEB						N/A	N/A	
50 km/h	AEB						N/A	N/A	
60 km/h	AEB						N/A	N/A	
70 km/h	AEB			N/A	N/A	N/A	N/A	N/A	
80 km/h	AEB			N/A	N/A	N/A	N/A	N/A	

Standard Range (obstructed)
 Extended Range (unobstructed)

The obstruction is formed by 3 vehicles parked at both sides along the VUT trajectory, parked either at the farside (when target approaches from the farside) or nearside (when target approaches from the nearside). The closest vehicle to the intersection is a Large obscuration vehicle, followed by a Small obscuration vehicle, and finally followed by any vehicle available at the premises of the test laboratory.

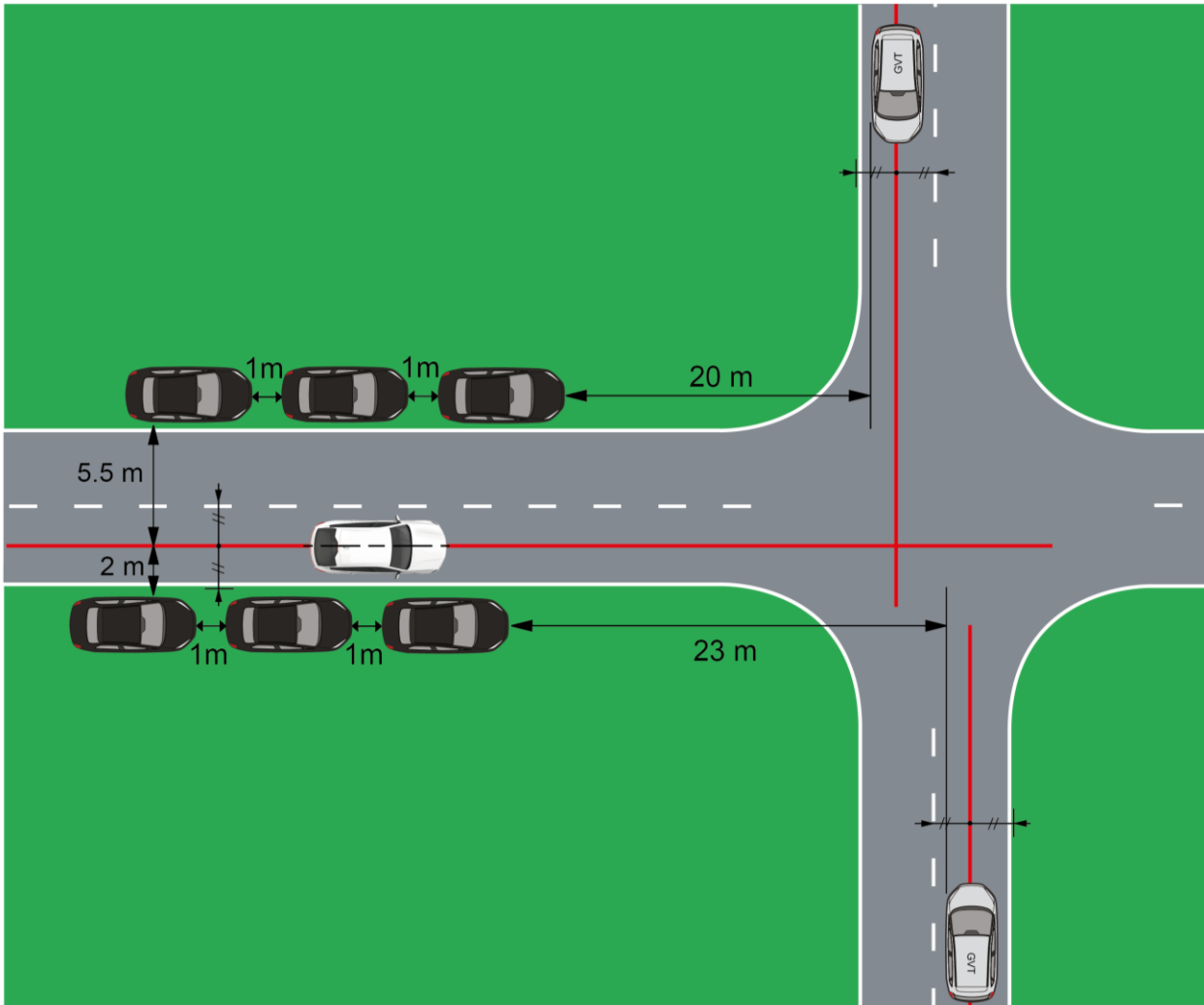


Figure 3-9 CCCscp, obstructed

For CCCscp, the impact location shall be 50%, for both Standard and Extended Range.

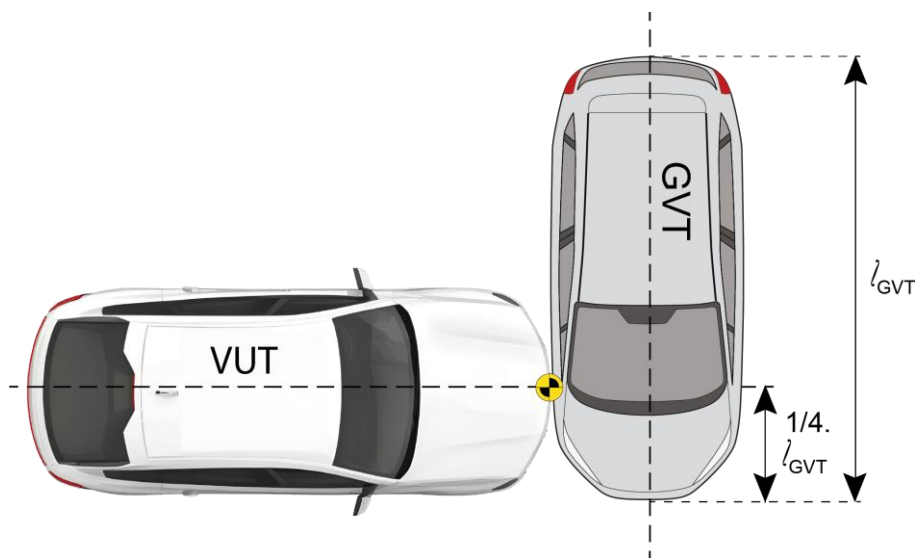


Figure 3-10 Impact location on CCCscp

3.1.3.2 Car-to-Motorcyclist Crossing

CMCscp	Function	EMT speed						
		20 km/h	30 km/h	40 km/h	50 km/h	60 km/h	70 km/h	80 km/h
20 km/h	AEB							
30 km/h	AEB							
40 km/h	AEB						N/A	N/A
50 km/h	AEB						N/A	N/A
60 km/h	AEB						N/A	N/A
70 km/h	AEB			N/A	N/A	N/A	N/A	N/A
80 km/h	AEB			N/A	N/A	N/A	N/A	N/A

Standard Range (Obstructed)
 Extended Range (Unobstructed)

The obstruction is formed by 3 vehicles parked at both sides along the VUT trajectory, parked either at the farside (when target approaches from the farside) or nearside (when target approaches from the nearside). The closest vehicle to the intersection is a Large obscuration vehicle, followed by a Small obscuration vehicle, and finally followed by any vehicle available at the premises of the test laboratory.

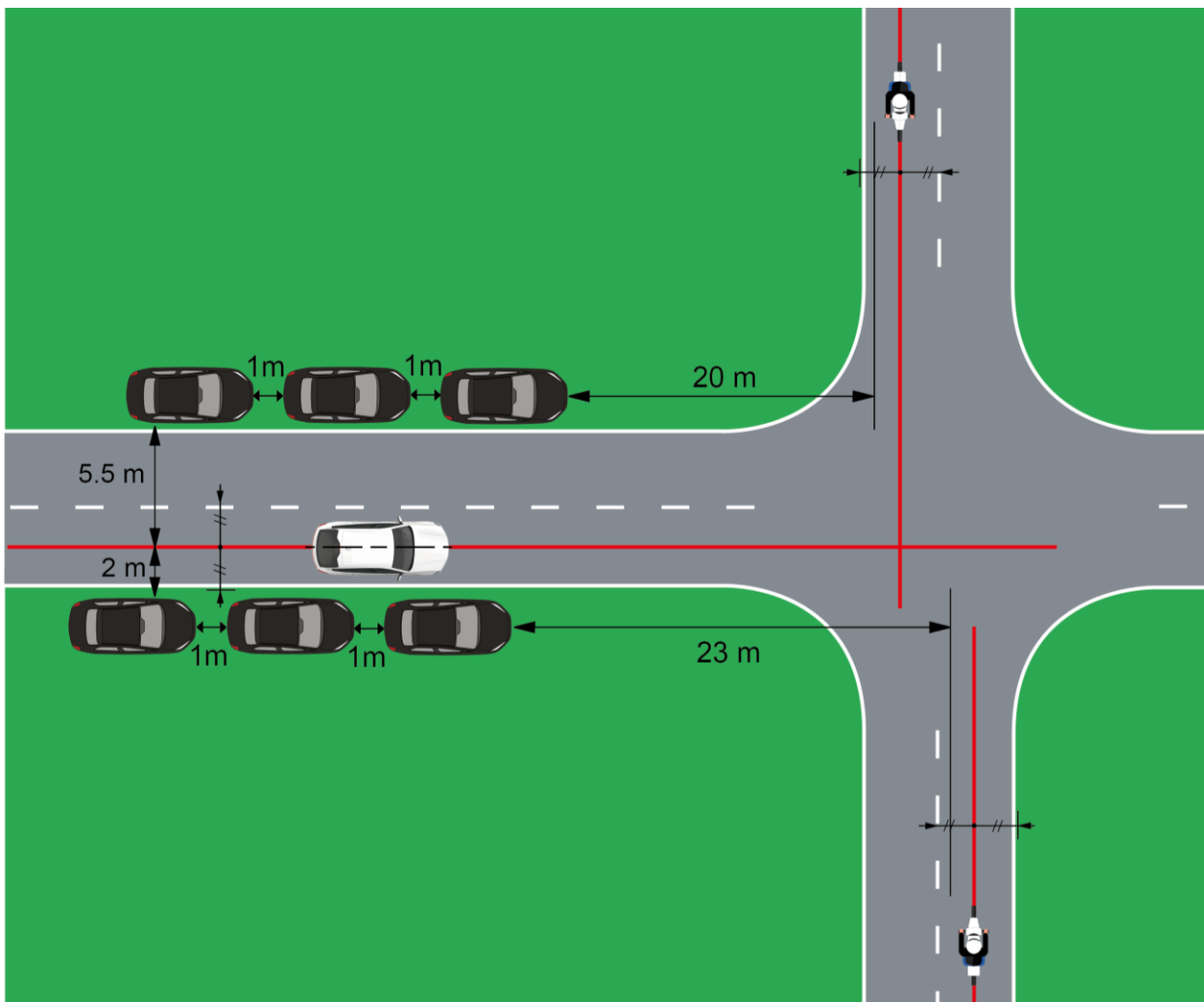


Figure 3-11 CMCscp, obstructed

For CMCscp, the impact location shall be 0% (target approaching from nearside) and 100% (target approaching from farside), for both Standard and Extended Range.

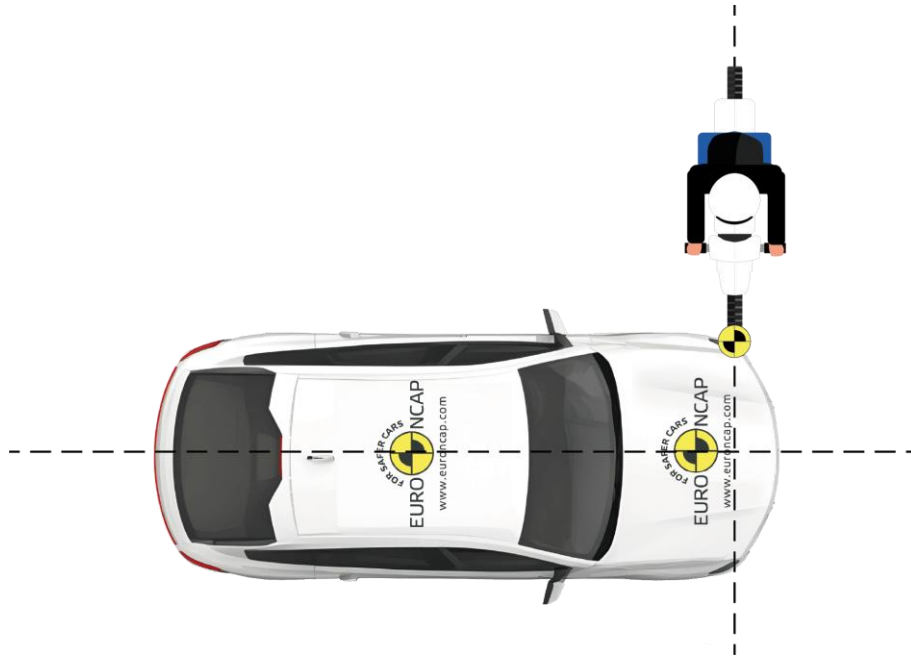


Figure 3-12 100% Impact location on CMCscp (target approaching from farside)

3.2 Pedestrian & Cyclist Scenarios

The Standard and Extended Ranges for Pedestrian & Cyclist scenarios are shown below:

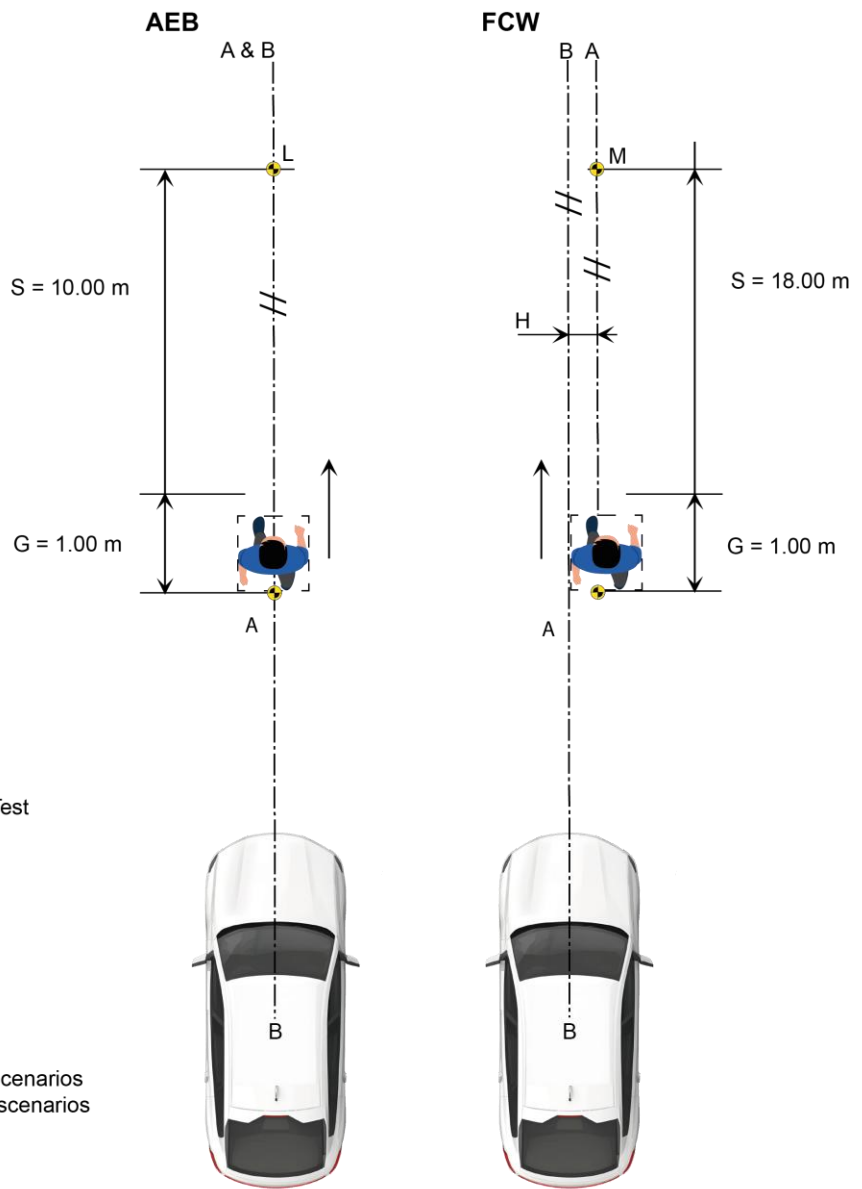
3.2.1 Longitudinal

3.2.1.1 Car-to-Pedestrian Longitudinal

CPLA	EPT speed	Function	*/C	Impact Location			
				10%	25%	50%	75%
10 km/h	5 km/h	AEB	*				
20 km/h	5 km/h	AEB	*				
30 km/h	5 km/h	AEB	*				
40 km/h	5 km/h	AEB	*				
50 km/h	5 km/h	AEB	*				
60 km/h	5 km/h	AEB	*				
50 km/h	5 km/h	FCW	*				
60 km/h	5 km/h	FCW	*				
70 km/h	5 km/h	FCW	*				
80 km/h	5 km/h	FCW	*				
10 km/h	5 km/h	AEB	C				
20 km/h	5 km/h	AEB	C				
30 km/h	5 km/h	AEB	C				
40 km/h	5 km/h	AEB	C				
50 km/h	5 km/h	AEB	C				
60 km/h	5 km/h	AEB	C				
50 km/h	5 km/h	FCW	C				
60 km/h	5 km/h	FCW	C				
70 km/h	5 km/h	FCW	C				
80 km/h	5 km/h	FCW	C				

	Standard Range
	Extended Range

For nighttime tests (marked with C), illumination conditions shall apply as described in APPENDIX C.



Axes

- AA - Trajectory of bicyclist rear tire
- 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 3-13 CPLA scenario, Longitudinal walking Adult

3.2.1.2 Car-to-Bicyclist Longitudinal

CBLA	EBT speed	Function	Impact Location			
			10%	25%	50%	75%
20 km/h	15 km/h	AEB				
30 km/h	15 km/h	AEB				
40 km/h	15 km/h	AEB				
50 km/h	15 km/h	AEB				
60 km/h	15 km/h	AEB				
50 km/h	15 km/h	FCW				
60 km/h	15 km/h	FCW				
70 km/h	15 km/h	FCW				
80 km/h	15 km/h	FCW				

Standard Range
 Extended Range

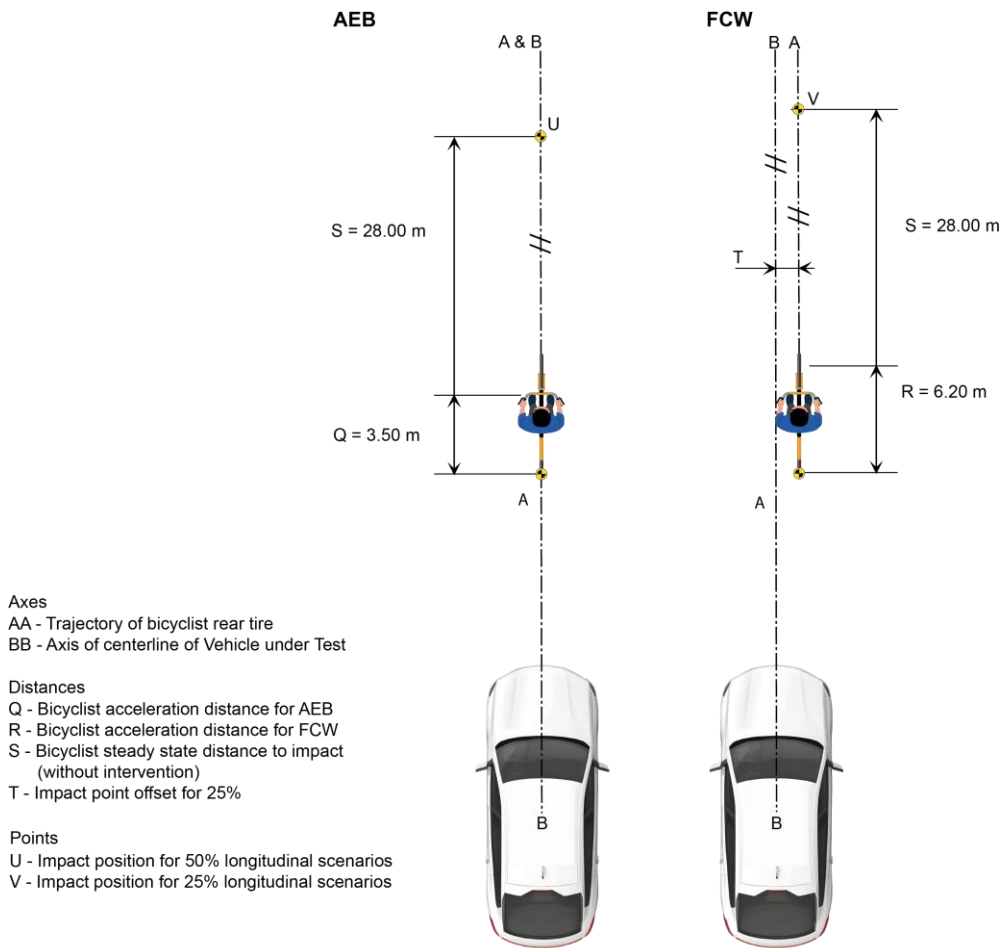


Figure 3-14 CBLA scenarios, Longitudinal Bicyclist (AEB left & FCW right)

3.2.2 Turning

3.2.2.1 Car-to-Pedestrian Turning

The CPTA scenario consists of 4 sub-scenarios

- CPTAfs: Farside turn, target travelling in the same direction
- CPTAfo: Farside turn, target travelling in the opposite direction
- CPTAns: Nearside turn, target travelling in the same direction
- CPTAno: Nearside turn, target travelling in the opposite direction

The 25 km/h turn as part of the Extended Range is conducted in the 20 km/h path (where applicable).

CPTAfs	Turn	EPT Direction	EPT Speed	Impact Location				
				10%	25%	50%	75%	90%
10 km/h	Farside	Same	5 km/h					
15 km/h	Farside	Same	5 km/h					
20 km/h	Farside	Same	5 km/h					
25 km/h	Farside	Same	5 km/h					

Standard Range
 Extended Range

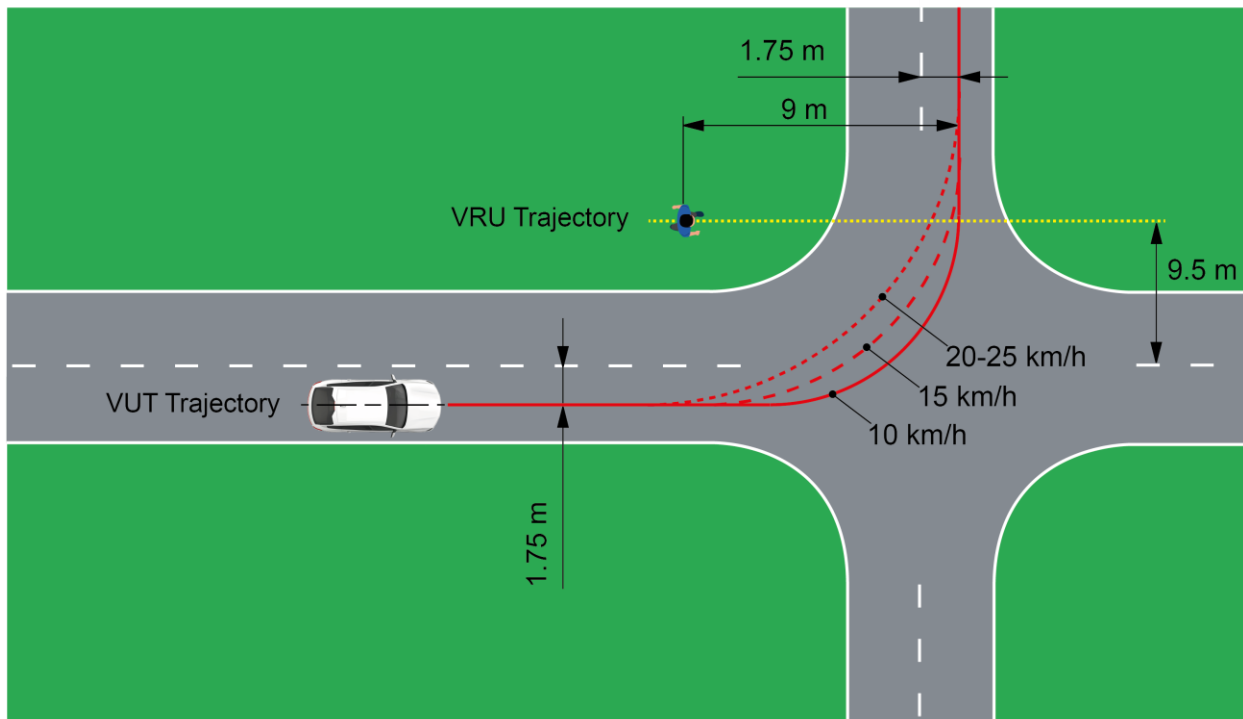


Figure 3-15 CPTAfs scenario – VUT left turn, pedestrian crossing from farside

CPTAfo	Turn	EPT Direction	EPT Speed	Impact Location				
				10%	25%	50%	75%	90%
10 km/h	Farside	Opposite	5 km/h					
15 km/h	Farside	Opposite	5 km/h					
20 km/h	Farside	Opposite	5 km/h					
25 km/h	Farside	Opposite	5 km/h					

Standard Range
 Extended Range

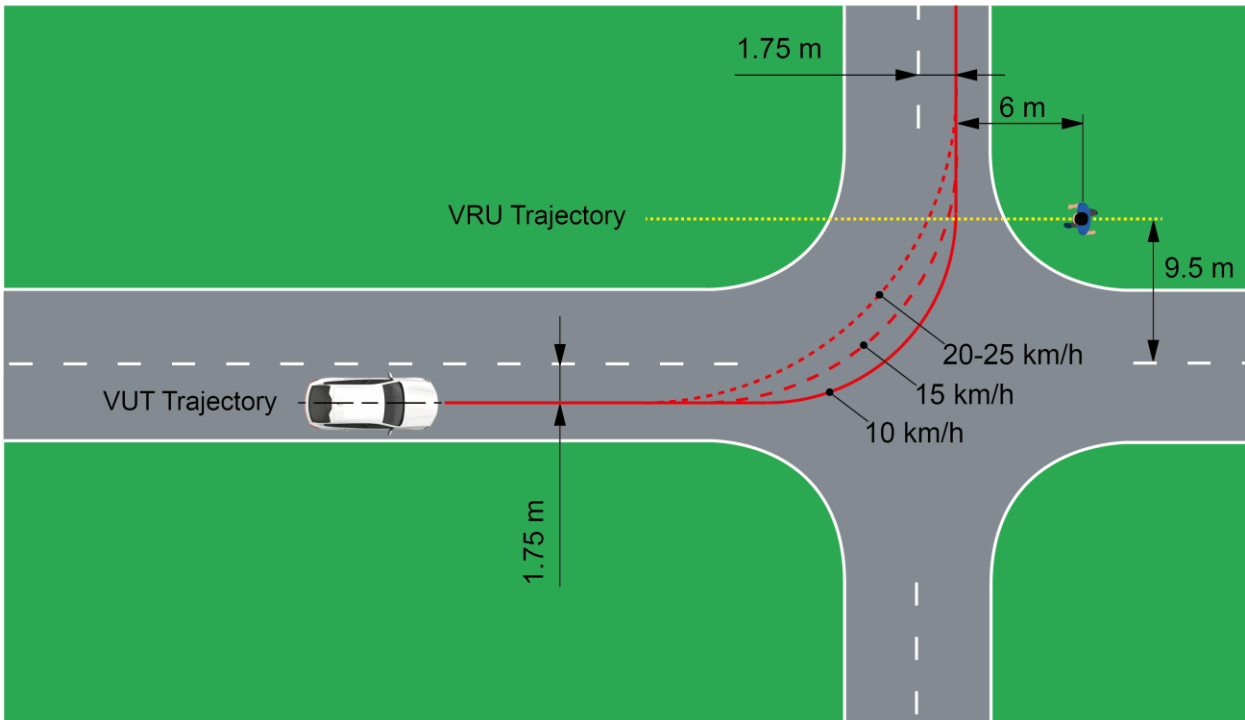


Figure 3-16 CPTAfo scenario – VUT left turn, pedestrian crossing from nearside

CPTAno	Turn	EPT Direction	EPT Speed	Impact Location				
				10%	25%	50%	75%	90%
10 km/h	Nearside	Opposite	5 km/h					

Standard Range
 Extended Range

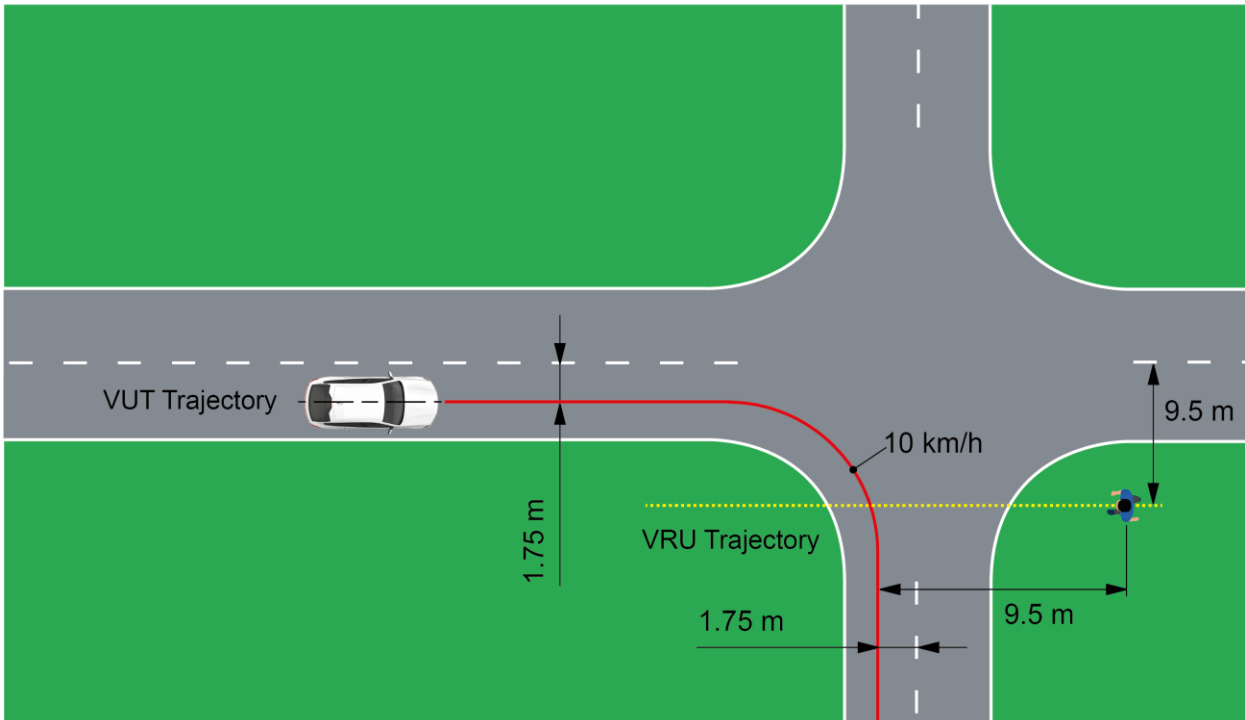


Figure 3-17 CPTAno scenario – VUT right turn, pedestrian crossing from farside

CPTAns	Turn	EPT Direction	EPT Speed	Impact Location				
				10%	25%	50%	75%	90%
10 km/h	Nearside	Same	5 km/h					

Standard Range
 Extended Range

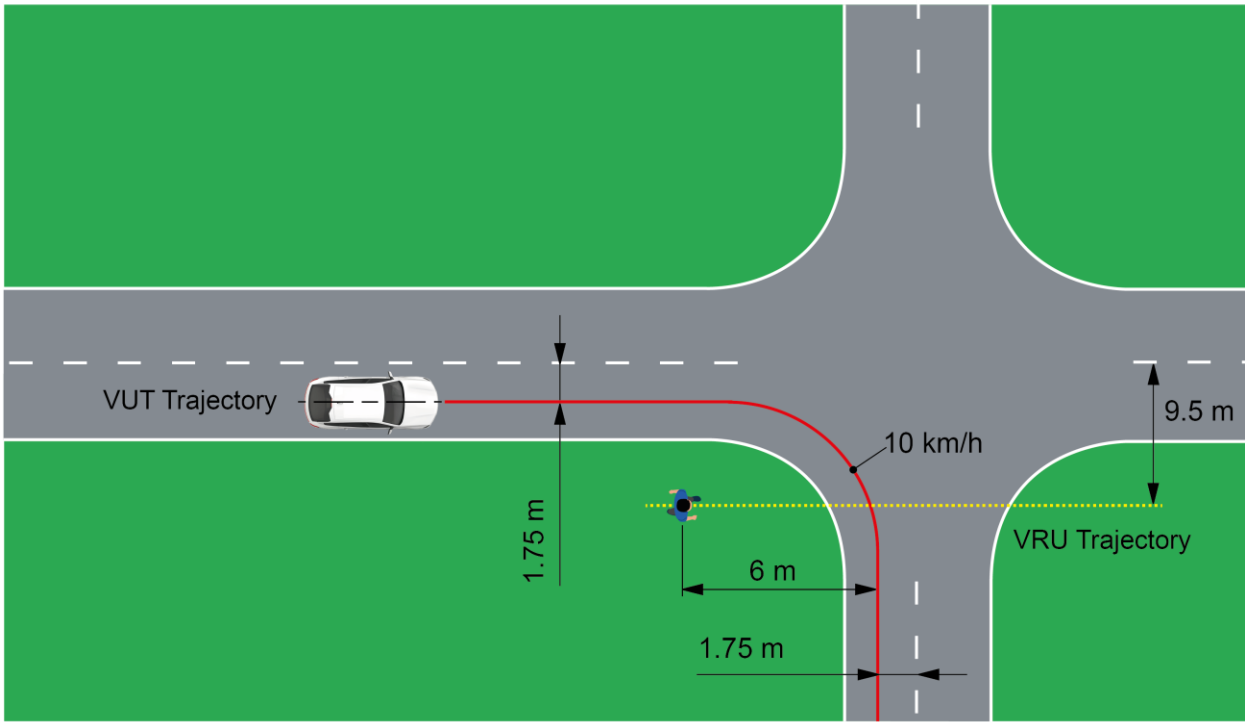


Figure 3-18 CPTAns scenario – VUT right turn, pedestrian crossing from nearside

3.2.2.2 Car-to-Bicyclist Turning

The CBTA scenario consists of 4 sub-scenarios

- CBTAfs: Farside turn, target travelling in the same direction
- CBTAfo: Farside turn, target travelling in the opposite direction
- CBTAns: Nearside turn, target travelling in the same direction
- CBTAno: Nearside turn, target travelling in the opposite direction

In all cases, the target speed is 15 km/h.

The 25 km/h turn as part of the Extended Range is conducted in the 20 km/h path (where applicable).

CBTAfs	Turn	EBT Direction	EBT Speed	Impact Location	
				100%	Front Axle
10 km/h	Farside	Same	15 km/h		
15 km/h	Farside	Same	15 km/h		
20 km/h	Farside	Same	15 km/h		
25 km/h	Farside	Same	15 km/h		

CBTAfo	Turn	EBT Direction	EBT Speed	Impact Location				
				10%	25%	50%	75%	90%
10 km/h	Farside	Opposite	15 km/h					
15 km/h	Farside	Opposite	15 km/h					
20 km/h	Farside	Opposite	15 km/h					
25 km/h	Farside	Opposite	15 km/h					

CBTAns	Turn	EBT Direction	EBT Speed	Impact Location	
				Front Axle	0%
10 km/h	Nearside	Same	15 km/h		

CBTAno	Turn	EBT Direction	EBT Speed	Impact Location		
				25%	50%	75%
10 km/h	Nearside	Opposite	15 km/h			

Standard Range
 Extended Range

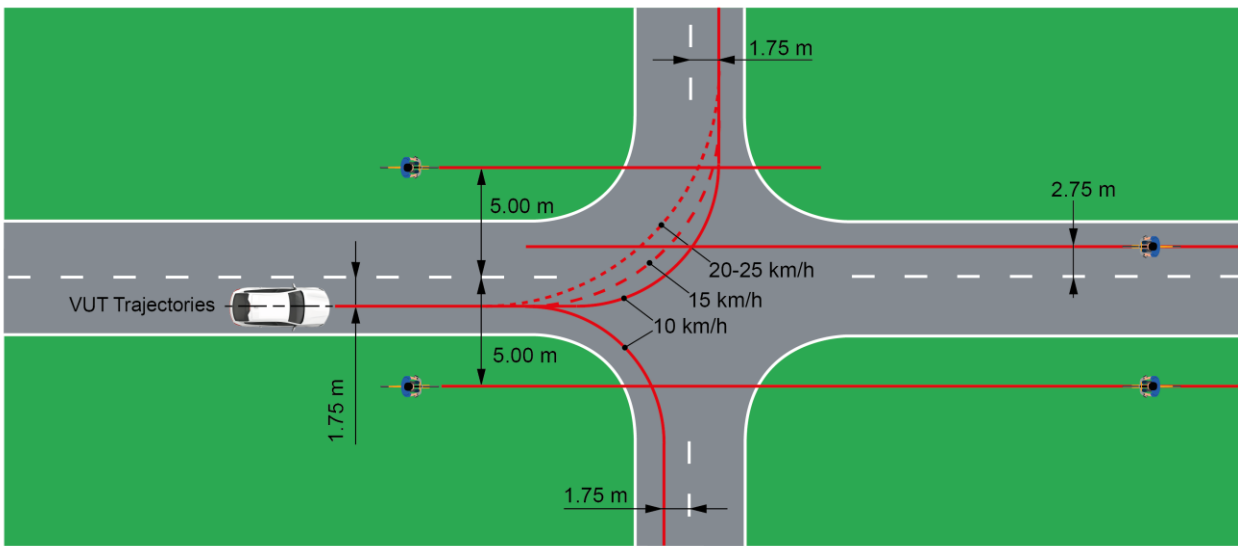


Figure 3-19 CBTA scenario

3.2.3 Crossing

3.2.3.1 Car-to-Pedestrian Crossing

CPNA	EPT Speed	*/C	Impact Location				
			10%	25%	50%	75%	90%
10 km/h	5 km/h	*					
20 km/h	5 km/h	*					
30 km/h	5 km/h	*					
40 km/h	5 km/h	*					
50 km/h	5 km/h	*					
60 km/h	5 km/h	*					
10 km/h	5 km/h	C					
20 km/h	5 km/h	C					
30 km/h	5 km/h	C					
40 km/h	5 km/h	C					
50 km/h	5 km/h	C					
60 km/h	5 km/h	C					

 Standard Range
 Extended Range

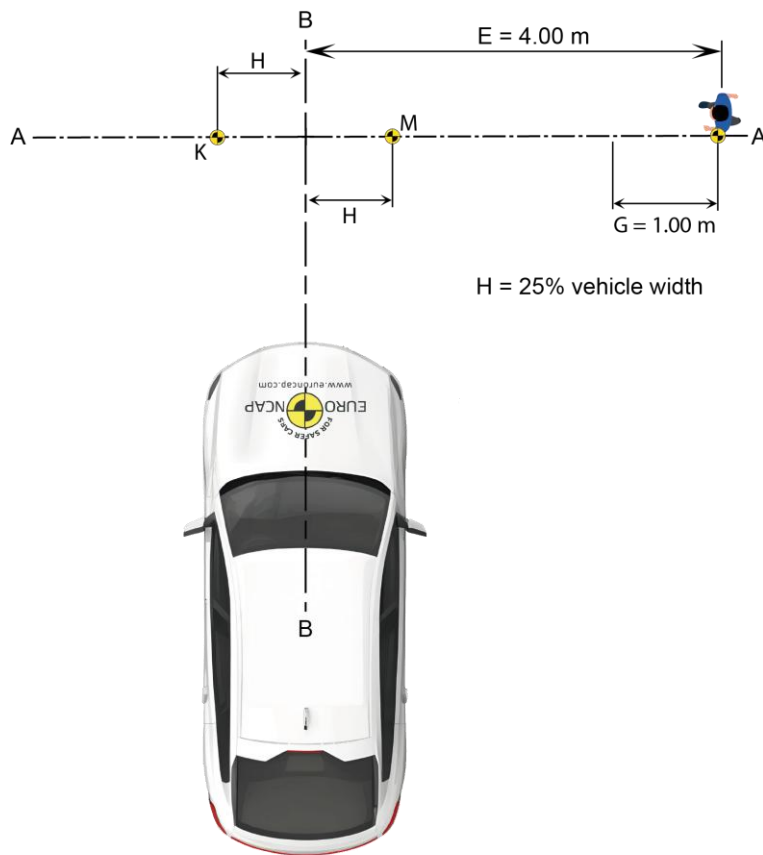


Figure 3-20 CPNA-25 & CPNA-75 scenarios, Walking Adult from Nearside

CPFA	EPT Speed	*/C	Impact Location				
			10%	25%	50%	75%	90%
10 km/h	8 km/h	*					
20 km/h	8 km/h	*					
30 km/h	8 km/h	*					
40 km/h	8 km/h	*					
50 km/h	8 km/h	*					
60 km/h	8 km/h	*					
10 km/h	8 km/h	C					
20 km/h	8 km/h	C					
30 km/h	8 km/h	C					
40 km/h	8 km/h	C					
50 km/h	8 km/h	C					
60 km/h	8 km/h	C					

Standard Range
 Extended Range

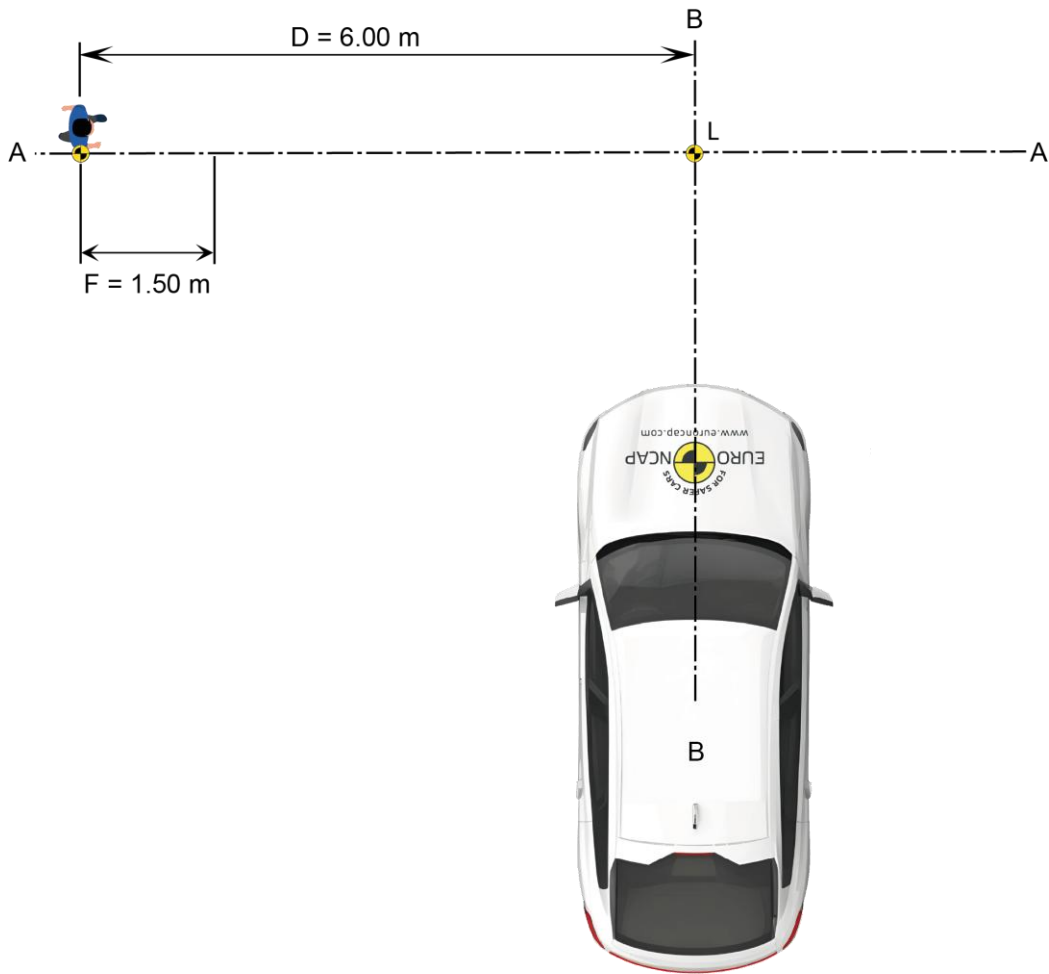


Figure 3-21 CPFA-50 scenario, Adult running from Farside

CPNCO	EPTc Speed	*/C	Impact Location		
			25%	50%	75%
10 km/h	5 km/h	*			
20 km/h	5 km/h	*			
30 km/h	5 km/h	*			
40 km/h	5 km/h	*			
50 km/h	5 km/h	*			
60 km/h	5 km/h	*			
10 km/h	5 km/h	C			
20 km/h	5 km/h	C			
30 km/h	5 km/h	C			
40 km/h	5 km/h	C			
50 km/h	5 km/h	C			
60 km/h	5 km/h	C			

 Standard Range
 Extended Range

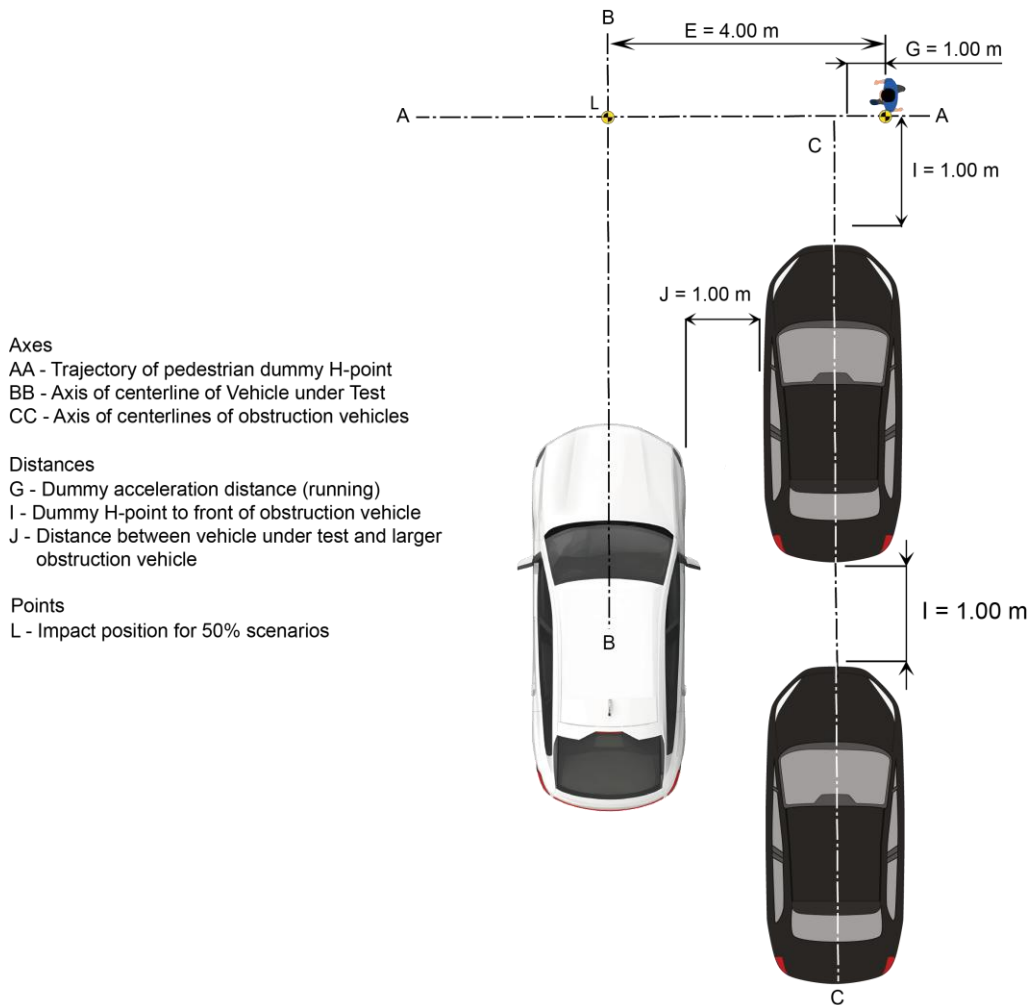


Figure 3-22 CPNCO-50 scenario, Running Child from Nearside from Obstruction (Annex B)

3.2.3.2 Car-to-Bicyclist Crossing

CBNA	EBT Speed	Impact Location				
		10%	25%	50%	75%	90%
10 km/h	15 km/h					
20 km/h	15 km/h					
30 km/h	15 km/h					
40 km/h	15 km/h					
50 km/h	15 km/h					
60 km/h	15 km/h					

Standard Range
 Extended Range

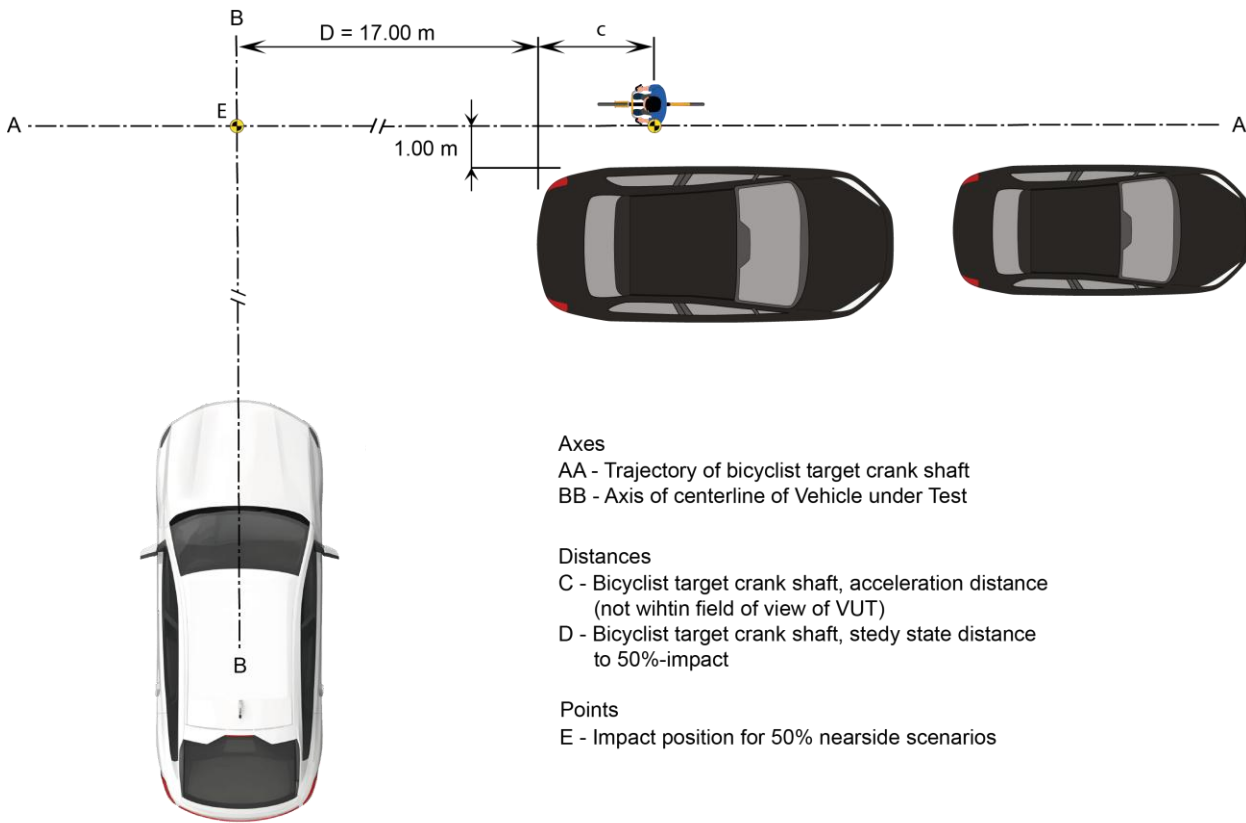


Figure 3-23 CBNA scenario, Bicyclist from Nearside

CBNAO	EBT Speed	Impact Location				
		10%	25%	50%	75%	90%
10 km/h	10 km/h					
20 km/h	10 km/h					
30 km/h	10 km/h					
40 km/h	10 km/h					
50 km/h	10 km/h					
60 km/h	10 km/h					

Standard Range
 Extended Range

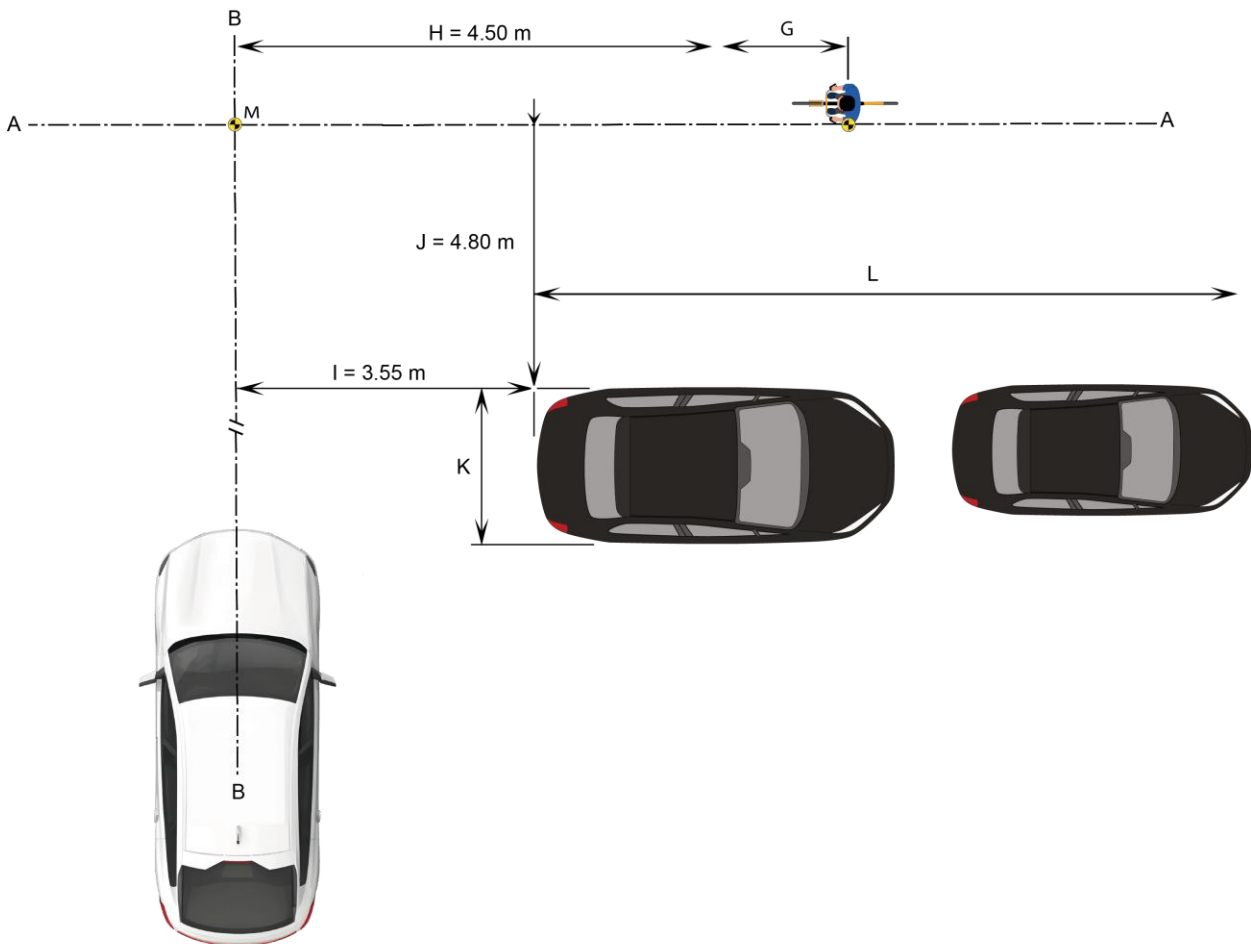


Figure 3-24 CBNAO scenario, Bicyclist from Nearside (obstructed)

CBFA	EBT Speed	Impact Location				
		10%	25%	50%	75%	90%
10 km/h	20 km/h					
20 km/h	20 km/h					
30 km/h	20 km/h					
40 km/h	20 km/h					
50 km/h	20 km/h					
60 km/h	20 km/h					

Standard Range
 Extended Range

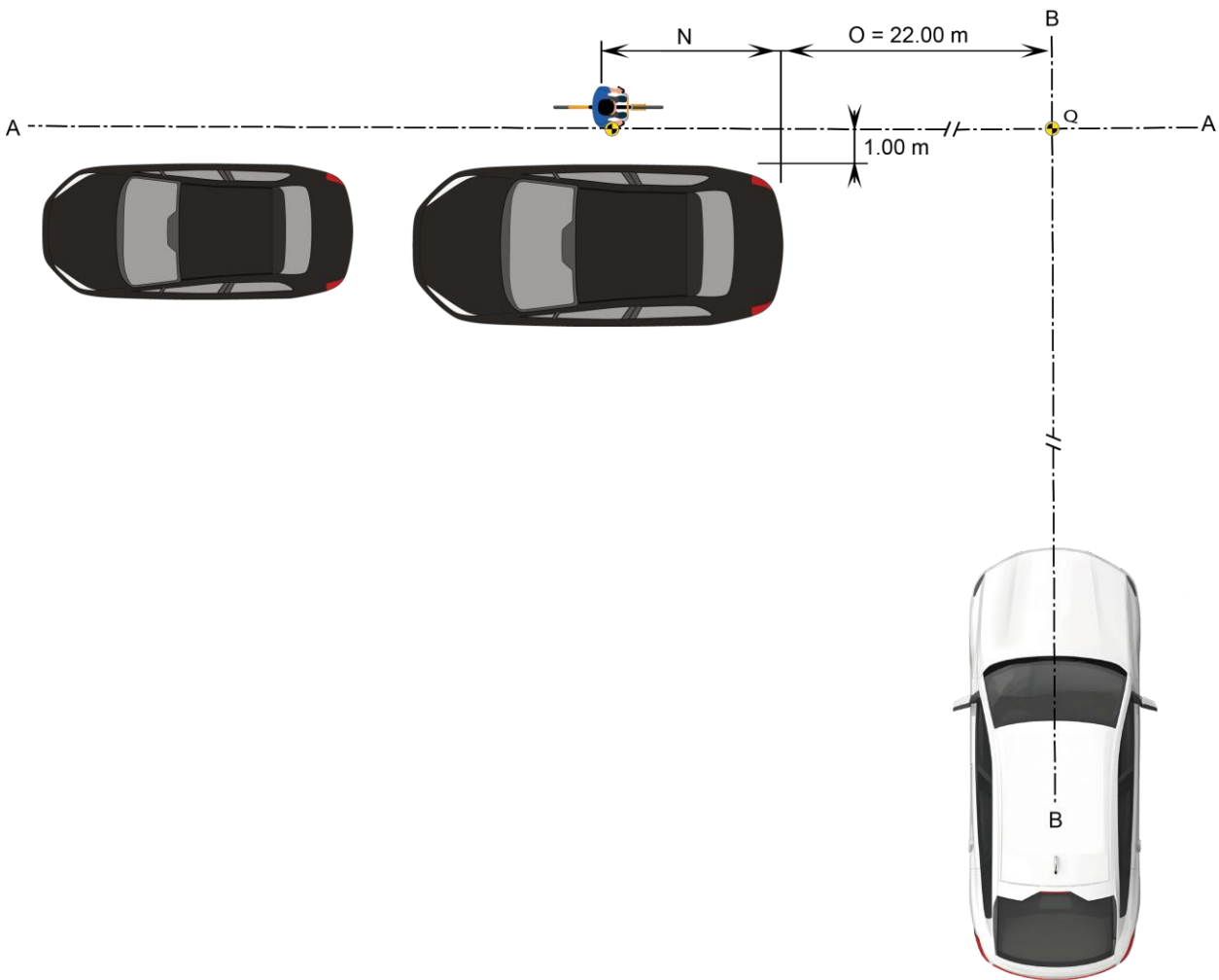


Figure 3-25 CBFA scenario, Bicyclist from Farside

4 TEST EXECUTION

4.1 General Test Conduct

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.

For all AEB and AEB / FCW test scenarios where the assessment is based on a GRID prediction provided by the OEM, the actual grid cells to be tested for verification of the manufacturer prediction will be chosen randomly, distributed in line with the predicted colour distribution.

For Pedestrian and Cyclist FCW systems tests, based on the Vehicle Manufacturer prediction, test the highest test speed of each scenario where the FCW is issued at a TTC $\geq 1.7s$, plus one randomly selected test speed per scenario where the FCW is issued at a TTC $\geq 1.7s$.

If the FCW is not issued at a TTC $\geq 1.7s$ in any of these tests, perform tests at all remaining test speeds in the scenario in 10km/h increments.

4.2 Manufacturer Predictions

4.2.1 Manufacturer Supplied Data

The vehicle manufacturer is required to provide the Euro NCAP Secretariat with vehicle performance predictions as colour data (expected impact speeds are not required) applicable to each grid cell in the standard and extended range of tests.

The manufacturer is also required to provide the Euro NCAP Secretariat with a declaration of performance for each applicable robustness layer that their vehicle can successfully overcome.

The information shall be supplied by the manufacturer before any testing begins, preferably with delivery of the test vehicle(s).

4.2.2 Absence of Manufacturer Data

Given the absence of performance predictions, proceed with the back-up procedure as outlined below:

4.2.2.1 Car-to-car & Car-to-Motorcyclist Rear

Standard Range

- a. Randomly select either 100% or 0% impact location scenario commencing testing at the lowest VUT test speed. When there is complete avoidance, the subsequent test speed for the

next test is incremented with 20 km/h. When there is contact, first perform a test at a test speed 10 km/h less than the test speed where contact occurred. After this test continue to perform the remainder of the tests with speed increments of 10 km/h. Stop testing when the speed reduction seen in the test is less than 5km/h, or the relative impact speed is greater than 20 km/h for two consecutive test speeds.

- b. Continue with either 75% or 25% impact location test scenario (depending on whether 100% or 0% was initially chosen, respectively). Commence testing at the lowest test speed for the scenario or highest 100% (or 0%) impact location avoidance speed, whichever is greater. Increment subsequent test speeds as described in a).
- c. Continue with the 50% impact location test scenario. Commence testing at the lowest test speed for the scenario or highest 75% (or 25%) impact location avoidance speed, whichever is greater. Increment subsequent test speeds as described in a).
- d. For FCW system tests, follow the process outlined in a) to c) for AEB testing. Only perform tests at the test speeds where there was no avoidance in the AEB function tests for applicable scenarios.
- e. To ensure symmetry, retest the 100% and 75% two highest avoidance speeds. Where there is a difference in performance, perform all tests on 0% and 25% impact location.

Extended Range

Test both 125 and -25% impact location ranges, commencing testing at the lowest VUT test speed. When there is complete avoidance, the subsequent test speed for the next test is incremented with 20 km/h. When there is contact, first perform a test at a test speed 10 km/h less than the test speed where contact occurred. After this test continue to perform the remainder of the tests with speed increments of 10 km/h. Stop testing when the speed reduction seen in the test is less than 5km/h, or the relative impact speed is greater than 20 km/h for two consecutive test speeds.

4.2.2.2 Rest of scenarios

Test all cases.

4.2.3 VTA

Where VTA is used, simulations are to be provided as outlined in Euro NCAP VTA protocol.

Test Execution

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.

4.2.4 AEB tests

Accelerate the VUT and target to the respective test speeds where needed. The test shall start at T₀ and is valid when all boundary conditions are met between T₀ 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 CPTA and CBTA)	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 CMRs FCW and CMRb 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

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.

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 $\leq 0.3\text{m}$ 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. This does not apply for the CPRA tests.

The CMRs and CMRb 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 $-4 \text{ m/s}^2 - 0.50 \text{ m/s}^2$ 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 ANNEX C will be applied to scale the brake level to $-4 \text{ m/s}^2 - 0.50 \text{ m/s}^2$.

If no brake profile is provided, apply default brake profile as described in ANNEX C.

5 ASSESSMENT CRITERIA & SCORING

5.1 General requirements

To be eligible for scoring points in this assessment, the 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.
- 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 CPNA-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 CPNA-75 scenario at 20 km/h, also for both day and night.
- For the AEB CCRs scenario, full avoidance shall be achieved for test speeds up to and including 20 km/h for all impact locations within the Standard Range, which is verified by one randomly selected test point.

5.2 Method of assessment

The Vehicle Manufacturer shall provide the Euro NCAP with colour data detailing the predicted performance of the AEB/FCW system for all test scenarios. The predicted performance will be used as a reference to verify performance using randomly selected verification tests.

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 grid cells forming a matrix are grouped into 2 groups: Standard Range and Extended Range.

In addition, a number of points are awarded on each scenario for system Robustness, with Robustness Layers assessed against grid cells of the Standard Range where there is performance, as described in 5.3.1.

5.2.1 Standard Ranges

For score calculation in the Standard Ranges, first each grid cell is given a score of 1 point, which is then scaled with the colour code criteria described in 5.2.4 according to the Vehicle Manufacturer prediction; and secondly, the sub-score resulting from adding up all the grid cells is normalized to the maximum available score on each Standard Range (rounded to hundredth).

5.2.2 Extended Ranges

To be eligible for scoring points in Extended Ranges across scenarios, there shall be $\geq 25\%$ of the total available score in the Standard Range.

For score calculation in the Extended Ranges, first each grid cell is which passes the acceptance criteria described in 5.2.4 according to the Vehicle Manufacturer prediction is given a score of 1 point; and secondly, the sub-score resulting from adding up all the grid cells is normalized to the maximum available score on each Standard Range (rounded to hundredth).

Finally, the total score for each Extended Range in a given scenario is calculated as follows:

Extended Range Scoring	
% of total available score	Total score
$50 \leq X < 75$	50% of total available score
$75 \leq X < 100$	75% of total available score
$X = 100$	100% of total available score

5.2.2.1 AES

For the impact locations in the Extended Range, the Vehicle Manufacturer may implement an AES function that provides full avoidance by in-lane steering. The Vehicle Manufacturer shall elaborate to Euro NCAP the AES function strategy and will provide a specific test method to verify performance, which shall be carried out by the test laboratory.

5.2.2.2 ESS

For the following situations, the Vehicle Manufacturer may implement an ESS function that provides full avoidance by supporting a driver initiated steering manoeuvre:

- CCRs & CMRs for speeds ≥ 60 km/h
 - o Farside/Nearside steering avoidance (In-lane) → Impact locations: -25%, 125%
 - o Farside steering avoidance (with partial lane change*) → Impact locations: 0%, 25%, 50%
- CPLA & CBLA for speeds ≥ 50 km/h
 - o Farside/Nearside steering avoidance (In-lane) → Impact locations: 10%, 90%
 - o Farside steering avoidance (with partial lane change*) → Impact locations: 25%, 50%

* Only when ESS is able to evaluate free space in neighbour lane. If lane is occupied with oncoming/overtaking targets, the performance criteria should be based on nominal conditions (i.e., $>1.7s$ TTC for Longitudinal VRU / colour-code speed reduction by FCW/AEB).

The Vehicle Manufacturer shall elaborate to Euro NCAP the ESS function strategy and will provide a specific test method to verify performance, which shall be carried out by the test laboratory.

5.2.3 Robustness Layers

To be eligible for scoring points in Robustness Layers across scenarios, there shall be $\geq 50\%$ of the total available score in the Standard Range. The score for each Robustness layer in a given scenario is calculated as follows:

Robustness Layers Scoring	
Performance *	Total score
YES	100% of total available score
NO	0% of total available score

*Against grid cells within Standard Range where there is performance

5.2.4 Verification tests

[The exact number of verification tests and overall acceptance criteria for the verification testing are still to be agreed withing the WG]

5.2.4.1 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 section 5.3 without applying a tolerance to the impact speed.

5.2.5 Virtual Testing

The Vehicle Manufacturer may provide performance predictions based in simulation, following the provisions outlined in Euro NCAP VTA Protocol, for the following assessment elements:

- Standard Range
- Extended Range
- Robustness layers where 'VTA' is indicated in 5.3.1

5.3 Assessment criteria

The assessment criteria is linked to the ability of the FCW and/or AEB system to avoid or mitigate the severity of a crash, measured either by $V_{reduction}$ or V_{rel_speed} (for mitigation or avoidance) or Pass/Fail (for avoidance-only) across scenarios:

Criteria	KPI	Scenarios	
		Car & PTW	Pedestrian & Cyclist
Mitigation or avoidance	V_{rel_speed}	Rear	Longitudinal, Crossing
Mitigation	$V_{reduction}$	Front	-
Avoidance	Pass/Fail	Turning, Crossing	Turning

Where V_{rel_speed} or $V_{reduction}$ are used, a stepped sliding scale using colour bands is applied:

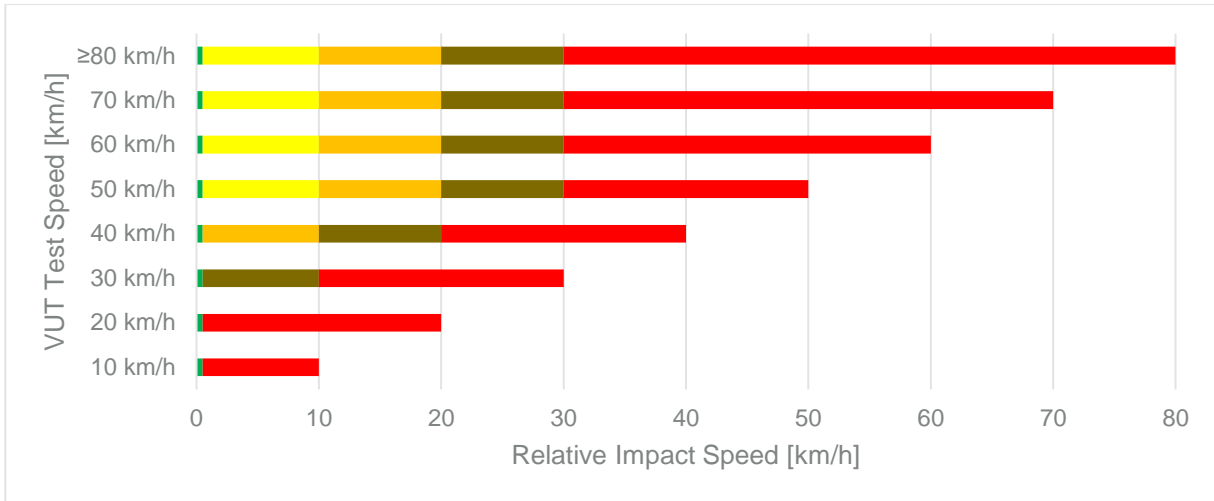


Figure 5-1 Relative Impact Speed colour band criteria (applicable for Car & PTW Rear, and Pedestrian & Cyclist Longitudinal / Crossing)

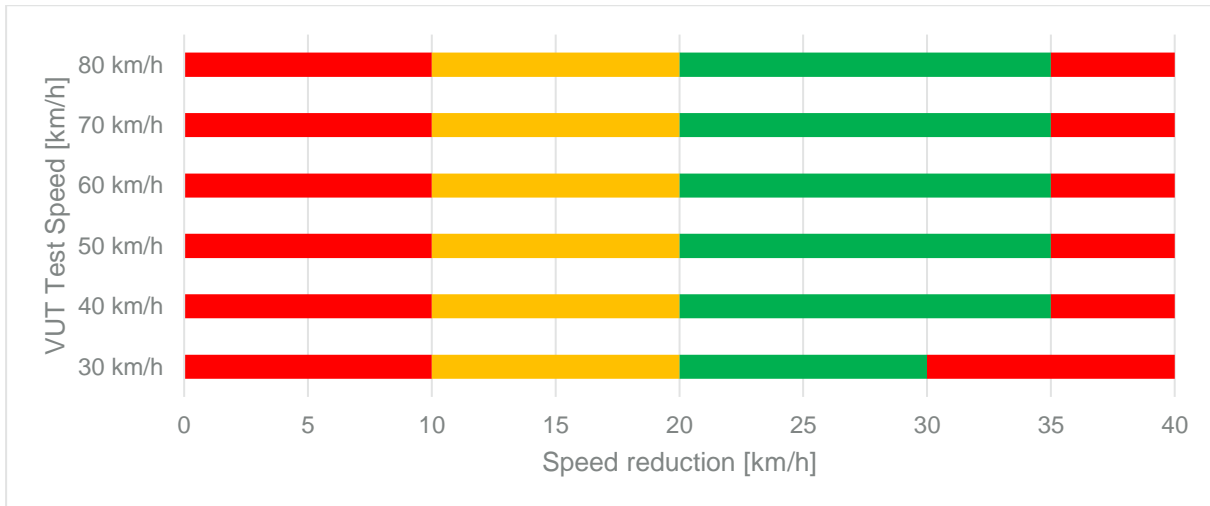


Figure 5-2 Speed Reduction colour band criteria (applicable to Car & PTW Front)

For each predicted colour, the following scaling is applied to each grid cell of the Standard and Extended Range:

Predicted Colour	Grid cell scaling (mitigation & avoidance scenarios)				
	Standard Range	Extended Range			
		Impact Location		VUT Speed	
		≤2 colours down*	>2 colours down*	≤1 colour down*	>1 colour down*
Green	1	PASS	FAIL	PASS	FAIL
Yellow	0,75				
Orange	0,50				
Brown	0,25	FAIL	FAIL	FAIL	
Red	0				

* When compared against the adjacent grid cell of that parameter (Excluding Red), where impact location has higher priority than vehicle speed.

For all avoidance-only scenarios in both Standard and Extended Ranges, as well as for Robustness Layers, the following scaling is applied:

- PASS (Avoidance) = 1
- FAIL (Impact) = 0

5.3.1 Robustness

In order to evaluate the overall robustness of the system, the Standard Range of each scenario (where there is performance) is assessed against individual parameter or condition variations referred to as layers, clustered in 3 types: VUT, Target and Environment.

Robustness layers		Description	Verification Test	Input source
Type	Layer			
VUT	Driver input pre-crash	Normal driving without steering robot and/or speed control function	Yes	OEM information on system overriding conditions
Target	Speed	Small variance in the nominal target speed	Yes	VTA or OEM self-claim
	Acceleration	Small variance in the nominal target acceleration	Yes	
	Initial position offset	Small variance in the nominal target initial position	Yes	
	Trajectory/ Heading	Small variance in the nominal target heading	Yes	
	Type	Different collision partner type with similar kinematics	No	FOT data**
	Appearance	Same collision partner type but with different appearance (e.g., colour, accessories, shape)	No	
Environment	Adverse weather conditions	Functionality available under the presence of Rain, Fog, Dirt/ice/moisture	No	FOT data**
	Illumination (Night time)	Performance in darkness (1 lux) for all daytime scenarios	No*	
	Illumination - Glare	Functionality available under the presence of glare caused by Low sun (all scenarios)	No	
		Functionality available under the presence of glare caused by headlights of a stationary vehicle on adjacent lane (all standard nighttime scenarios)	No*	
	Infrastructure / clutter	Performance in environments cluttered with objects such as urban furniture or secondary road users (without fully obscuring the main target)	No*	

Robustness layers		Description	Verification Test	Input source
Type	Layer			
	Obscuration / Obstruction	Variance in the layout of nominal obstructions	No*	

* May be tested under request of Euro NCAP Secretariat.

** Where FOT data is required, the Vehicle Manufacturer shall demonstrate that the system perception is not significantly degraded, assessed in real driving conditions. This is to be reported according to the provisions set forth in the FOT Data Template Technical Bulletin.

5.3.1.1 Verification Tests

Where verification tests are done, the following conditions apply:

VUT Robustness layers		Verification condition*	Assessment Criteria**
Layer	Scenarios		
Driver input pre-crash	Longitudinal	<ul style="list-style-type: none"> - VUT Lateral deviation 0 ± 0.25 m (without steering robot) - VUT Speed ± 5 km/h (without speed limiter) - Impact location tolerance (against nominal) ±20% 	Same
	Crossing	<ul style="list-style-type: none"> - VUT Lateral deviation 0 ± 0.25 m (without steering robot) - Impact location tolerance (against nominal) ±20% 	
	Turning	<ul style="list-style-type: none"> - VUT Lateral deviation 0 ± 0.4 m (manual turn) - Impact location tolerance (against nominal) ±20% 	

Target Robustness layers		Test condition*	Assessment Criteria**
Layer	Scenarios		
Speed	CCFhos/hol CCFtap, CCFtap CCCscp, CMCscp	+5 km/h	≤1 colour down
		-5 km/h	Same
	CPTA, CBTA CPNA, CPNA, CBNA, CBFA, CPNCO, CBNAO	+3 km/h	≤2 colours down
		-2 km/h	Same
Deceleration	CCRb, CMRb	-50% m/s ²	Same

Target Robustness layers		Test condition*	Assessment Criteria**
Layer	Scenarios		
		+50% m/s ²	≤1 colour down
Initial position offset	CPTA, CBTA CPNA, CPNA, CBNA, CBFA, CPNCO, CBNCO	-25% m of distance to impact point	≤2 colours down
	CCFtap, CMFtap	±0.5m Path offset	Same
	CCRb, CMRb	±0.5s Time headway	≤1 colour down
Trajectory/ Heading	CCRs, CMRs CPNA, CPNA, CBNA, CBFA, CPNCO, CBNCO	±20°	Same

5.3.1.2

Environment robustness layers		Test condition*	Assessment Criteria**
Layer	Scenarios		
Illumination (Night time)	ALL except Standard nighttime scenarios	Performance in darkness (1 lux) for all daytime scenarios	≤1 colour down
Illumination – Glare	ALL Standard nighttime scenarios	Headlight of stationary vehicle on adjacent lane	≤1 colour down vs standard nighttime
Infrastructure / clutter	CCRs	Vehicle aside of main target	Same
	CMRs	Vehicle aside of main target OR GVT in front of main target	Same
	CCRm, CCRb, CMRb	Vehicle aside of main target (moving)	Same
	CCRb	GVT in front of main target (moving)	Same
	Turning (C2P, C2B)	Typical crossing scenery e.g., traffic sign, refuge, trash bin	Same
	CCCscp, CMCscp	Typical crossing scenery e.g., traffic sign, stationary pedestrians on sidewalk, stationary (secondary) GVT on crossing road	Same
	C2P, C2B Crossing	Randomly selected case from ANNEX A (except CPNCO)	≤2 colours down

Environment robustness layers		Test condition*	Assessment Criteria**
Layer	Scenarios		
Obscuration / Obstruction	CPNCO	Randomly selected CPNCO case from ANNEX A	≤2 colours down
	CBNCO	TBD	≤2 colours down

* Versus the condition used in the Standard Range (where there is performance)

**Colour down for mitigation or avoidance scenarios; PASS/FAIL for avoidance-only scenarios

5.4 Links to Driver State

The Vehicle Manufacturer may implement a sensitivity change strategy for FCW and/or AEB according to the state of the driver detected by the DSM as described in the Euro NCAP Driver Engagement protocol, provided that following conditions are met:

- The DSM shall offer minimum performance across different driver states:
 - o Transient states: >50% of total intervention score
 - o Non-transient states: Drowsiness and Sleep
- The sensitivity change shall be immediately set back to nominal if DSM is degraded , non-functional or turned off.

The criteria for sensitivity change is based on the speed reduction that either FCW and/or AEB shall offer as a minimum across different scenarios when linked to the driver state, as summarized in the table below:

FCW/AEB Sensitivity Change			
Impact location ranges	Standard Range (outermost)	Extended Range	Extended Range
AEB/FCW	FCW and/or AEB	FCW	AEB
Frontal Collision Scenarios	CCRs, CMRs, CCRm	CCRs, CMRs CPLA, CBLA	CPNA, CPFA, CBNA, CBFA CPTA CPLA, CBLA CCCscp, CMCscp CCFhos/I
Acceptance criteria*	≤ 1 colour down	≤ 4 colours down OR function suppression	

* Assessed under Attentive and/or unimpaired driver state

The vehicle manufacturer may request, for the scenarios in the table above, that the verification test is performed with a test driver that is classified as distracted.

In addition, Euro NCAP may verify that the acceptance criteria is met as described in the table above, under the attentive driver condition.

For FCW tests, the brake robot actuation will be delayed 1.2 seconds by default from the start of the acoustic warning, accounting for the reaction time of a driver assumed to be distracted and/or impaired. However, the Vehicle Manufacturer may implement alternative driver models in the FCW strategy based on the true state of the driver detected by DSM, and/or alternative/supplementary FCW strategies which are effective at reducing driver reaction times:

- Distracted/impaired driver: 1.2 seconds
- Attentive driver : -[0.5] seconds
- Alternative/supplementary FCW e.g., seatbelt jerk: -[0.25] seconds

In addition, driver models based on steering may be used to avoid a crash against a road user travelling in the same direction at a high offset e.g., ESS function for CPLA, CBLA and CCR/CMR, provided the driver is classified as distracted or impaired.

Euro NCAP

The Vehicle Manufacturer shall document in detail to Euro NCAP the FCW and/or AEB strategy when linked to the state of the driver as detected by the DSM, including specific test provisions to verify performance under the distracted/impaired setting.

5.5 Scoring

5.5.1 Car & PTW

The point distribution for Car & PTW scenarios is summarized in the table below:

Car & PTW	Maximum Points			
	Standard Range 32	Extended Range 4	Robustness Layers 4	TOTAL 40
Longitudinal	12	1.5	1.5	15
Car-to-Car Rear	5.2	0.65	0.65	6.5
<i>CCRs</i>	1.2	0.15	0.15	1.5
<i>CCRm</i>	2.4	0.3	0.3	3
<i>CCRb</i>	1.6	0.2	0.2	2
Car-to-Car Front	4	0.5	0.5	5
<i>CCFhos</i>	2	0.25	0.25	2.5
<i>CCFhol</i>	2	0.25	0.25	2.5
Car-to-Motorcycle Rear	2.8	0.35	0.35	3.5
<i>CMRs</i>	1.2	0.15	0.15	1.5
<i>CMRb</i>	1.6	0.2	0.2	2
Turning	8	1	1	10
Car-to-Car Turn Across Path	4	0.5	0.5	5
Car-to-Motorcycle Turn Across Path	4	0.5	0.5	5
Crossing	12	1.5	1.5	15
Car-to-Car Crossing	6	0.75	0.75	7.5
Car-to-Motorcycle Crossing	6	0.75	0.75	7.5

5.5.2 Pedestrian & Cyclist

The point distribution for Pedestrian & Cyclist scenarios is summarized in the table below:

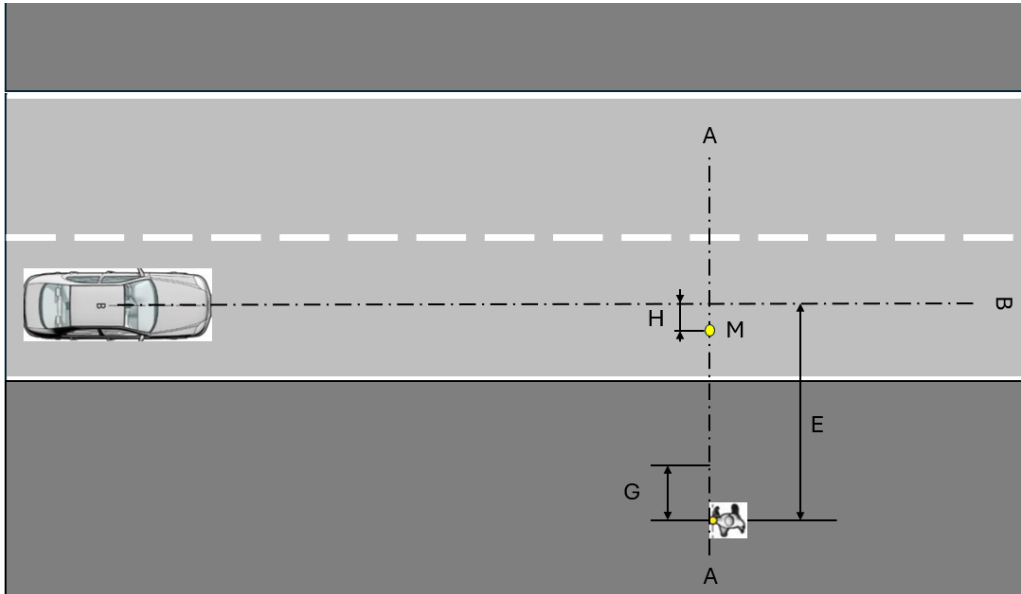
Pedestrian & Cyclist assessment	Maximum points			
	Standard Range 16	Extended Range 2	Robustness Layers 2	TOTAL 20
Longitudinal	4	0.5	0.5	5
Car-to-Pedestrian Longitudinal	2	0.25	0.25	2.5
Car-to-Bicyclist Longitudinal	2	0.25	0.25	2.5
Turning	4	0.5	0.5	5
Car-to-Pedestrian Turning	2	0.25	0.25	2.5
Car-to-Bicyclist Turning	2	0.25	0.25	2.5
Crossing	8	1	1	10
Car-to-Pedestrian Crossing	4	0.5	0.5	5
CPNA	1	0.125	0.125	1.25
CPFA	1	0.125	0.125	1.25
CPNCO	2	0.25	0.25	2.5
Car-to-Bicyclist Crossing	4	0.5	0.5	5
CBNA	1	0.125	0.125	1.25
CBFA	1	0.125	0.125	1.25
CBNAO	2	0.25	0.25	2.5

APPENDIX A ROBUSTNESS LAYERS

A.1 Infrastructure/Clutter (Car-to-Pedestrian & Car-to-Bicyclist)

A.1.1 CPNA – 25% with variation of starting position

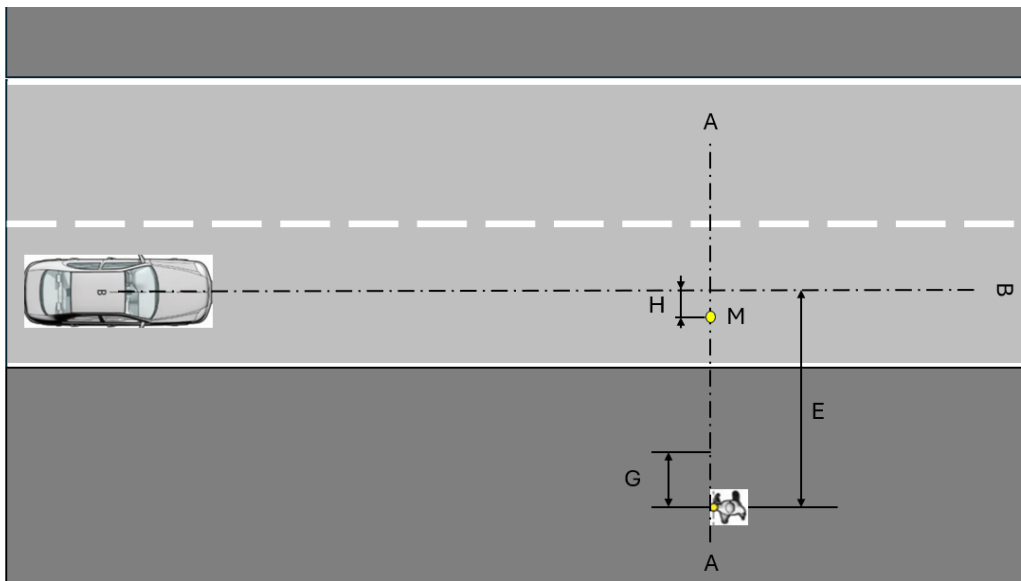
Standard CPNA-25% with variation of starting point E for the pedestrian.



Axes		Values
AA	Trajectory of pedestrian dummy H-point	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m - 25%
G	Dummy acceleration distance (walking)	1.0m
H	Impact point offset for 25%	
Points		
M	Impact position for 25% near-side scenario	

A.1.2 CPNA – 25% with variation of target speed

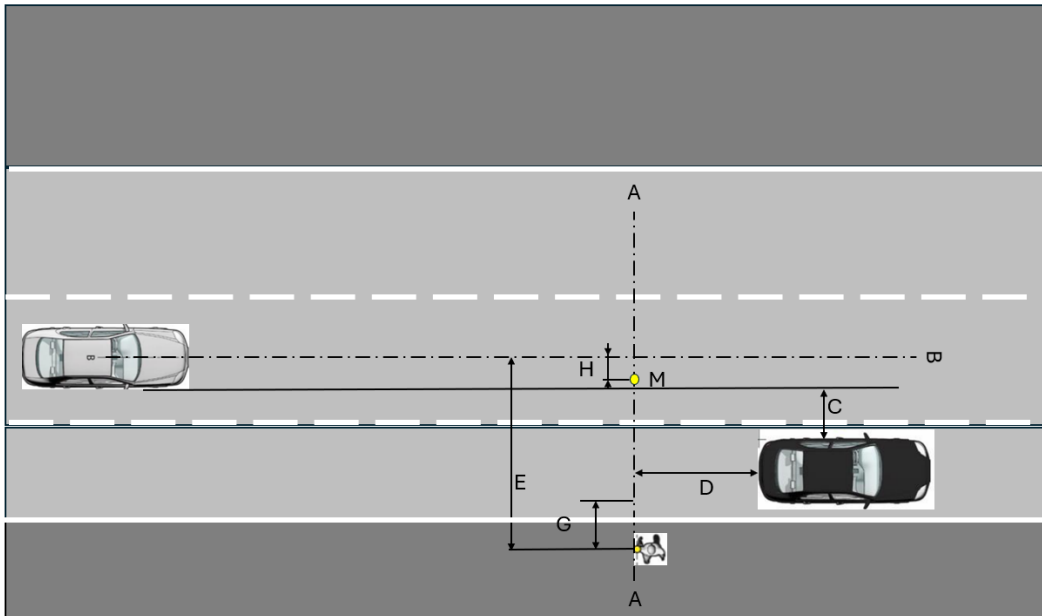
Standard CPNA-25% with pedestrian speed of 8km/h.



Axes		Values
AA	Trajectory of pedestrian dummy H-point	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m
G	Dummy acceleration distance (walking)	1.5m
H	Impact point offset for 25%	
Points		
M	Impact position for 25% near-side scenario	

A.1.3 CPNA – 25% with parked vehicle behind

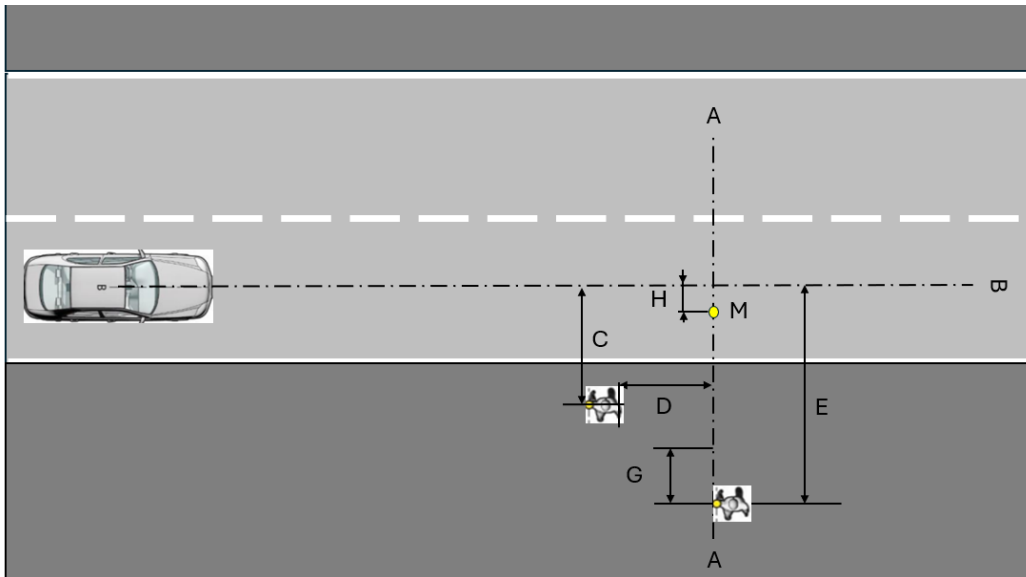
Standard CPNA-25% with dark SUV parked after pedestrian path AA.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m
G	Dummy acceleration distance (walking)	1.0m
C	Distance between Vehicle Under Test and the parked vehicle	1.0m
D	Mid rear of parked vehicle to pedestrian path	1.5-2.5m
H	Impact point offset for 25%	
Points		
M	Impact position for 25% near-side scenario	

A.1.4 CPNA – 25% with stationary pedestrian in front of pedestrian path

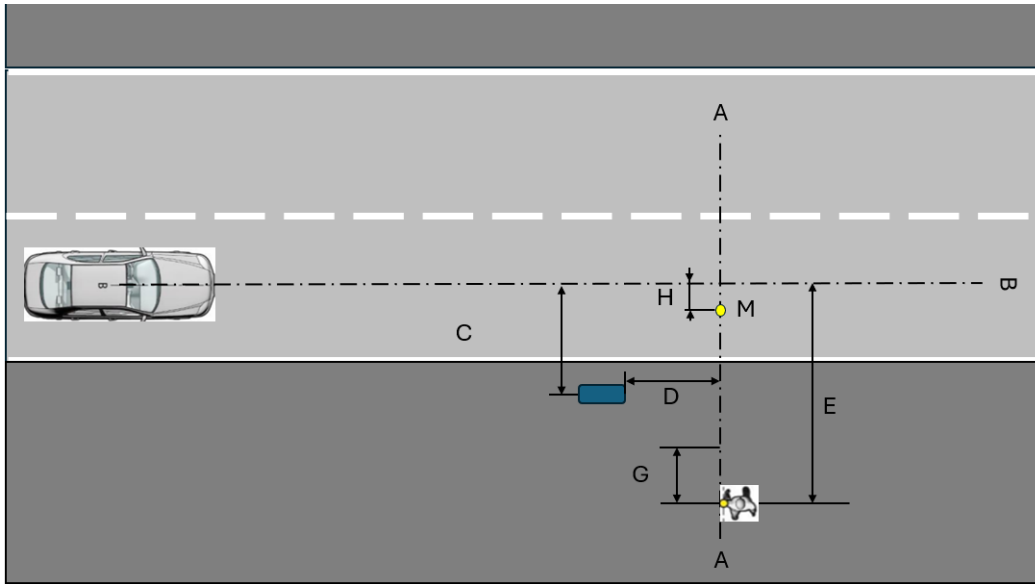
Standard CPNA-25% with stationary pedestrian standing before walking pedestrian path AA.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m
G	Dummy acceleration distance (walking)	1.0m
C	Stationary dummy H-point to VUT centreline BB	2.5m
D	Stationary dummy right shoulder to pedestrian path AA	1.0-1.5m
H	Impact point offset for 25%	
Points		
M	Impact position for 25% near-side scenario	

A.1.5 CPNA – 25% with Electrical cabinet / Trash bin in front of pedestrian path

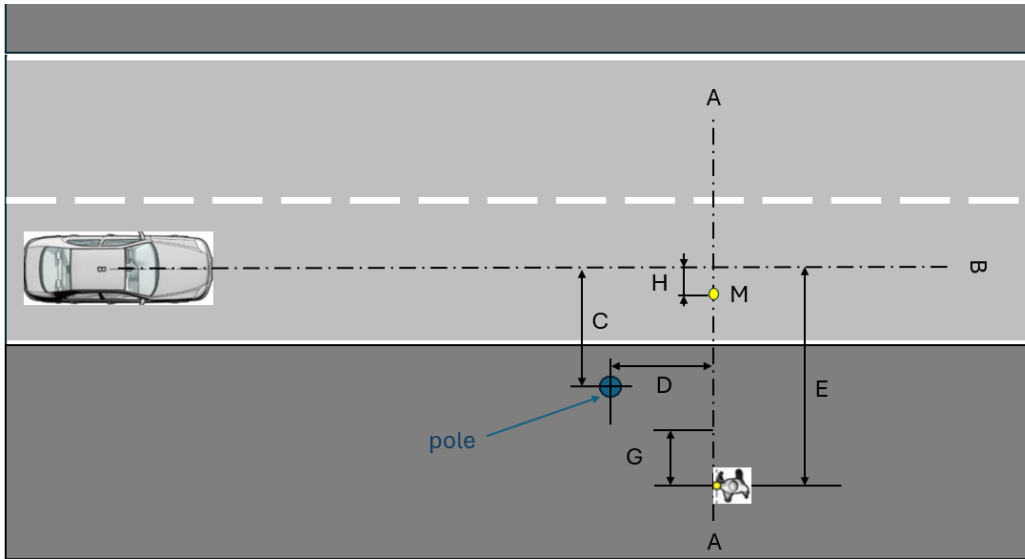
Standard CPNA-25% with Electrical cabinet/ trash bin before pedestrian path AA.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m
G	Dummy acceleration distance (walking)	1.0m
C	Mid Electrical Cabinet </Trash bin to VUT centreline BB	2.5m
D	Side Electrical Cabinet/Trash bin to pedestrian path AA	1.0-1.5m
H	Impact point offset for 25%	
Points		
M	Impact position for 25% near-side scenario	

A.1.6 CPNA – 25% with Street light pole in front of pedestrian path

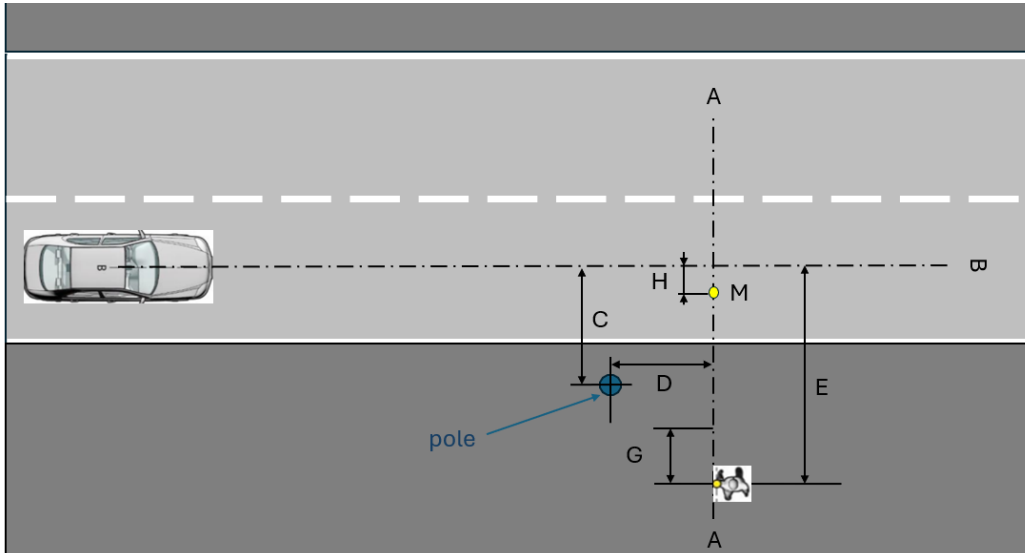
Standard CPNA-25% with Street light pole Ø 23 cm in front of pedestrian path AA.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m
G	Dummy acceleration distance (walking)	1.0m
C	Mid Pole to VUT centreline BB	2.5m
D	Mid Pole to pedestrian path AA	1.0-1.5m
H	Impact point offset for 25%	
Points		
M	Impact position for 25% near-side scenario	

A.1.7 CPNA – 25% with Traffic light pole in front of pedestrian path

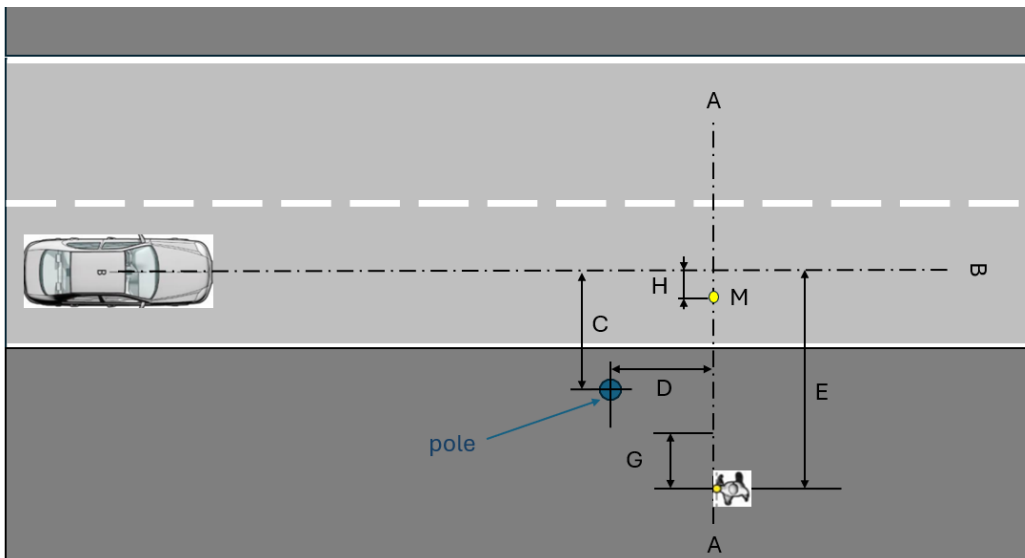
Standard CPNA-25% with Traffic light pole Ø 12 cm in front of pedestrian path AA.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m
G	Dummy acceleration distance (walking)	1.0m
C	Mid Pole to VUT centreline BB	2.5m
D	Mid Pole to pedestrian path AA	1.0-1.5m
H	Impact point offset for 25%	
Points		
M	Impact position for 25% near-side scenario	

A.1.8 CPNA – 25% with Traffic sign pole in front of pedestrian path

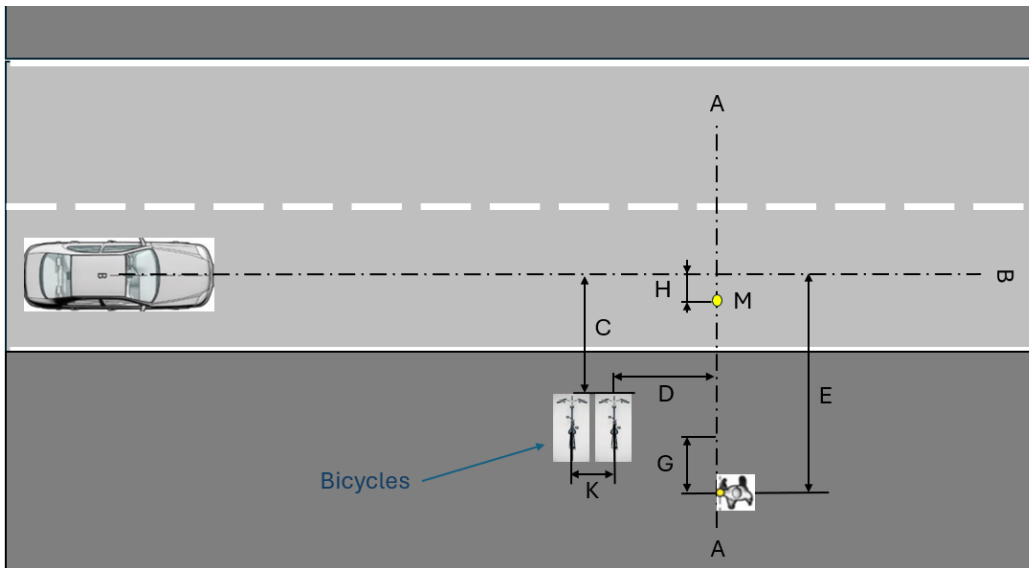
Standard CPNA-25% with Traffic sign pole \varnothing 7 cm in front of pedestrian path AA.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m
G	Dummy acceleration distance (walking)	1.0m
C	Mid Pole to VUT centreline BB	2.5m
D	Mid Pole to pedestrian path AA	1.0-1.5m
H	Impact point offset for 25%	
Points		
M	Impact position for 25% near-side scenario	

A.1.9 CPNA – 25% with parked bicycles in front of pedestrian path

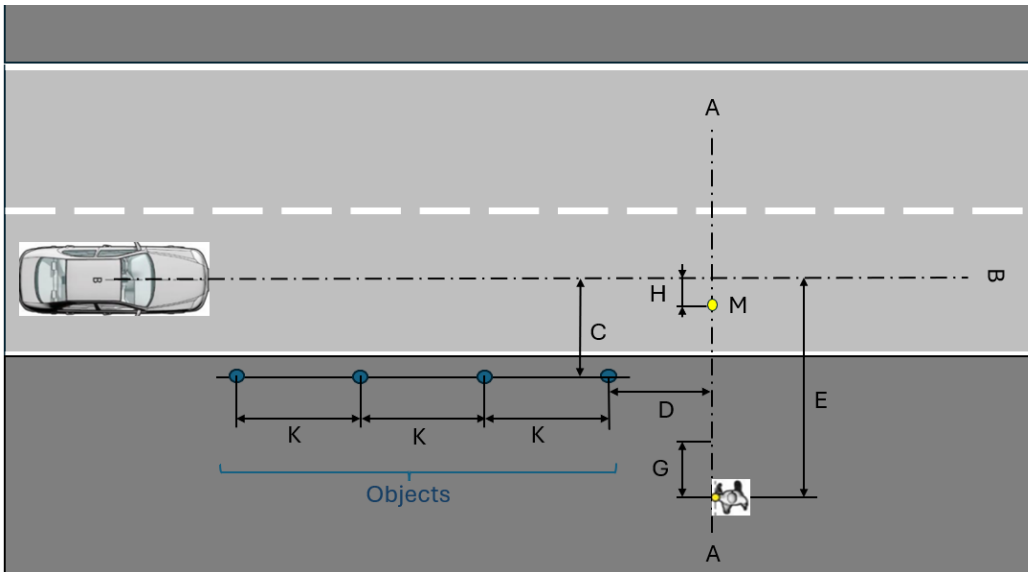
Standard CPNA-25% with two parked bicycles in front of pedestrian path AA.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m
G	Dummy acceleration distance (walking)	1.0m
C	Front bicycle wheel to VUT centreline BB	2.5m
D	Mid front wheel on bicycle to pedestrian path AA, for the bicycle closest to pedestrian path.	1.0-1.5m
K	Between the two parallel parked bicycles	1.0m
H	Impact point offset for 25%	
Points		
M	Impact position for 25% near-side scenario	

A.1.10 CPNA – 25% with multiple bollards in front of pedestrian path

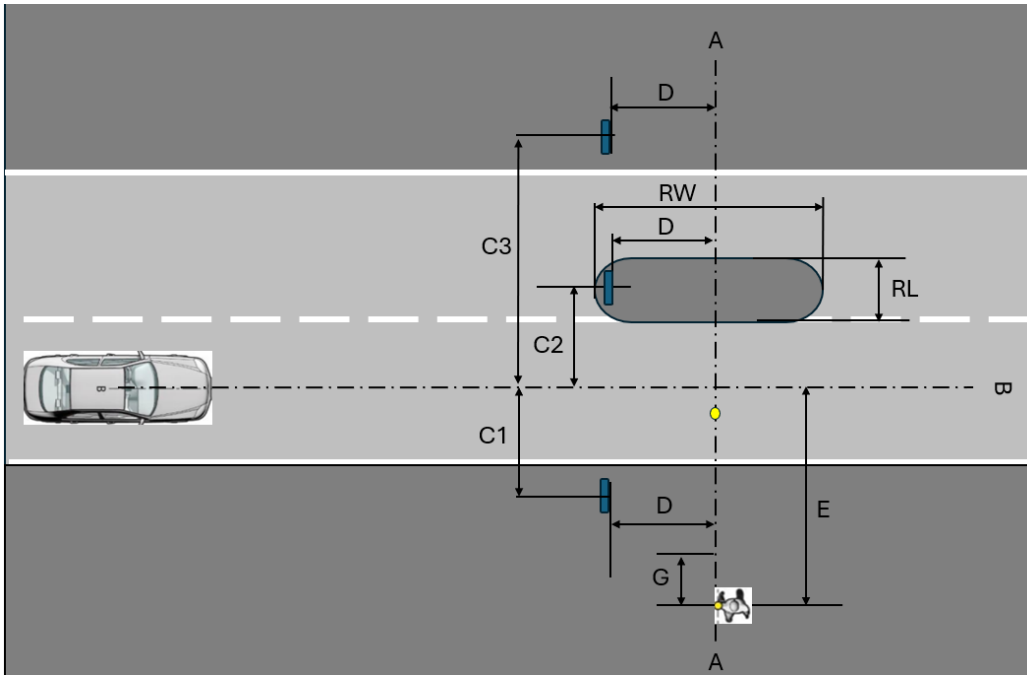
Standard CPNA-25% with four bollards in front of pedestrian path AA.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m
G	Dummy acceleration distance (walking)	1.0m
C	Mid of the bollards to the VUT centreline BB	2.25m
D	Mid of the last bollard to the pedestrian path	1.0-1.5m
K	Mid to mid of the closest bollards	1.0m
H	Impact point offset for 25%	
Points		
M	Impact position for 25% near-side scenario	

A.1.11 CPNA – 25% with lower sign bars/poles on both sides

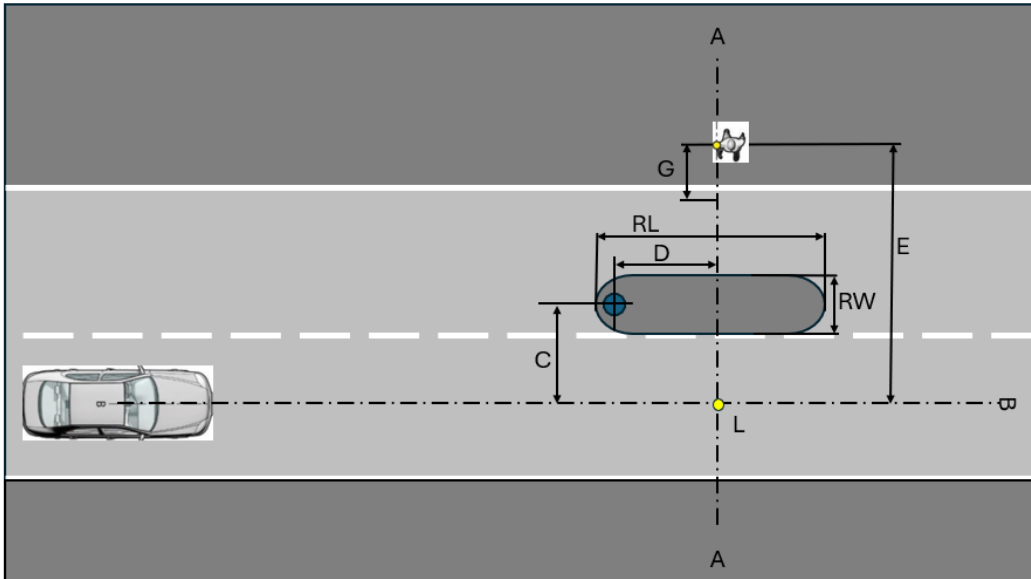
Standard CPNA-25% with lower sign bars/poles on both sides.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m
G	Dummy acceleration distance (walking)	1.0m
C1	Distance mid of the sign to the VUT centreline BB	
C2	Distance mid of the sign to the VUT centreline BB	
C3	Distance mid of the sign to the VUT centreline BB	
D	Distance backside of the sign to pedestrian path AA	1.0-1.5m
RW	Refuge length	
RL	Refuge width	1.2m
H	Impact point offset for 25%	
Points		
M	Impact position for 25% near-side scenario	

A.1.13 CPFA – 50% with traffic light pole on refuge

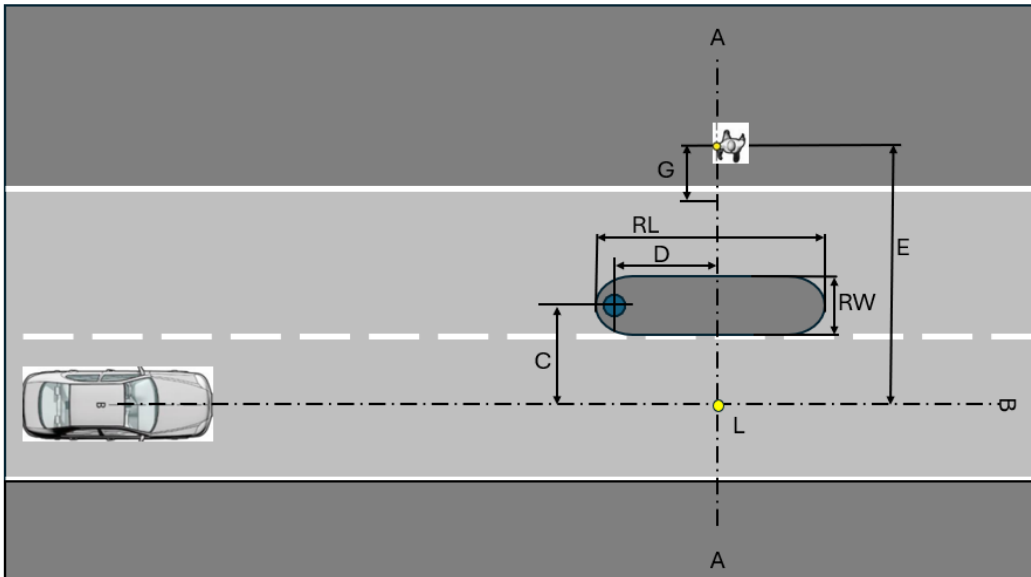
Standard CPFA-50% with traffic light pole Ø 12cm on refuge.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	6.0m
G	Dummy acceleration distance (walking)	1.5m
C	Mid pole to the VUT centreline BB	2.35m
D	Mid pole to pedestrian path AA.	1.0-1.5m
RL	Refuge length	
RW	Refuge width	1.2m
Points		
L	Impact position for 50% scenarios	

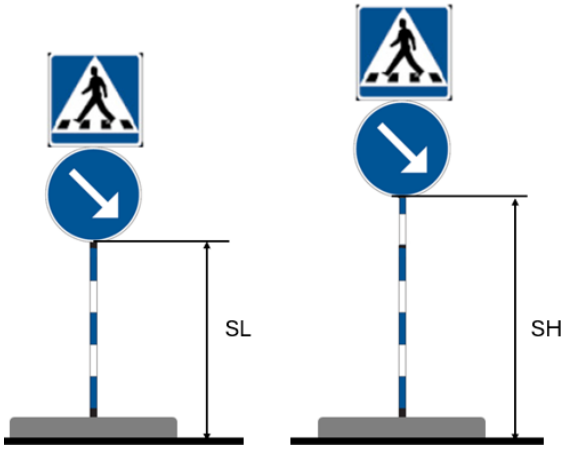
A.1.14 CPFA – 50% with traffic sign pole on refuge

Standard CPFA-50% with traffic sign pole Ø 7cm on refuge. Two traffic signs on the pole positioned in two variants (low mounted and high mounted).



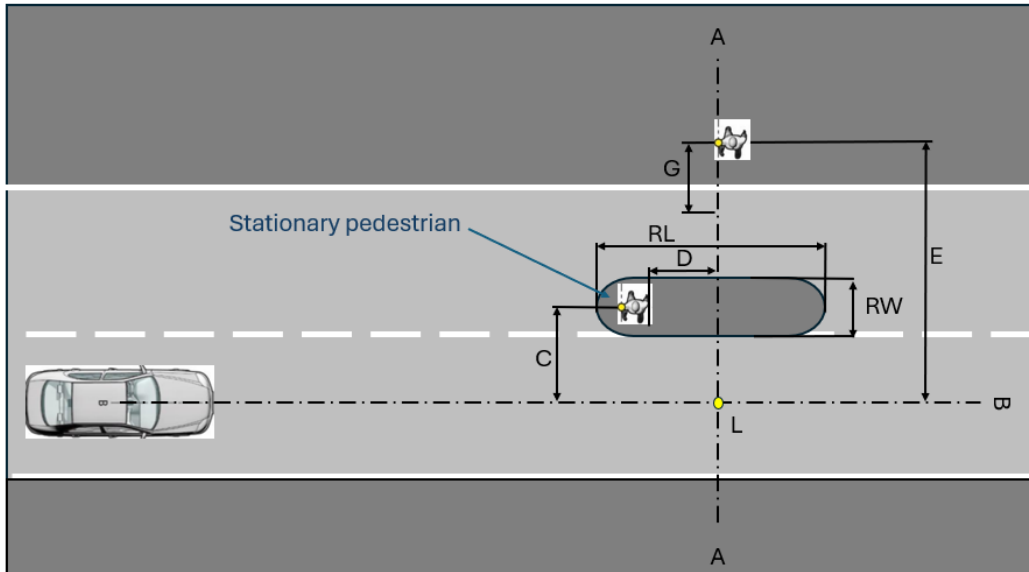
Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	6.0m
G	Dummy acceleration distance (walking)	1.5m
C	Mid pole to the VUT centreline BB	2.35m
D	Mid pole to pedestrian path AA.	1.0-1.5m
RL	Refuge length	
RW	Refuge width	1.2m
Points		
L	Impact position for 50% scenarios	
Heights		
SL	Lowest edge of lowest sign to ground	1.45m
SH	Lowest edge of lowest sign to ground	1.75m

Example of signs:



A.1.15 CPFA – 50% with stationary pedestrian on refuge before pedestrian path

Standard CPFA-50% with stationary pedestrian standing on refuge in front of pedestrian path AA.

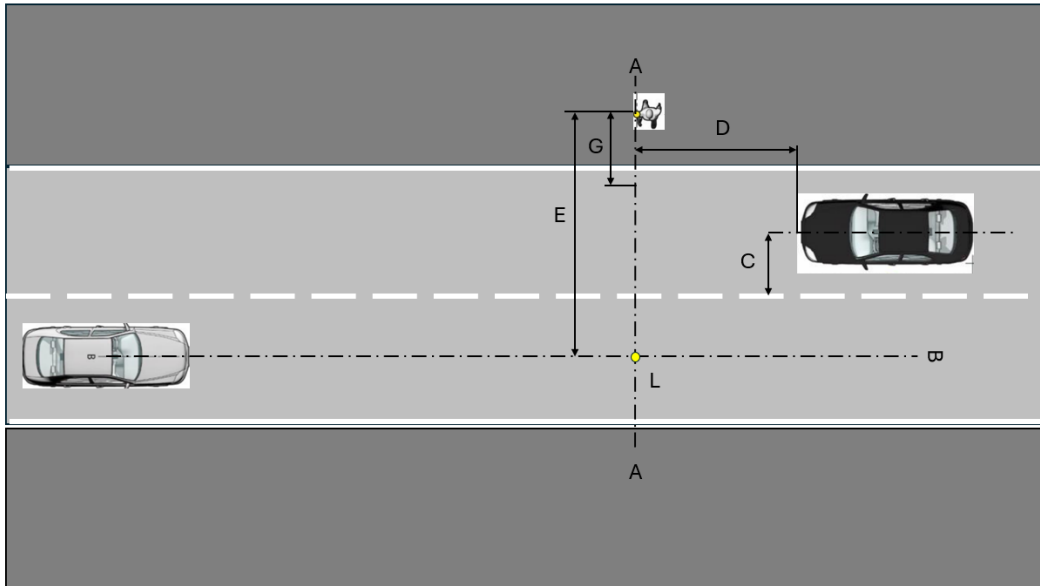


Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle Under Test	
Distances		
E	Dummy H-point, start to 50%-impact	6.0m
G	Dummy acceleration distance (walking)	1.5m
C	Stationary pedestrian H-point to VUT centreline BB	2.35m
D	Stationary pedestrian left shoulder to pedestrian path AA.	1.0-1.5m
RL	Refuge length	
RW	Refuge width	1.2m
Points		
L	Impact position for 50% scenarios	

A.1.16 CPFA – 50% with stopped oncoming vehicle in adjacent lane behind pedestrian path

Standard CPFA-50% with stopped oncoming vehicle in adjacent lane behind pedestrian path AA.

Oncoming vehicle positioned middle of adjacent lane.



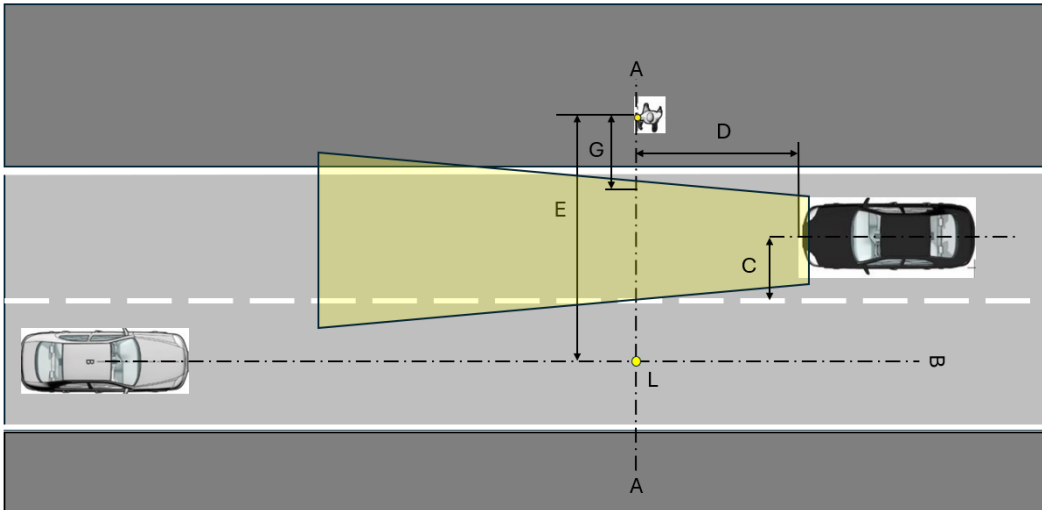
Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle under Test	
Distances		
E	Dummy H-point, start to 50%-impact	6.0m
G	Dummy acceleration distance (walking)	1.5m
C	Centre line stopped vehicle to centre of the centre dashed lane marking of the VUT lane.	1.75m
D	Mid front stopped vehicle to pedestrian path AA	1.5-2.5m
Points		
L	Impact position for 50% scenarios	

A.2 Illumination – Glare (Car-to-Pedestrian Nighttime)

A.2.1 CPFA – 50% with stopped oncoming vehicle in adjacent lane behind pedestrian path, nighttime with streetlights and low beam.

Standard CPFA-50% with stopped oncoming vehicle in adjacent lane behind pedestrian path.

Oncoming vehicle positioned middle of adjacent lane with low beam. Streetlights according to Euro NCAP CPFA night test.

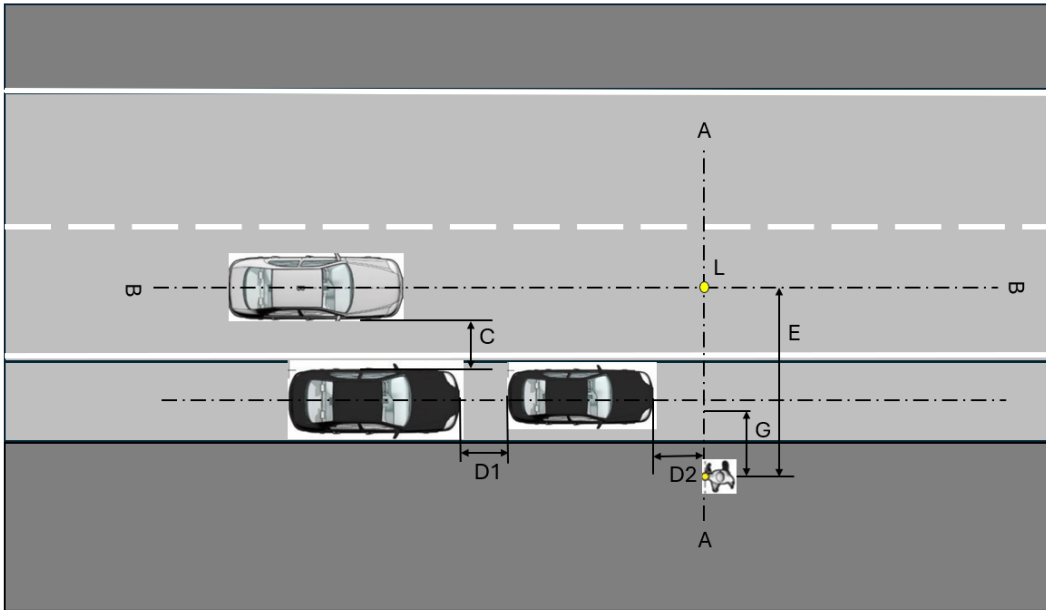


Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle under Test	
Distances		
E	Dummy H-point, start to 50%-impact	6.0m
G	Dummy acceleration distance (walking)	1.5m
C	Centre line stopped vehicle to centre of the centre dashed lane marking of the VUT lane.	1.75m
D	Mid front stopped vehicle to pedestrian path AA	1.5-2.5m
Points		
L	Impact position for 50% scenarios	

A.3 Obstruction/Obscuration (Car-to-Pedestrian)

A.3.1 CPNCO – 50% with variation of starting position

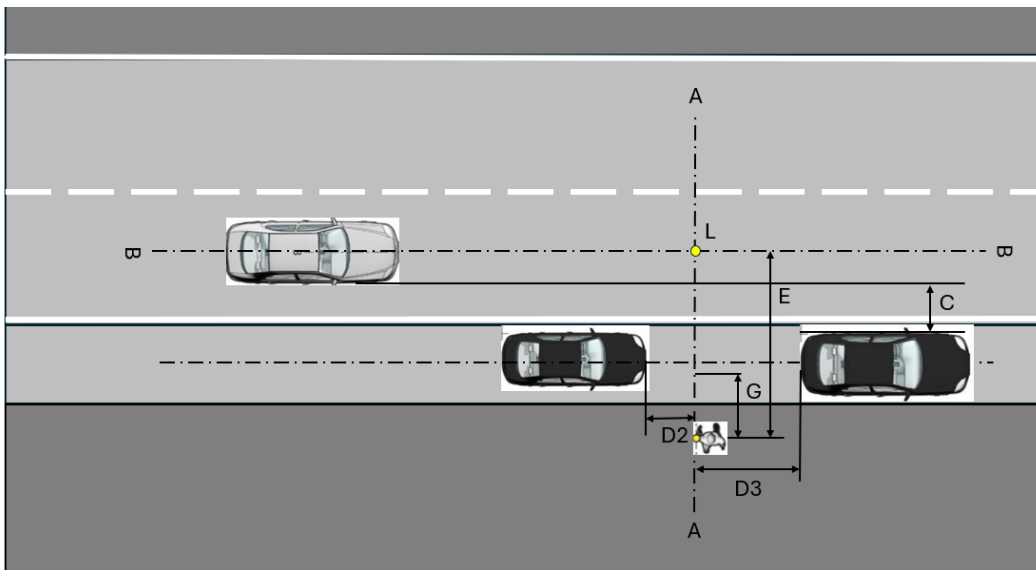
Standard CPNCO-50% with variation of starting point E for the pedestrian.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m ± 25%
G	Dummy acceleration distance (walking)	1.0m
C	Distance between Vehicle Under Test and larger obstruction vehicle	1.0m
D1	Distance front of first obstruction vehicle to rear of second obstruction vehicle	1.0m
D2	Dummy H-point to front of obstruction vehicle	1.0m
H	Impact point offset for 25%	
Points		
M	Impact position for 25% near-side scenario	

A.3.2 CPNCO – with pedestrian walking in between parked vehicles.

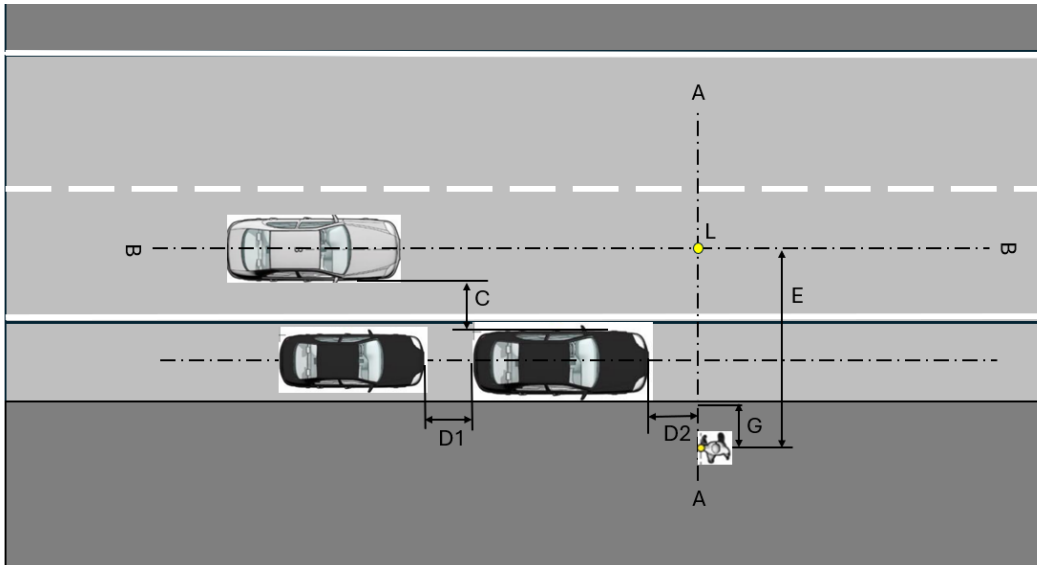
Standard CPNCO-50% with 1st parked vehicle moved to behind the pedestrian path. Allowing the pedestrian to walk in between the two vehicles.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m
G	Dummy acceleration distance (walking)	1.0m
C	Distance between Vehicle Under Test and larger obstruction vehicle	1.0m
D2	Distance dummy H-point to front of obstruction vehicle	1.0m
D3	Distance dummy H-point to rear of the parked vehicle behind the pedestrian path.	1.3m
Points		
L	Impact position for 50% scenarios	

A.3.3 CPNCO – with reversed order of the parked vehicles before pedestrian path.

Standard CPNCO-50% with reversed order of the two parked vehicles, so the larger vehicle is in front of the smaller vehicle.



Axes		Values
AA	Trajectory of pedestrian dummy H-point in std CPNA	
BB	Axis of centreline of Vehicle under Test	
Distances		
E	Dummy H-point, start to 50%-impact	4.0m
G	Dummy acceleration distance (walking)	1.0m
C	Distance between Vehicle Under Test and larger obstruction vehicle	1.0m
D1	Distance front of first obstruction vehicle to rear of second obstruction vehicle	1.0m
D2	Distance dummy H-point to front of obstruction vehicle	1.0m
Points		
L	Impact position for 50% scenarios	

APPENDIX B OBSTRUCTION DIMENTIONS

A.4 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

A.5 Larger obstruction vehicle

The larger obstruction vehicle should be of the category Small Off-road 4x4 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

APPENDIX C TESTING AT LOW AMBIENT LIGHT CONDITIONS

A.6 Illumination Situation

Based on a GIDAS hotspot analysis, this annex will describe a test condition for a night test scenario in urban situations.

A.7 Reference EN 13201

This European Standard defines performance requirements, which are specified as lighting classes for road lighting aiming at the visual needs of road users, and it considers environmental aspects of road lighting.

EN 13201, Road lighting is a series of documents that consists of the following parts:

- Part 1: Guidelines on selection of lighting classes [Technical Report];
- Part 2: Performance requirements [present document];
- Part 3: Calculation of performance;
- Part 4: Methods of measuring lighting performance;
- Part 5: Energy performance indicators.

A.8 Terms and definitions

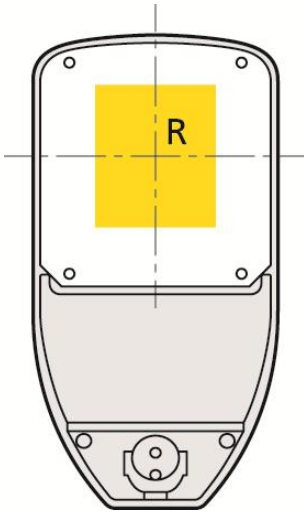
E - horizontal illuminance over a road area measured in lux (lx)

$\overline{E_{min}}$ - horizontal illuminance averaged over a road area measured in lux (lx).

E_{min} - lowest illuminance on a road area measured in lux (lx).

$\overline{E_{max}}$ - horizontal illuminance averaged over a road area measured in lux (lx).

Reference point R - **The reference point of the lamp shall be the geometric centre of the light field**



A.8.1 Derivation of parameter

The test condition in this annex is based on accident analysis. The illumination values refer to DIN EN 13201.

The main illumination situations are main roads in urban situations with velocity 30...60 km/h, where main users are motorized vehicles and where bicycles and pedestrians are permitted.

The illuminance is based on class ME3. For ME3 comparative classes are available: C3 und S1. For Illuminance class S1 following values are defined in EN 13201:

Values for Class S1:

$$\overline{E_{min}} > 15lx \text{ AND } E_{min} > 5lx$$

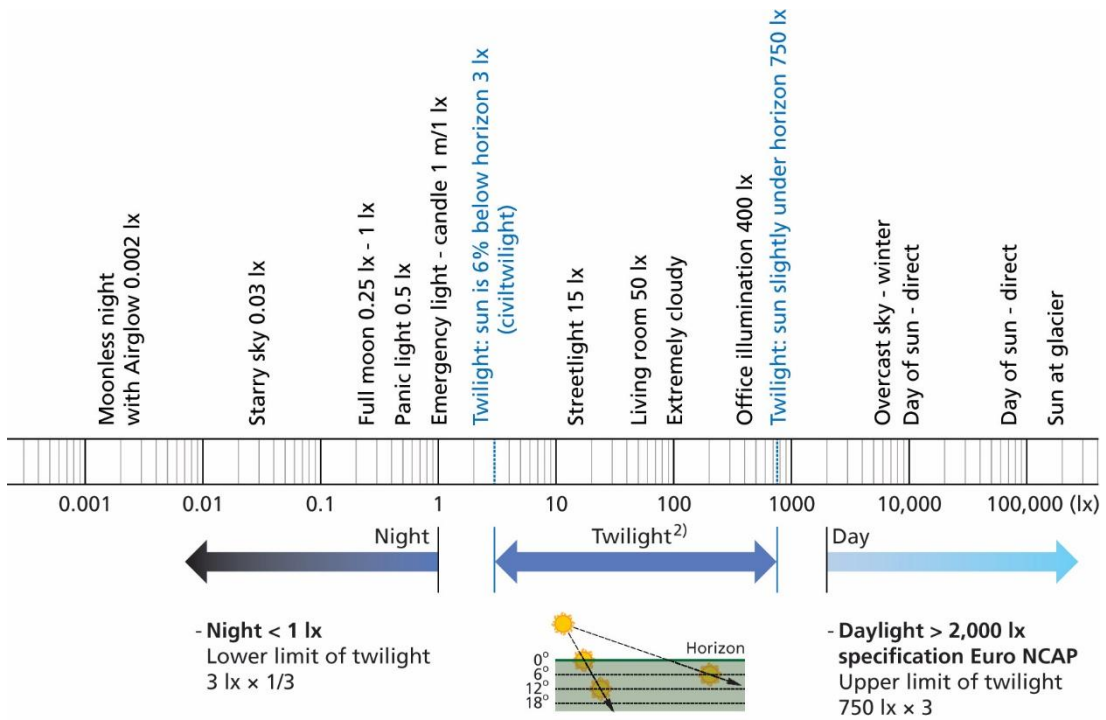
$$\overline{E_{max}} < 1,5 * \overline{E_{min}} \quad \text{AND} \quad \overline{E_{max}} < 22,5lx$$

$\overline{E_{ref}}$ - In order to reach a stable measurement setup, a reference value is defined as:

$$\overline{E_{ref}} = \frac{\overline{E_{min}} + \overline{E_{max}}}{2} = \frac{15lx + 22,5lx}{2} = 18,75lx$$

A.9 Light condition

There is a wide range of illuminance values in different situations. (see figure below).



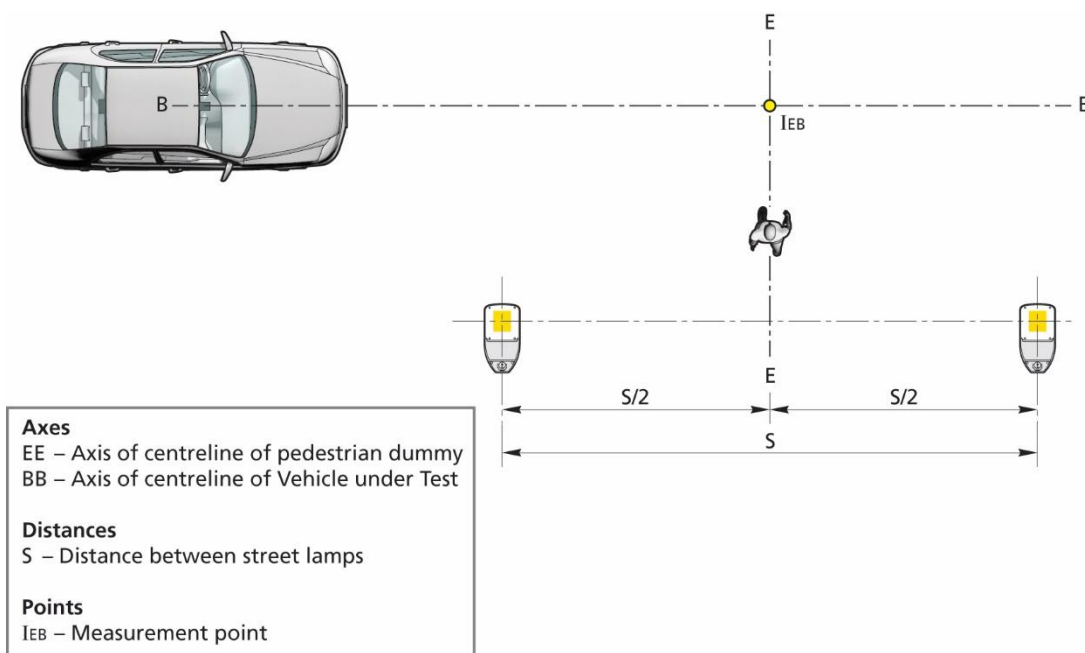
A.9.1 Background illuminance

The background illumination is an additive value to the streetlight illumination.

The position of the measurement of the background illumination shall be measured at the collision point. During measurement of background illumination all lamps and vehicle light shall be switched off.

Maximum of the background illumination on a test area during night shall be less than:

$$I_{EB} < 1lx$$



A.9.2 Illuminance at VUT path

The illuminance of VUT path (\overline{IVUT}) is defined as an average of illuminance measurement points along the VUT path, trajectory BB. For CPNA-25, CPNA-75 and CPNCO the average illuminance shall be in a range of:

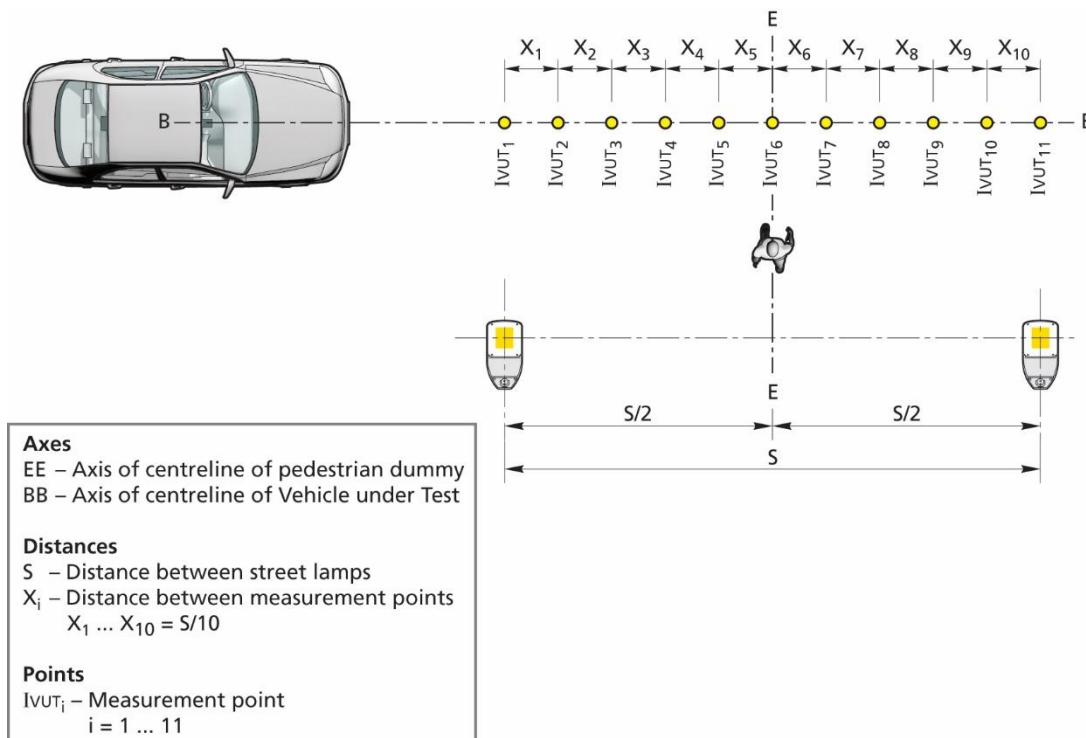
$$\overline{IVUT} = \overline{E_{ref}} \pm Tolerance = 19lx \pm 3lx$$

$$\overline{IVUT} = \frac{1}{11} \sum_{i=1}^{11} IVUT_i; \quad 16lx < \overline{IVUT} < 22lx$$

For CPFA, two additional lamps on the farside shall be switched on and the average illuminance shall be in a range of:

$$\overline{IVUT} = \overline{E_{ref}} \pm Tolerance = 25lx \pm 5lx$$

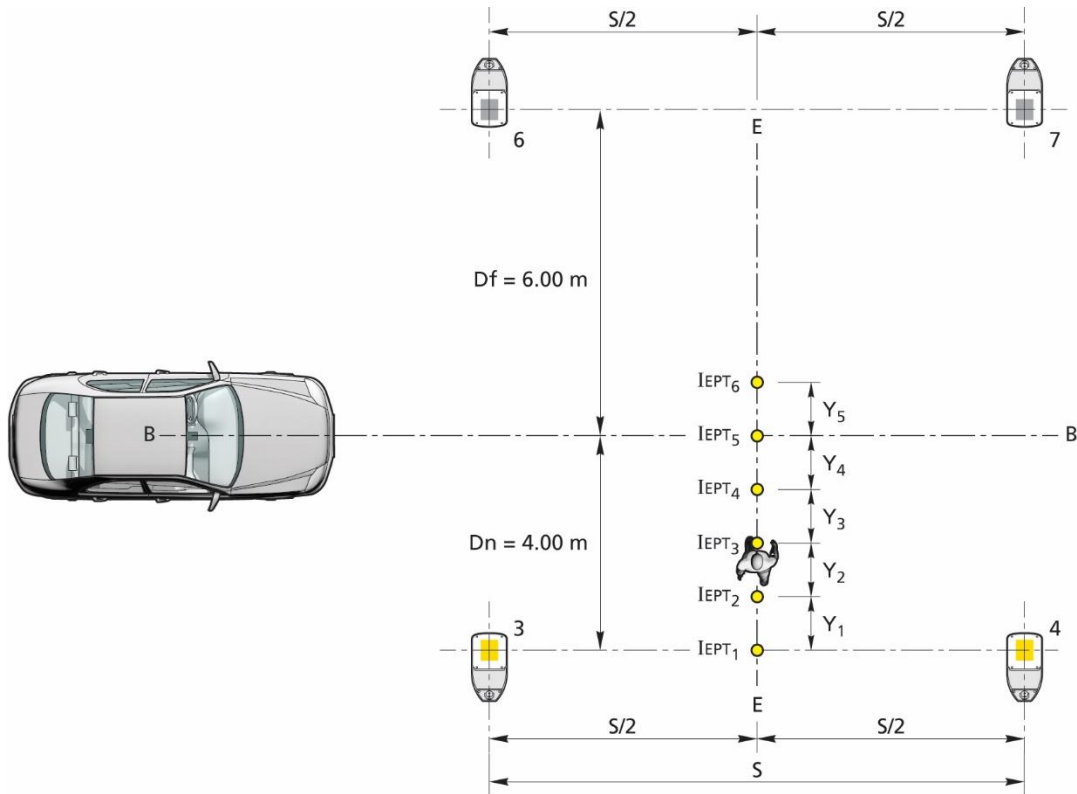
$$\overline{IVUT} = \frac{1}{11} \sum_{i=1}^{11} IVUT_i; \quad 20lx < \overline{IVUT} < 30lx$$



A.9.3 Illuminance at EPT path

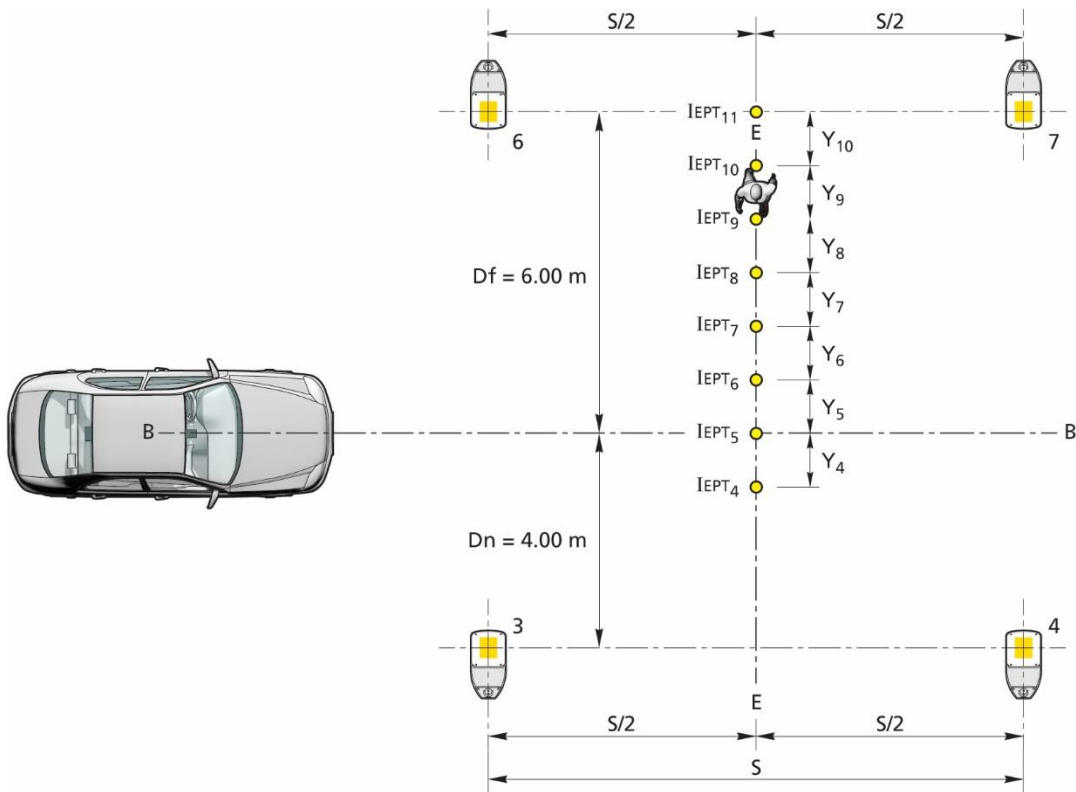
The illuminance along the EPT path, trajectory EE shall be at least $I_{EPT_i} > E_{min}$. I_{EPT_i} ranges from 1 to 6 in nearside scenarios (Figure B5), where street lamps 6 and 7 are switched off. I_{EPT_i} ranges from 4 to 11 in farside scenarios (Figure B6).

$I_{EPT_i} > 5lx$



Axes	
EE	– Axis of centreline of pedestrian dummy
BB	– Axis of centreline of Vehicle under Test
Distances	
Dn	– Lateral distance between the centre of the light field and the VUT path (nearside)
Df	– Lateral distance between the centre of the light field and the VUT path (farside)
S	– Distance between street lamps
Y_i	– Distance between measurement points
	$Y_1 \dots Y_5 = 1m$
Points	
I_{EPT_i}	– Measurement point
	$i = 1 \dots 6$

Figure 5: Illuminance EPT path - nearside scenarios



Axes
EE – Axis of centreline of pedestrian dummy
BB – Axis of centreline of Vehicle under Test
Distances
Dn – Lateral distance between the centre of the light field and the VUT path (nearside)
Df – Lateral distance between the centre of the light field and the VUT path (farside)
S – Distance between street lamps
Y_i – Distance between measurement points
$Y_4 \dots Y_{10} = 1\text{m}$
Points
$IEPT_i$ – Measurement point
$i = 4 \dots 11$

Figure 5: Illuminance EPT path - farside scenarios

A.9.4 Measurement tolerances

All measurement tolerances shall be

E : $\pm 1\text{lx}$

A.10 Test Equipment

A.10.1 General requirement

The chosen lamp setup must reflect real world conditions. It is not allowed to install separate lamps to reach the required conditions. For the night test, a LED lamp shall be used due to its overall advantages like homogeneous illumination, long-term stability, power consumption etc.

A.10.2 Glaring

The lamps shall not be tilted towards the SV path to avoid any glaring which could affect the sensor performance. Glaring of the sensor system shall not occur everywhere on the test area and especially not along the section of the vehicle path.

A.10.3 Constant illumination function

To reach constant test conditions during test and lifetime, the lamp shall have a constant illumination function.

A.10.4 Colour temperature

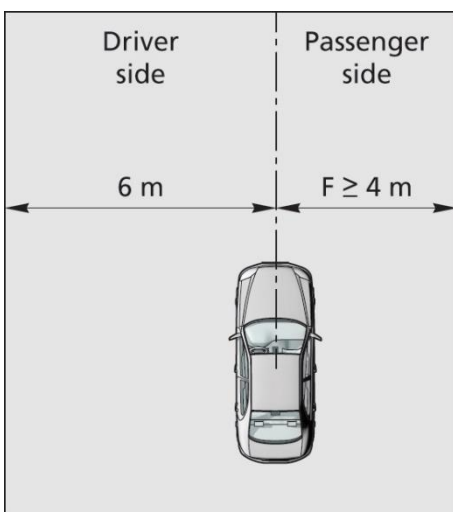
The colour temperature of the lamps shall be between 4500 ± 1000 K.

A.10.5 Mounting device

The lamps can be either installed stationary on a fixed pole, or on a mobile tripod. The mounting device must be designed to withstand wind speeds up to 20 m/s.

A.10.6 Free Space (F)

In the passenger side of the VUT test path it is not allowed to install any mounting device from the lamp.



The free space F between the VUT path and the mounting facility shall be **$F \geq 4\text{m}$** .

A.10.7 Test setup

Four lamps in front of the pedestrian path and three lamps behind the pedestrian path are required (see figure below). That lamp configuration provides a homogeneous illumination of the test scenario according to real world situations.

The position of the EPT is between lamp 3 and 4 (6 and 7 for CPFA).

Lamps 3, 4, 6 and 7 must be the same model lamp.

Lamps 6 and 7 are only switched on for the farside scenario.

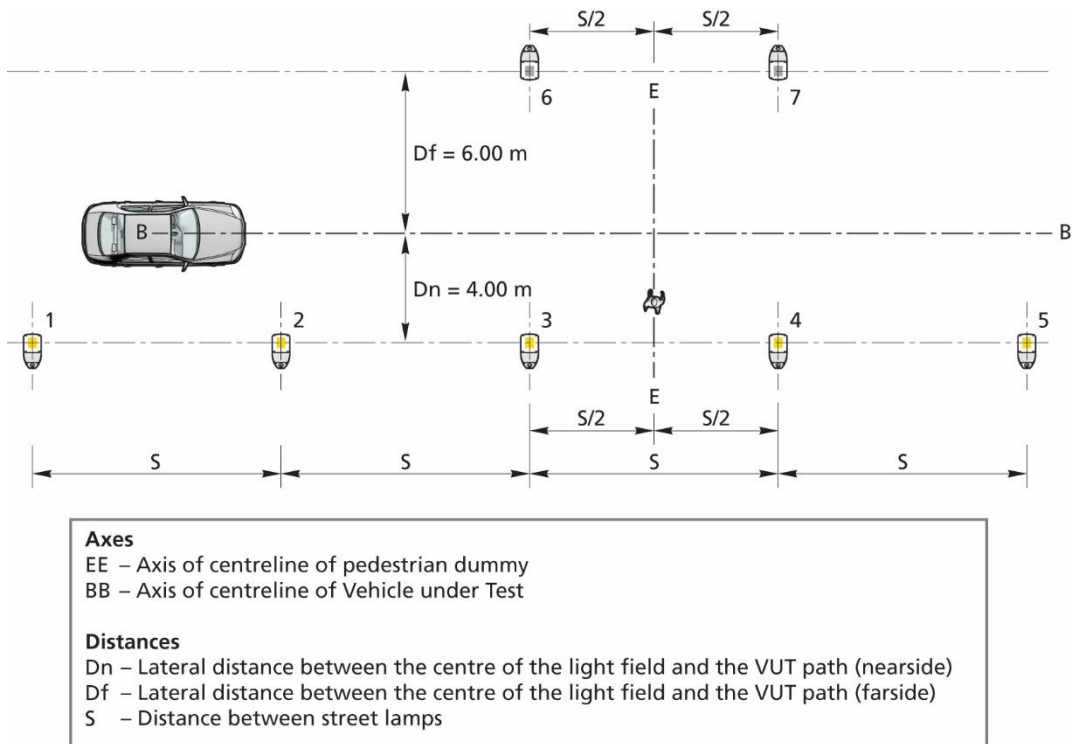
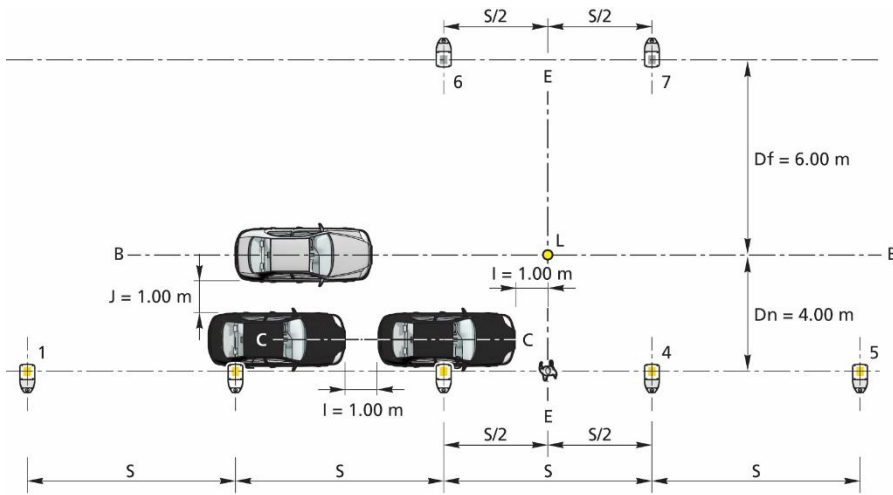


Figure B8: CPNA Night-time setup

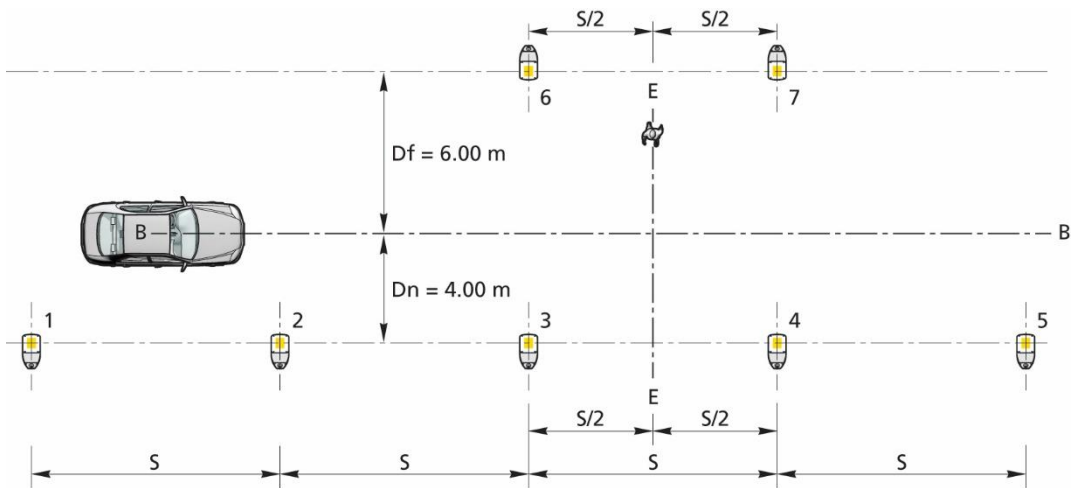


Axes
 EE – Axis of centreline of pedestrian dummy
 BB – Axis of centreline of Vehicle under Test
 CC – Axis of centrelines of obstruction vehicles

Distances
 Dn – Lateral distance between the centre of the light field and the VUT path (nearside)
 Df – Lateral distance between the centre of the light field and the VUT path (farside)
 S – Distance between street lamps
 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 B9: CPNCO Night-time setup



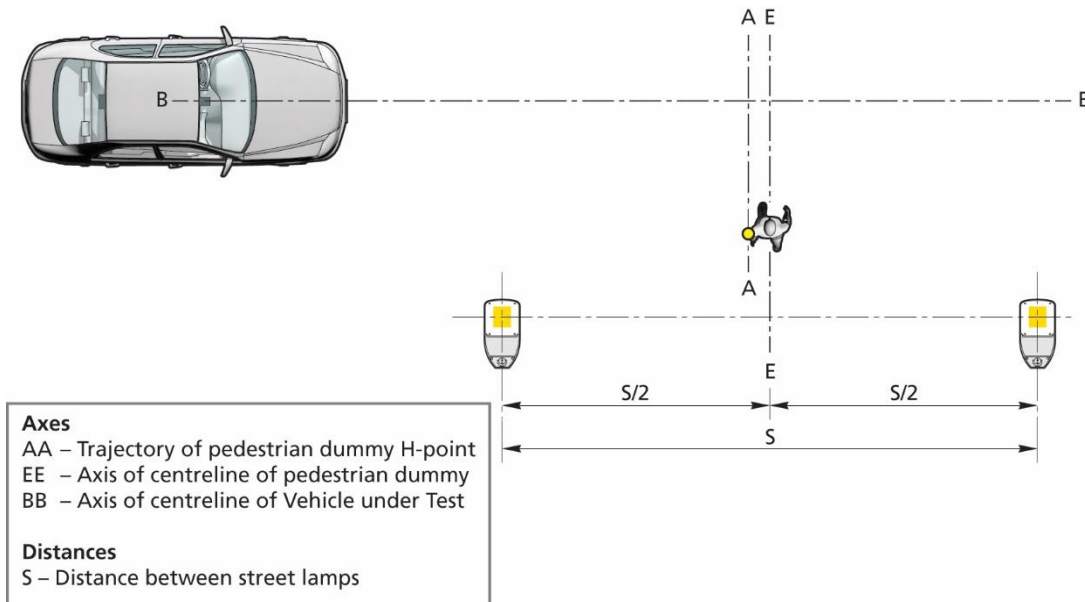
Axes
 EE – Axis of centreline of pedestrian dummy
 BB – Axis of centreline of Vehicle under Test

Distances
 Dn – Lateral distance between the centre of the light field and the VUT path (nearside)
 Df – Lateral distance between the centre of the light field and the VUT path (farside)
 S – Distance between street lamps

Figure B10: CPFA Night-time setup

A.10.8 EPT position

The EPT track EE shall be positioned between the street lamp 3 and 4 and passes the centreline of the EPT. Reference point for test setup is trajectory AA, which passes the pedestrian dummy H-point.



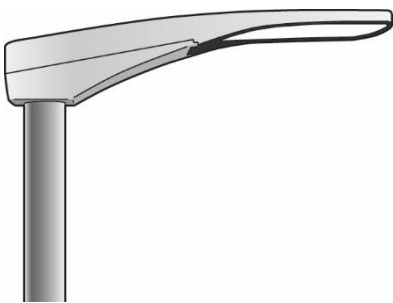
A.11 Example Test Equipment

As a reference and to demonstrate feasibility, the following sections provides example test equipment, test set-up and reference measurements that can be taken to ensure that the set-up will meet the requirements of this ANNEX.

Lamp type

Schuch, 48_LED (48 2403 ABX CL), or

Schuch, 47_LED (48 2403 ABX CL)



A.11.1 Requirement test setup adjustment

To be sure to reach requirement B4.2 and B4.3 the following parameters are allowed to be adjusted.

The distance of the lamp should be adjustable in order to reach the requested illumination values.

S: 25m ± 0,5m

The lateral distance between the centre of the LED-area and the vehicle path is adjustable in a range of

Dn: 4,0m ± 0,1m ; Df: 6,0m ± 0,1m

The height of the lamp should be adjustable in order to reach the requested illumination values.

H: 5m ± 0,1m

Angle against ground and pole.

α : 90° ± 0,5°

The tilt of the lamp is adjustable in three different positions. (0° standard, 5°, 10°)

T: 0° standard position

The inclination of road and test site surfaces is typically ~2.5%

γ : < 1,5°

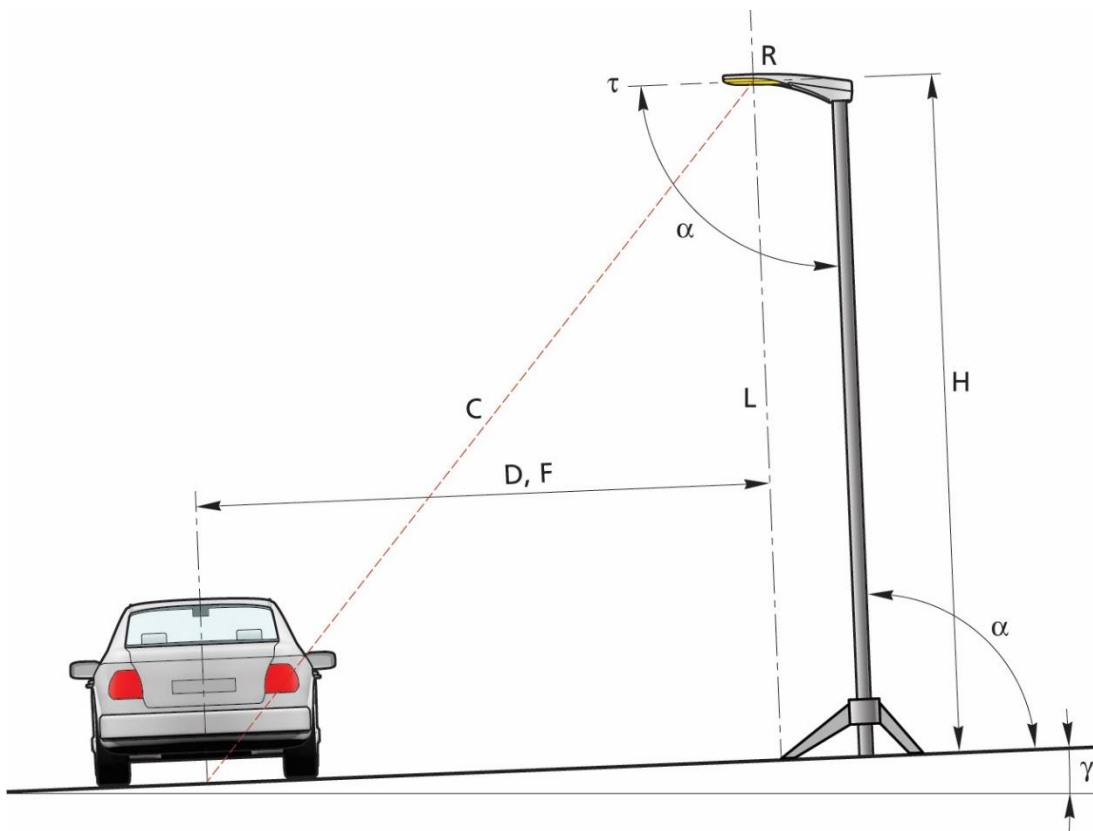
To ensure that the centre lines L of the lamps are oriented at right angles to the street even under the above conditions the length of the control line C (for both nearside Cn and farside Cf) shall be verified. Approval for the two lamps adjacent to the pedestrian path is sufficient:

$$C_n = \sqrt{Dn^2 + H^2} = \sqrt{4m^2 + 5m^2}$$

Cn: 6,4m ± 0,1m;

$$C_f = \sqrt{Df^2 + H^2} = \sqrt{6m^2 + 5m^2}$$

Cf: 7,8m ± 0,1m;

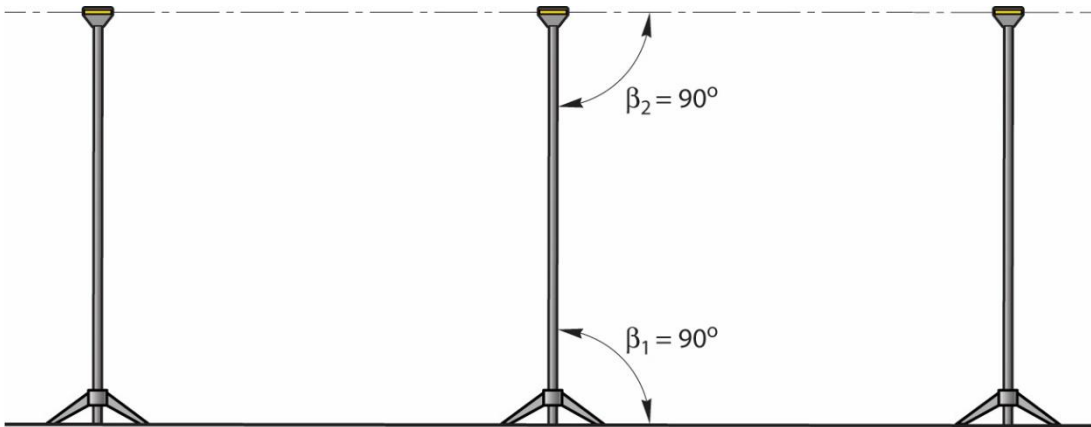


- R – Reference point geometric centre of the light field
- L – Centre line of the lamp (parallel to the pole)
- D – Lateral distance between the centre of the light field and the VUT path
- F – Free space between driving path of VUT and equipment
- H – Height of lamp
- C – Control line
- τ – Tilt of lamp
- α – Angle against ground and pole
- γ – Cross slope

A.11.2 Longitudinal inclination of lamp

In order to get well balanced light distribution, it is necessary that the inclination of the lamp is in a range of:

$\beta_{1,2}: 90^\circ \pm 0.5^\circ$

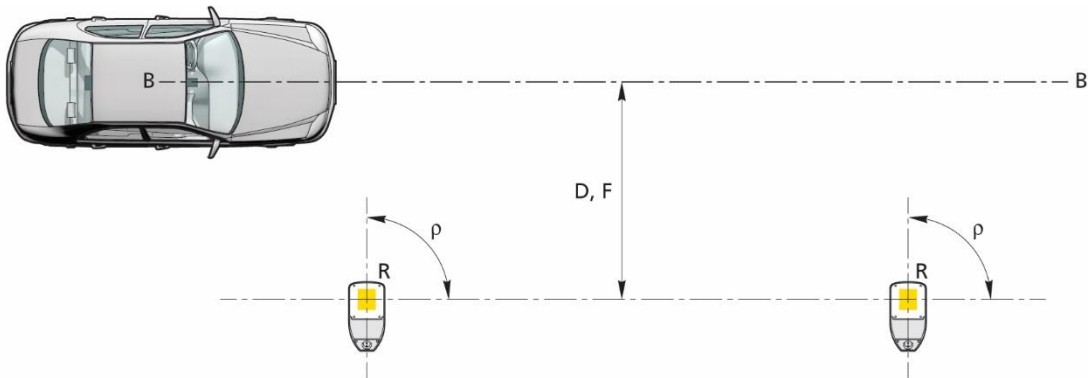


β_1 – Inclination of lamp to ground
 β_2 – Inclination of lamp to pole

A.11.3 Orientation of lamp

In order to get well balanced light distribution, it is necessary that the rotation of the lamp in a range of:

$\rho: 90^\circ \pm 0,1^\circ$



Axes

BB – Axis of centreline of Vehicle under Test

Angles

ρ – rotation of lamp

Distances

F – Free space between driving path of VUT and equipment

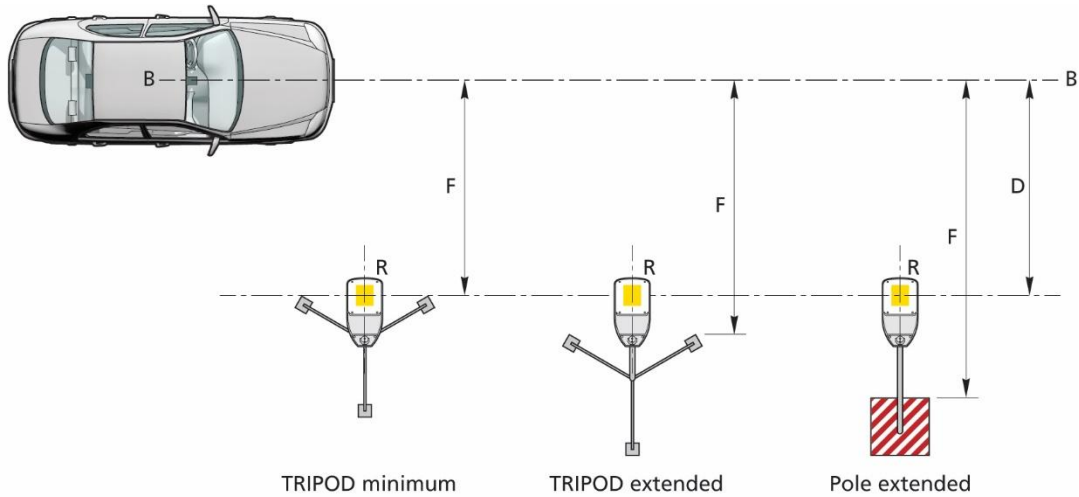
D – Lateral distance between the centre of the light field and the VUT path

Points

R – Reference point geometric centre of the light field

A.11.4 Example solutions

It is not allowed to install any mounting device within the free space. Different solutions are possible to reach the requirement as defined in B5.6.

**Axes**

BB – Axis of centreline of Vehicle under Test

Distances

F – Free space between driving path of VUT and equipment

D – Lateral distance between the centre of the light field and the VUT path

Points

R – Reference point geometric centre of the light field

A.11.5 Example mounting devices

It is not allowed to install any mounting device within the free space. Different solutions are possible to reach the requirement as defined in B5.6.

Towerlight TF5.5

<http://www.towerlight.de/produkt/tf-5-5-7m/>

(Date 2017-05-15)



configuration tripod



configuration cement pole

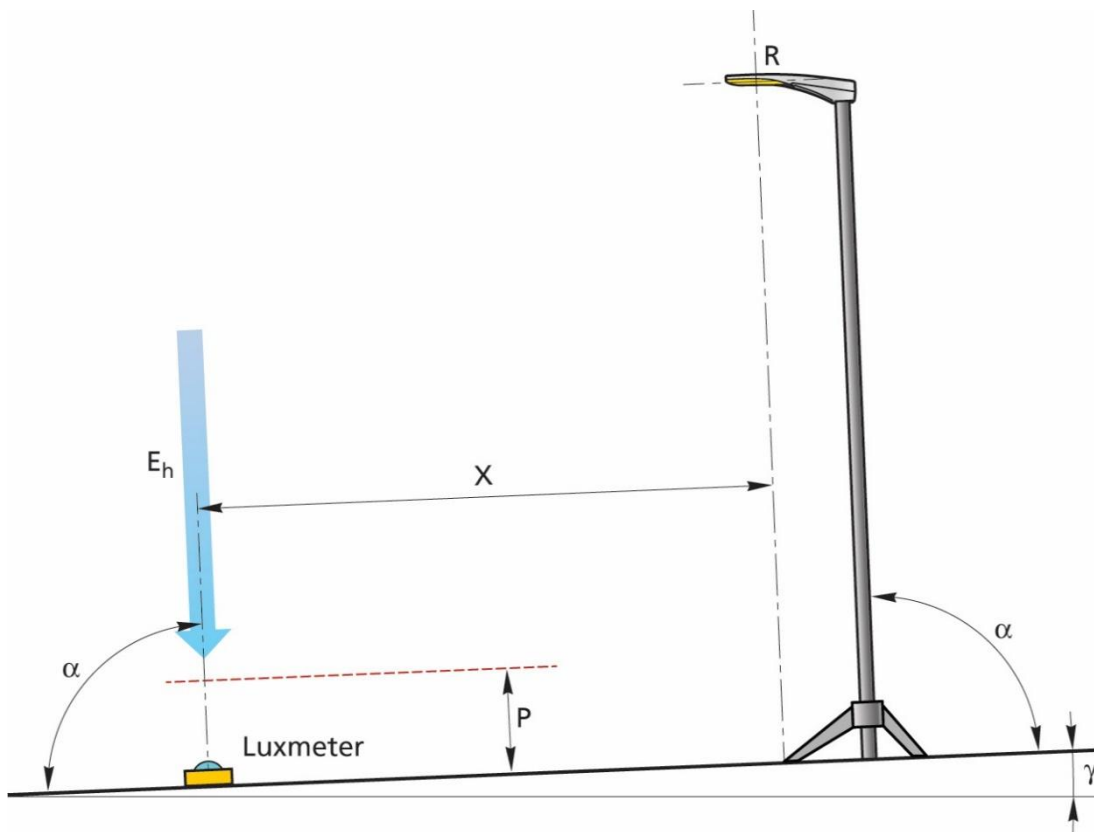
A.12 Measurement

To ensure, that the parameter defined in B4.1, B4.2 and B4.3 are in line with test setup, the parameter must be verified and documented.

A.12.1 Measurement setting

To measure the illumination, a calibrated luxmeter must be set on ground in a right angle to the street.

P: < 0,2m



E_h – Horizontal illumination
R – Reference point geometric centre of light field
P – Maximal height over ground
X – Position X
 α – Angle against ground
 γ – Cross slope

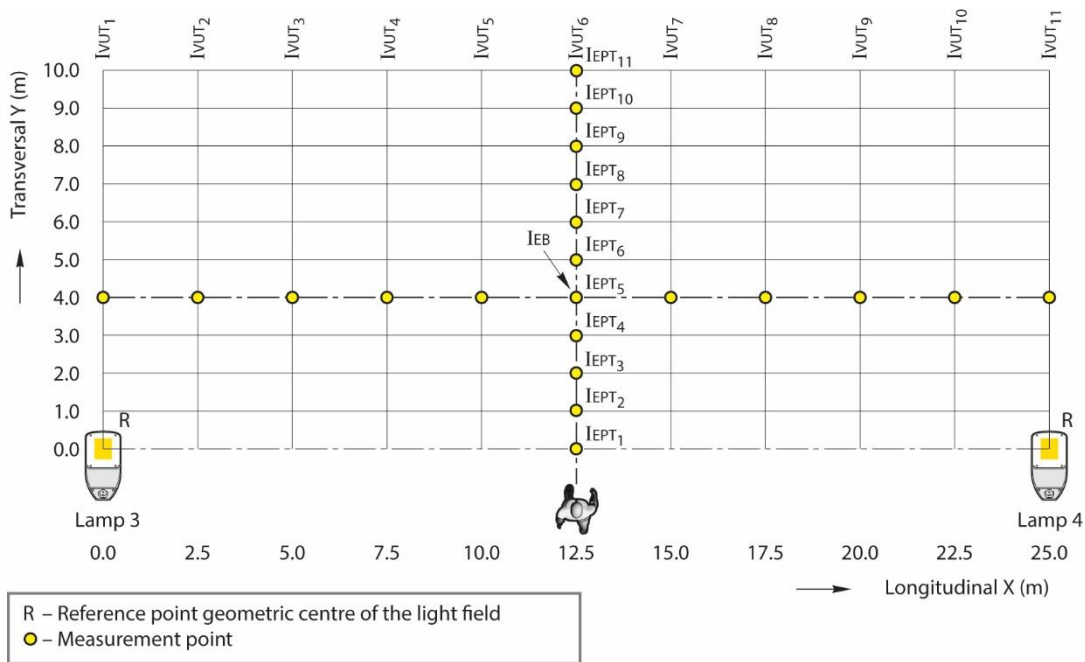
A.12.2 Example measurement grid

To ensure, that the parameter defined in B4.1, B4.2 and B4.3 are in line with test setup, the parameter must be verified and documented.

For I EPT5, I VUT6, I EB the position for measurement is:

X=12,5m, Y=4,0m.

The other values see figure below.



A.12.3 Example measurement tools

To measure the illuminance values, a calibrated luxmeter shall be used. The tolerance shall be:

Maximal error tolerance < 5%.

Luxmeter LMT B 360

<http://www.lmt-berlin.de/de/b360.html>

(Date 2017-05-15)



Luxmeter LMT B 360

Luxmeter Konika T-10A

<https://www.konicaminolta.eu/de/messgeraete/produkte/licht-messtechnik/luxmeter/t-10a/einfuehrung.html>

(Date 2017-05-15)



figure: Luxmeter Konika T-10A

A.12.4 Measurement documentation

The following values shall be measured and documented before and after a complete test series.

- **Background illuminance I_{EB} (A.9.1)**

With all lamps and vehicle lights switched OFF, measure and record I_{EB} before and after a full test series.

- **Illuminance at VUT, EPT path (A.9.2 & A.9.3)**

With all lamps ON and vehicle lights OFF, measure and record the illuminance at VUT and EPT path.

APPENDIX D BRAKE APPLICATION PROCEDURE

The braking input characterisation test determines the brake pedal displacement and force necessary to achieve a vehicle deceleration typical of that produced by a typical real-world driver in emergency situations.

A.13 Definitions

T_{BRAKE} - The point in time where the brake pedal displacement exceeds 5mm.

$T_{-6\text{m/s}^2}$ - The point in time is defined as the first data point where filtered, zeroed and corrected longitudinal acceleration data is less than -6 m/s^2 .

$T_{-2\text{m/s}^2}$, $T_{-4\text{m/s}^2}$ - similar to $T_{-6\text{m/s}^2}$.

A.14 Measurements

Measurements and filters to be applied as described in Chapter 4 of this protocol.

A.15 Brake Characterization Procedure

First perform the brake and tyre conditioning tests as described in 7.1.2 and 7.1.3. The brake input characterisation tests shall be undertaken within 10 minutes after conditioning the brakes and tyres.

A.15.1 Brake Displacement Characterisation Tests

- Push the brake pedal through the full extent of travel and release.
- Accelerate the VUT to a speed in excess of 85km/h. Vehicles with an automatic transmission will be driven in D. For vehicles with a manual transmission select the highest gear where the RPM will be at least 1500 at the 85km/h.
- Release the accelerator and allow the vehicle to coast. At a speed of $80 \pm 1.0\text{km/h}$ initiate a ramp braking input with a pedal application rate of $20 \pm 5\text{mm/s}$ and apply the brake until a longitudinal acceleration of -7 m/s^2 is achieved. For manual transmission vehicles, press the clutch as soon as the RPM drops below 1500. The test ends when a longitudinal acceleration of -7 m/s^2 is achieved.

- Measure the pedal displacement and applied force normal to the direction of travel of the initial stroke of the brake pedal, or as close as possible to normal as can be repeatedly achieved.

A.15.1.1 Perform three consecutive test runs. A minimum time of 90 seconds and a maximum time of 10 minutes shall be allowed between consecutive tests. If the maximum time of 10 minutes is exceeded, perform three brake stops from 72 km/h at approximately 0.3g.

- Using second order curve fit and the least squares method between T-2 m/s², T-6 m/s², calculate the pedal travel value corresponding to a longitudinal acceleration of -4 m/s² (=D4, unit is m). Use data of at least three valid test runs for the curve fitting.
- This brake pedal displacement is referred to as D4 in the next chapters.
- Using second order curve fit and the least squares method between T-2 m/s², T-6 m/s², calculate the pedal force value corresponding to a longitudinal acceleration of -4 m/s² (=F4, unit is N). Use data of at least three valid test runs for the curve fitting.
- This brake pedal force is referred to as F4 in the next chapters.

A.15.2 Brake Force Confirmation and Iteration Procedure

- Accelerate the VUT to a speed of 80+1km/h. Vehicles with an automatic transmission will be driven in D. For vehicles with a manual transmission select the highest gear where the RPM will be at least 1500 at the 80km/h.
- Apply the brake force profile as specified in A.16, triggering the input manually rather than in response to the FCW. Determine the mean acceleration achieved during the window from TBRAKE +1s TBRAKE +3s. If a mean acceleration outside the range of -4 -0.5 m/s² results, apply the following method to ratio the pedal force applied.

$F4_{new} = F4_{original} * (-4 / \text{mean acceleration})$, i.e. if $F4_{original}$ results in a mean acceleration of -5 m/s², $F4_{new} = F4_{original} * -4 / -5$

- Repeat the brake force profile with this newly calculated F4, determine the mean acceleration achieved and repeat the method as necessary until a mean acceleration within the range of -4 -0.5 m/s² is achieved.

A.15.2.1 Three valid pedal force characteristic tests (with the acceleration level being in the range as specified) are required. A minimum time of 90 seconds and a maximum time of 10 minutes shall be allowed between consecutive tests. If the maximum time of 10 minutes is exceeded, perform three brake stops from 72 km/h at approximately 0.3g.

- before restarting the brake pedal force characterisation tests. This brake pedal force is referred as F4 in the next chapters.

A.16 Brake Application Profile

- Detect T_{FCW} during the experiment in real-time.
- Release the accelerator at $T_{FCW} + 1$ s.
- Perform displacement control for the brake pedal, starting at $T_{FCW} + 1.2$ s with a gradient of the lesser of $5 \times D4$ or 400mm/s (meaning the gradient to reach pedal position D4 within 200ms, but capped to a maximum application rate of 400mm/s).
- Monitor brake force during displacement control and use second-order filtering with a cut-off frequency between 20 and 100 Hz (online) as appropriate.
- Switch to force control, maintaining the force level, with a desired value of F4 when
 - i. the value D4 as defined in A.15.1.1 is exceeded for the first time,
 - ii. the force F4 as defined in A.15.1.1 is exceeded for the first time, whichever is reached first.
- The point in time where position control is switched to force control is noted as T_{switch} .
- Maintain the force within boundaries of $F4 \pm 25\% F4$. A stable force level should be achieved within a period of 200ms maximum after the start of force control. Additional disturbances of the force over $\pm 25\% F4$ due to further AEB interventions are allowed, as long as they have a duration of less than 200ms.
- The average value of the force between $T_{FCW} + 1.4$ s and the end of the test should be in the range of $F4 \pm 10$ N.