#FORSAFERTRUCKS

Version 1.20
July 2025

Collision Avoidance Frontal Collisions

Truck-to-Vulnerable Road User

Test Protocol

Implementation November 2024

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 Euro NCAP secretariat should be immediately informed. Any such incident may be reported to the manufacturer and the person concerned may not be allowed to attend further Euro NCAP tests.

CONTENTS

DEFINITIONS

Throughout this protocol the following terms are used:

Heavy Goods Vehicle (HGV) – a category N2 or N3 vehicle with gross mass exceeding 3,500 kg.

Peak Braking Coefficient (PBC) – the measure of tyre to road surface friction based on the maximum deceleration of a rolling tyre, measured using the American Society for Testing and Materials (ASTM) F 2493-20 (SRTT16) standard reference test tyre, in accordance with ASTM Method E 1337-19 (2019), at a speed of 64.4 km/h, without water delivery. Alternatively, 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 audiovisual warning that is provided automatically by the vehicle in response to the detection of a likely collision to alert the driver.

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

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

Vehicle Under Test (VUT) – the vehicle, or vehicle and trailer combination, tested according to this protocol with a pre-crash collision mitigation or avoidance system on board.

Vehicle width – the widest point of the vehicle ignoring the rear-view mirrors/camera monitoring system, sensors, access steps, 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.

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

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

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

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

T_{AEB} – the time where the AEB system activates. Activation time is determined by identifying the last data point where the filtered acceleration signal is below -1.0 m/s^2, and then going back to the point in time where the acceleration first crossed -0.3 m/s^2.

T_{impact} – the time at which the profiled line around the front end of the VUT coincides with the square box around the EPT or EBT as shown in Figure 0-1 and Figure 0-2 below.

V_{impact} – the speed at which the profiled line around the front end of the VUT coincides with the square box around the EPT or EBT as shown in Figure 0-1 and Figure 0-2 below.

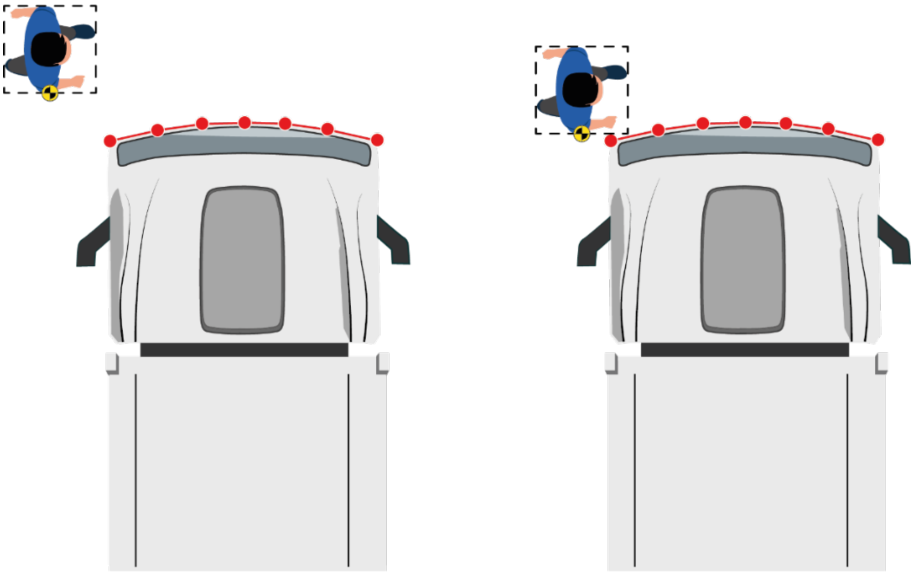


Figure 0-1 Front profile and EPT

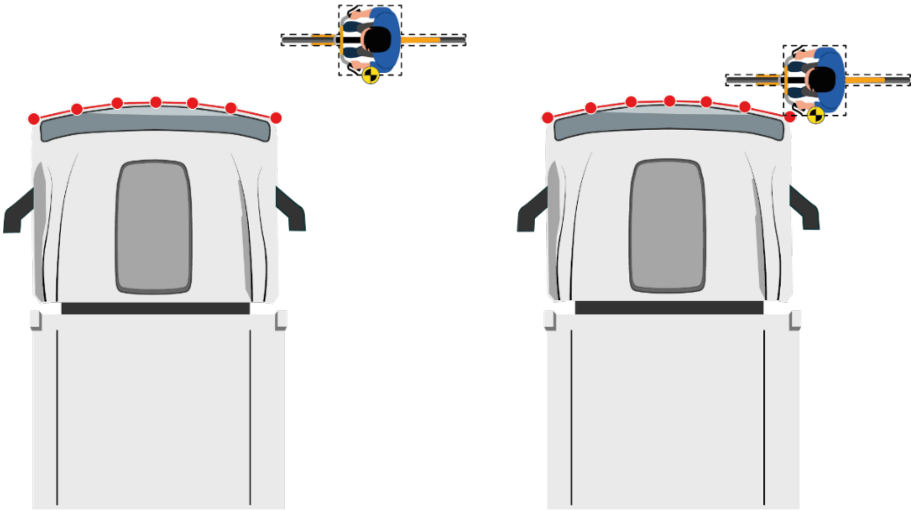


Figure 0-2 Front profile and EBT

V_{rel_test} – the relative speed between the VUT and the EPT or EBT by subtracting the longitudinal velocity of the EPT or EBT from that of the VUT at the start of the test.

V_{rel_impact} – the relative speed at which the VUT hits the EPT or EBT by subtracting the velocity of the EPT or EBT from V_{impact} at the time of collision.

Area of intersection – the area of the EBT virtual box frozen at the point of collision in a near side turn scenario that is overrun by the footprint of the VUT defined by the virtual front and side profile

1 INTRODUCTION

An analysis of European road traffic crash data revealed that collisions with pedestrians account for 16 % of fatalities in HGV collisions, and bicyclists a further 10 %. International crash data does not offer easy breakdowns of crash type. However, a Euro NCAP study of police reported collisions occurring in the UK generally, and London specifically, identified that circa 40 to 45 % of all HGV to pedestrian fatalities occur when an HGV moving at normal traffic speeds collides with a pedestrian crossing in front of it, or walking ahead of it longitudinally. In urban areas about 20 % of pedestrian fatalities occur in those situations. Regarding bicyclists, circa 17 % of all HGV to bicyclist fatalities fall within the scope of the crossing and longitudinal scenarios, and circa 2 % of those occurring in urban areas.

Regarding HGV near side turning, the study identified that circa 3 % of all HGV to pedestrian fatalities fall within the scope of the near side turning scenarios, and circa 6 % of those occurring in urban areas. Regarding bicyclists, circa 22 % of all HGV to bicyclist fatalities fall within the scope of the near side turning scenarios, and circa 40 % of those occurring in London. Highway infrastructure is a defining factor in the nature of HGV to bicyclist near side turning collisions, affected by junction size and whether the HGV and bicyclist share the same road space or if a dedicated cycle lane is provided, offset from the vehicle lane.

Typical incidents occur in busy urban environments when the HGV is moving off or turning at low speed and enters into conflict with a pedestrian or bicyclist crossing or passing alongside. The vast majority of such collisions occur in daylight. The initial collision often occurs at low speed and regularly goes undetected because of the large HGV to VRU mass ratio and vehicle noise masking signs of the impact, and the large vehicle size and elevated driving position meaning the event is remote from the driver and/or not directly visible. The near-vertical front and sides of the HGV regularly cause the VRU to be knocked down and the significant injury mechanism is often the wheels overrunning the VRU, especially when turning as the rear axle(s) cut in.

To support the driver in avoiding collisions with VRUs, vehicle manufactures offer collision avoidance technology that monitors the road and traffic environment and has the ability to warn the driver of an imminent collision, support adequate braking and/or ultimately stop the vehicle by itself.

Whilst regulation makes AEB VRU a mandatory requirement for new HGVs in 2028, Euro NCAP strives to accelerate fitment ahead of this time and drive performance improvements to ensure robust and effective operation in a broad range of real-world collision types. To this end, the Euro NCAP scheme builds on the regulatory requirement by:

- Incorporating additional challenging real-world collision scenarios with walking and running adult and child pedestrians, cycling bicyclists, impact points offset from the centreline of the HGV and line of sight obstructions reminiscent of urban environments
- Rewarding systems that automatically intervene to apply braking when an HGV is in conflict with a VRU in critical near side turning collisions (Regulation only requires information and warning in this scenario)
- Encouraging higher speed operation and performance by offering maximum reward for avoiding collisions at higher test speeds

This protocol specifies the test procedures, which are used to evaluate system performance in a repeatable and reproducible manner for the HGV safety rating scheme.

2 REFERENCE SYSTEM

2.1 Convention

For the VUT EPT and EBT use the convention specified in ISO 8855:1991 in which the x-axis points towards the front of the vehicle, the y-axis towards the left and the z-axis upwards (right hand system), with the origin at the most forward point on the centreline of the VUT for dynamic data measurements as shown in Figure 2-1.

Viewed from the origin, roll, pitch and yaw rotate clockwise around the x, y and z axes respectively. Longitudinal refers to the component of the measurement along the x-axis, lateral the component along the y-axis and vertical the component along the z-axis.

This reference system should be used for both left hand drive (LHD) and right hand drive (RHD) vehicles tested. Figure 2-1 shows the near and far side of the vehicle for a left hand drive (LHD) vehicle. The far side always corresponds to the hand of drive, and therefore swaps sides accordingly for a right hand drive (RHD) vehicle.

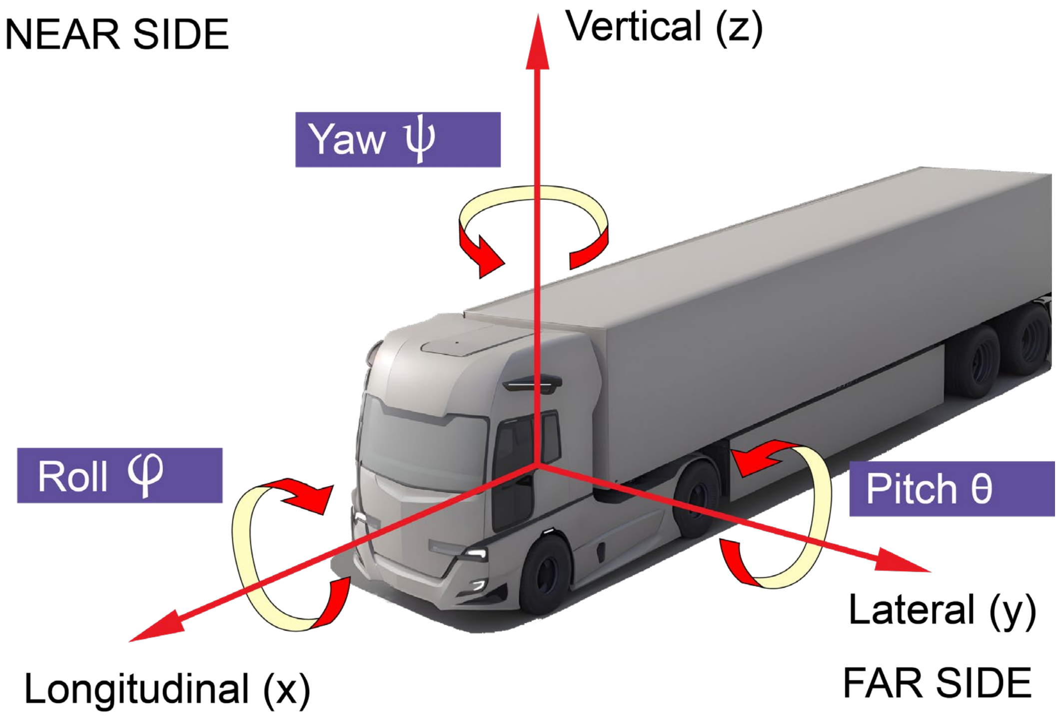


Figure 2-1 Coordinate system and notation (LHD & RHD) and near side – far side for LHD vehicle

2.2 Lateral Path Error

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

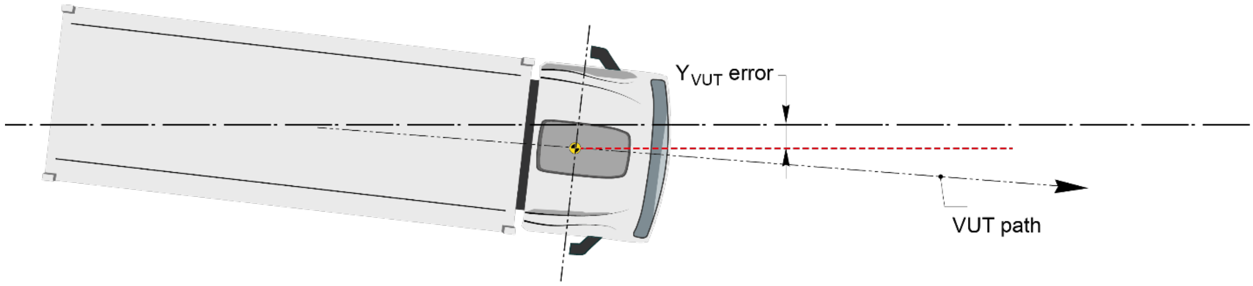


Figure 2-2 Lateral path error

2.3 Profile for Impact Speed Determination

A virtual profile is defined around the front of the VUT for V_{impact} calculation in case of a collision, determined in accordance with EU Regulation 2021/535 Section F: List of devices and equipment that are not required to be taken into account for the determination of the outermost dimensions. This profile is defined by six straight line segments connecting seven lateral locations that are equally distributed over the vehicle width minus 150 mm on each side, as shown in Figure 2 3. The foremost point at each lateral location may not necessarily be at the same height. The vehicle manufacturer is requested to provide profile xy coordinates for verification by the test laboratory.

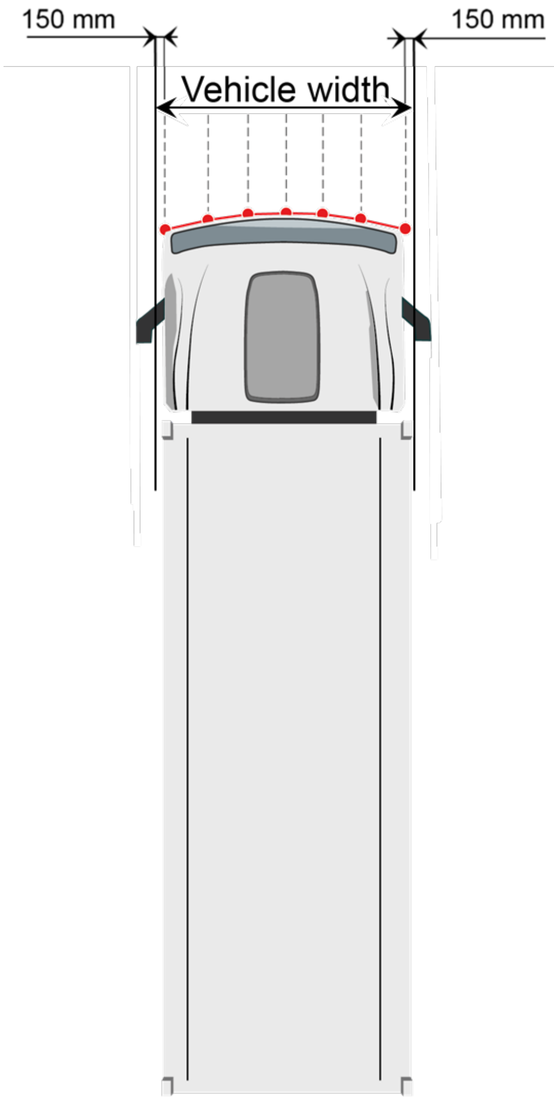


Figure 2-3 Virtual profile around the VUT front end

Around the EPT a virtual box is defined which is used to determine the impact speed. The dimensions of this virtual box are shown in Figure 2-4. For crossing scenarios, the reference point of the EPT is the HIP point and for the longitudinal scenario a virtual point where the centreline of the dummy crosses the virtual box.

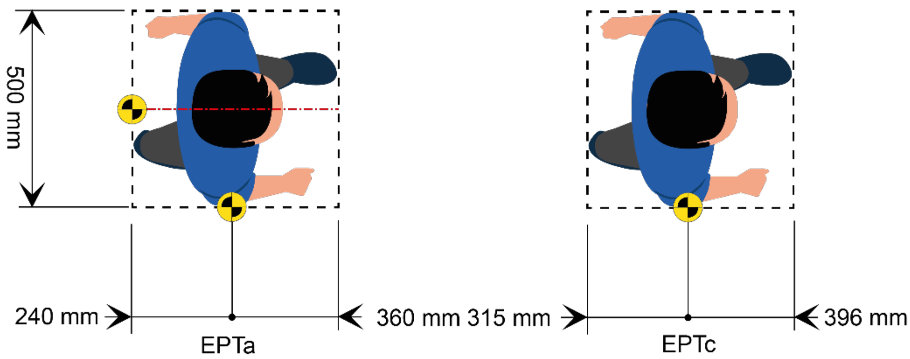


Figure 2-4 Virtual box dimensions around EPTa and EPTc

Around the EBT a virtual box is defined which is used to determine the impact speed and area of intersection. The dimensions of this virtual box are shown in Figure 2-5. For crossing scenarios, the reference point of the EBT is the centre of the bottom bracket (crank shaft) (dashed line in Figure 2-5) and for the longitudinal scenario the most rearward point on the rear wheel is used.

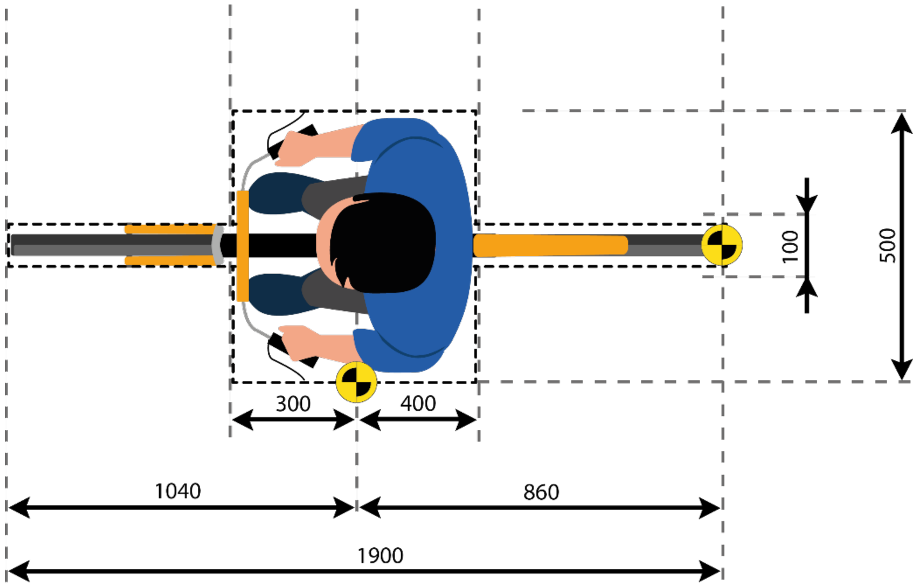


Figure 2-5 Virtual box dimensions around EBT

3 MEASURING EQUIPMENT

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

3.1 Measurements and Variables

Time	T
T_0 equals TTC = 4.0 s except for:	T_0
HPFA, HPNA, HBNA and HPNCO : T_0 starts when the target enters the steady state distance (0.5 s after EPT acceleration phase). For VUT, T_0 = TTC 4.0 s	
T_{AEB}, time when AEB activates	$\mathbf{T}_{AEB}$
T_{FCW}, time when FCW activates	$\mathbf{T}_{FCW}$
T_{impact}, time when VUT impacts the VRU target	$\mathbf{T}_{impact}$
Position of the VUT during the entire test	$\mathbf{X}_{VUT}$, $\mathbf{Y}_{VUT}$
Position of the target during the entire test	$\mathbf{X}_{EPT}$ / $\mathbf{X}_{EBT}$
	$\mathbf{Y}_{EPT}$ / $\mathbf{Y}_{EBT}$
Speed of the VUT during the entire test	$\mathbf{V}_{VUT}$
V_{impact}, VUT speed at T_{impact}	$\mathbf{V}_{impact}$
V_{rel_impact}, V_{impact} minus GVT speed at T_{impact}	$\mathbf{V}_{rel\_impact}$
Speed of the target during the entire test	$\mathbf{V}_{EPT}$ / $\mathbf{V}_{EBT}$
Acceleration of the VUT during the entire test	$\mathbf{A}_{VUT}$
Yaw velocity of the VUT during the entire test	$\dot{\boldsymbol{\Psi}}_{VUT}$
Steering wheel velocity of the VUT during the entire test	$\mathbf{\Omega}_{VUT}$

3.2 Measuring Equipment

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

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

3.3 Data Filtering

Filter the measured data as follows:

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

4 TARGET SYSTEMS

4.1 Euro NCAP Pedestrian and Bicyclist targets

Conduct the tests in this protocol using the Euro NCAP Pedestrian Target (EPTa and EPTc) and Euro NCAP Bicyclist and bike Target (EBT) dressed in a black shirt and blue trousers, as shown in Figure 4-1. The EPT and EBT replicate the visual, radar, lidar and PMD attributes of a typical pedestrian and bicyclist respectively and is impactable without causing significant damage to the VUT.

Figure 4-1 Euro NCAP Pedestrian Target (adult and child) and Bicyclist and bike Targets (EPTa, EPTc and EBT)

To ensure repeatable results, the propulsion system and VRU target must meet the requirements as detailed in ISO 19206 Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions:

Part 2:2018: Requirements for pedestrian targets (articulated targets only)
Part 4:2018: Requirements for bicyclist target

The EPT and EBT are designed to work with the following types of sensors:

Radar (24 and 76 to 81 GHz)
Lidar
Camera
Ultrasonic sensors

When a manufacturer believes that the EPT or EBT is not suitable for another type of sensor system used by the VUT but not listed above, the manufacturer is asked to contact the Euro NCAP Secretariat.

5 SYSTEM PERFORMANCE DATA

5.1 Pedestrian and Bicyclist Crossing and Longitudinal

The vehicle manufacturer is requested to provide the Euro NCAP Secretariat with colour data (expected impact speeds are not required) detailing the AEB performance of the VUT in the pedestrian and bicyclist test scenarios for all impact location and test speed combinations. All data should be supplied by the manufacturer before any testing begins, preferably with delivery of the test vehicle(s).

Data should be provided for each test scenario and test speed according to the colour scheme in Figure 5-1 for HPFA-50, HPNA-25, HPNA-75, HPNCO-50 and HBNA-50, Figure 5-2 for HPLA-25 and HPLA-50 and Figure 5-3 for HBLA-25 and HBLA-50.

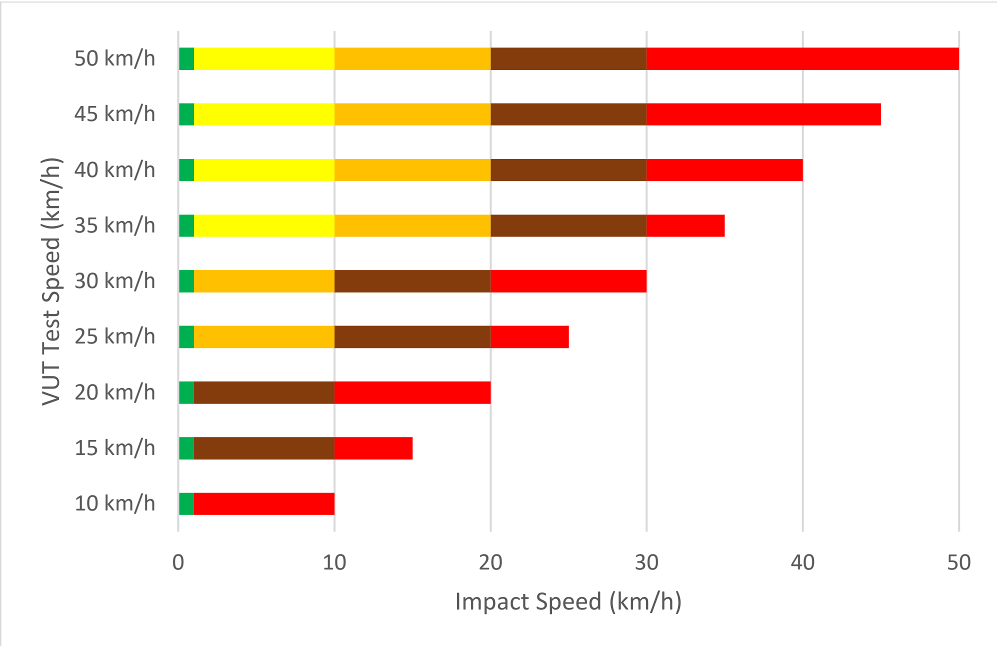


Figure 5-1 HPFA-50, HPNA-25, HPNA-75, HPNCAO-50 and HBNA-50 predicted performance

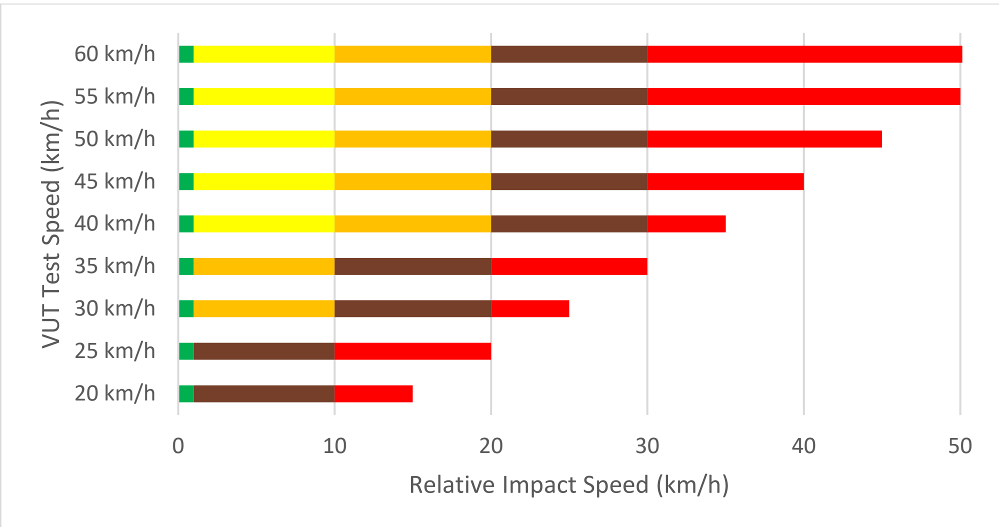


Figure 5-2 HPLA-25 and HPLA-50 predicted performance

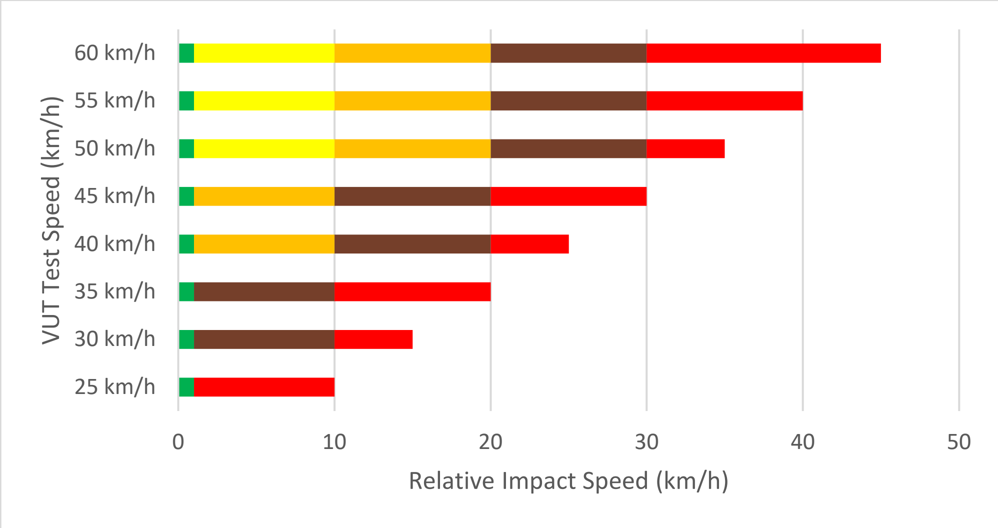


Figure 5-3 HBLA-25 and HBLA-50 predicted performance

Data should also be provided illustrating the anticipated FCW timing for HPLA-25 and HBLA-25.

5.1.1 Bicyclist Near Side Turn

To be defined.

6 TEST CONDITIONS

6.1 Test Track

6.1.1 Paved Surface

Conduct tests on a dry (no visible moisture on the surface), uniform, solid-paved surface with a consistent slope between level and 1 % in all directions. The test surface shall have a minimal peak braking coefficient (PBC) of 0.9.

The surface must be paved and may not contain any irregularities (e.g. large dips or cracks, manhole covers or reflective studs) within a lateral distance of 5.0 m to either side of the centre of the test lane and with a longitudinal distance of 20.0 m ahead of the VUT from the point after the test is complete.

The presence of lane markings is allowed. 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 3.0 m either side. Lines or markings may cross the test path but may not be present in the area where AEB activation is expected.

6.1.2 Junction and Lane Markings

Some scenarios described in this test protocol require the use of a junction. Where this is the case, the scenario description will illustrate the scenario on a junction as in Figure 6-1. The main approach lane where the VUT path starts, (horizontal lanes in Figure 6-1) will have a width of 3.5m. The side lane (vertical lanes in Figure 6-1) will have a width of 3.25 to 3.5 m. 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 0.15 m
- Solid line with a width between 0.10 and 0.25 m
- Junction without any central markings

Note that all dimensions reference the centre of the lane markings.

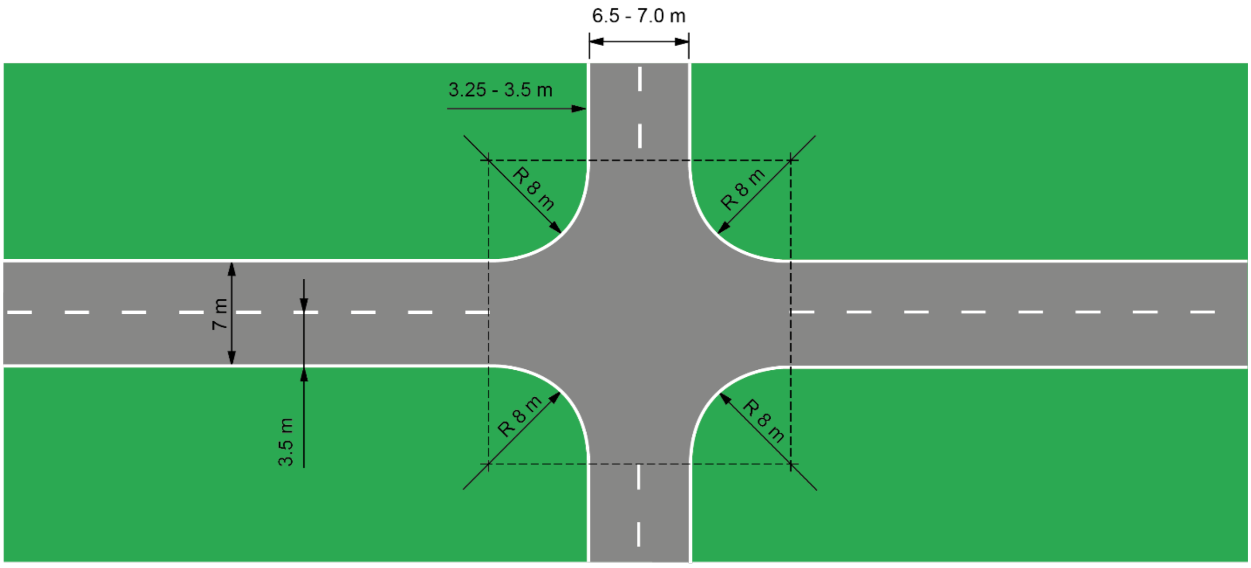


Figure 6-1 Layout of junction and the connecting lanes

6.1.3 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 1 km. The mean wind speed measured at a height of at least 1.0 m above the ground shall be less than 6.0 m/s with gusts not exceeding 10.0 m/s to minimise VUT disturbance.

Natural ambient illumination must be homogenous in the test area and in excess of 2,000 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 in m/s
- Wind direction in azimuth ° and/or compass point direction
- Ambient illumination in Lux

6.1.4 Surroundings

Conduct testing such that there are no other vehicles, highway infrastructure, obstructions (except where detailed in the test scenario), other objects or persons protruding above the test surface, that may give rise to abnormal sensor measurements within:

- 5.0 m either side of the VUT test path during the full duration of the test and within a longitudinal distance 20.0 m ahead of the VUT when the test ends,
- a circle of 2.0 m radius around the VRU target, and
- the visual axis between the geometric centre of the VUT and the circle surrounding the VRU target as illustrated in Figure 6-2.

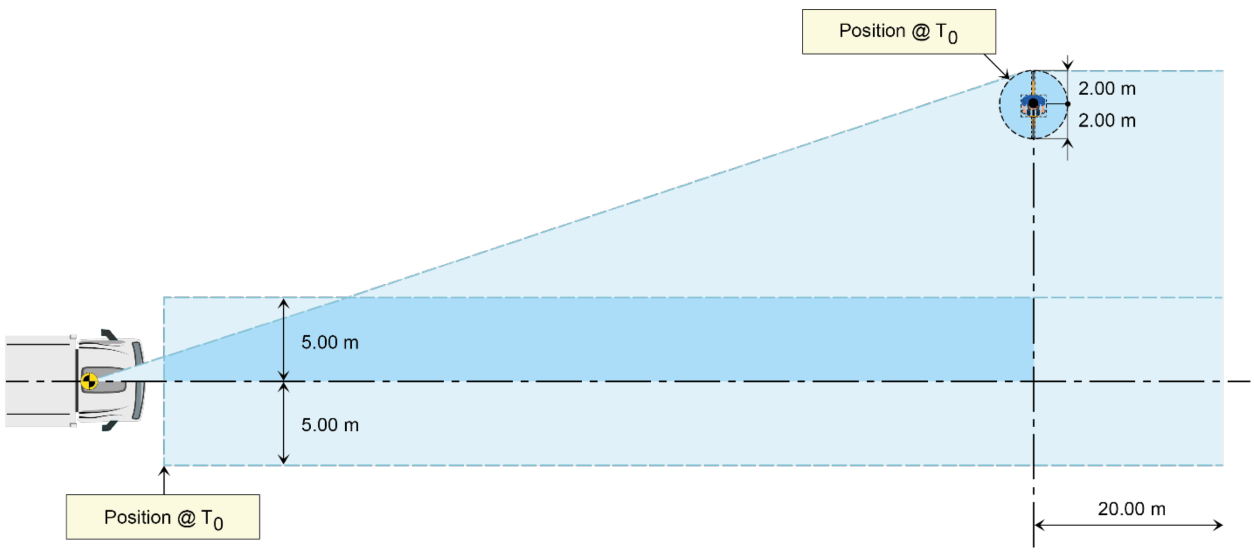


Figure 6-2 Free space requirements

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

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

6.2 VUT Preparation

6.2.1 System Settings

Set any driver configurable elements of the system to the middle setting or midpoint and then next latest setting similar to the examples shown in Figure 6-3.

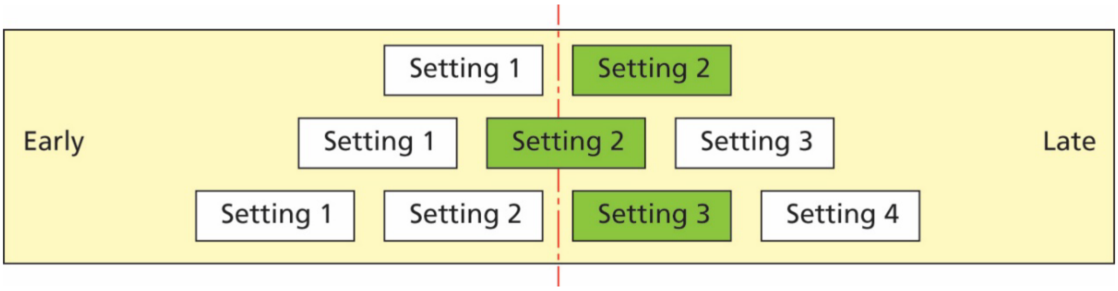


Figure 6-3 System setting for testing

6.2.2 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.

6.2.3 Trailer for Drawing Vehicles

Where the VUT is designed as a prime mover intended for drawing a trailer, complete testing with the VUT coupled to an appropriate trailer of the following specification:

- Of length and height approaching but not exceeding the maximum permitted by Annex 1 of Directive 96/53/EC
- Equipped with a three axle bogie (lift and/or steer axles are permitted to aid manoeuvrability however all axles must be deployed in their regular operating position during testing)
- Of adequate gross trailer mass to fulfil the gross train mass of the VUT
- With a flat floor i.e. not stepped, gooseneck or double deck
- With curtain side body in plain colour without branding
- Suitable for 5th wheel height of the VUT
- Equipped with disc brakes, an UN ECE Regulation 13 Category 1 Antilock Braking System (ABS) and an Electronic Braking System (EBS)
- Equipped with super single tyres (385/65R22.5) in good condition corresponding to the new original fitment tyres of the make, model, size, speed and load rating as specified by the trailer manufacturer

- Maintained in a fully operational condition in accordance with the manufacturer’s documentation and specifications with supporting evidence

Figure 6-1 Example of a suitable trailer for testing

For the purposes of determining drawing vehicle and trailer loading, a nominal trailer mass of 6,700 kg is considered. Weigh the trailer used for testing and account for any variation from the nominal trailer mass when applying the load as illustrated in 6.2.6.

6.2.4 Tyres

Perform the testing with good condition original fitment tyres of the make, model, size, speed and load rating as specified by the vehicle manufacturer. Use inflation pressures corresponding to the manufacturer’s instructions for the appropriate loading condition.

Run-in tyres according to the tyre conditioning procedure specified in 7.1.3. After running-in maintain the run-in tyres in the same position on the vehicle for the duration of the testing.

6.2.5 Running Order

Confirm that all VUT safety and operational systems are functioning correctly with no warning messages or indicators displayed to the driver. Rectify any faults before commencing testing.

Set any configurable driving controls to their automatic setting e.g. ride height setting. If an automatic setting is not available, set to a middle setting.

When driven on the test track with the steering control centrally aligned, ensure the VUT exhibits good straight line driving order. In case of unsatisfactory driving order, the test laboratory shall undertake remedial work to return the geometry to within the OEM tolerances and confirm good driving order.

6.2.6 Loading and Vehicle Preparation

Complete testing with the VUT half laden by mass to represent average category N vehicle operation. The procedure to prepare the VUT load requirement for testing is:

- If applicable, fill up the tank with fuel to at least 90% of the tank’s capacity of fuel, or in case of large tank capacity, partially fill the tank with adequate fuel to perform the testing, noting the fuel level and the vehicle manufacturer specified tank capacity
- Check that the levels of all fluids are within operating limits and top up where necessary

- Ensure that the VUT has all its bodywork and spare wheel on board, if fitted, along with any equipment or tools supplied. Nothing else should be in the VUT
- Ensure that all tyres are inflated according to the manufacturer's instructions for the appropriate loading condition
- Measure the VUT axle masses (without trailer for a drawing vehicle – unladen test trailer mass to be determined separately) to determine the 'measured kerb mass'
- If applicable, calculate the total mass including full fuel tank (accounting for absent fuel as necessary) and for drawing vehicles, adding the 'nominal trailer mass' in 6.2.3
- The total mass is the 'unladen kerb mass' of the VUT. Record calculation details and this mass in the test details
- Determine the 'maximum permitted mass' for the VUT as the lesser of:
    - The vehicle manufacturers maximum design mass, or
    - The maximum permitted mass of the relevant vehicle or vehicle combination that is legally complaint for international transport under the terms of Annex 1 of Directive 96/53/EC
- Note the 'maximum permitted mass' must include any applicable allowance to compensate for the mass of equipment associated with alternative fuel or zero emission technologies, clearly identified from a section on the vehicle plate titled 96/53/EC article 10b compliant
- Calculate the 'nominal as tested mass' as follows:

Nominal as tested mass = (unladen kerb mass + maximum permitted mass) / 2

Calculate the 'load mass' required to achieve the 'nominal as tested mass', accounting for absent fuel, and for drawing vehicles, any difference between the 'nominal trailer mass' and 'actual test trailer mass'

Load mass = nominal as tested mass - measured kerb mass - actual test trailer mass

Apply the 'load mass' to the vehicle comprising of the occupant(s), test equipment (i.e. on-board test equipment and instrumentation, associated cables, cabling boxes and power sources) and ballast, density of no less than 1,000 kg/m^3, placed directly on the load bed

Locate the centre of mass of the ballast centrally within the cargo space (longitudinally and laterally) as far as is as practically possible. Ballast must be securely attached to the VUT and regularly checked during testing to confirm security. If water is used as ballast, it shall be used in full containers to prevent the movement under acceleration

Measure the VUT axle masses with the occupant(s), test equipment and ballast on board and determine the 'as tested mass', confirming that individual axle weights do not exceed their permitted maximums

The difference between the 'actual as tested mass' and the 'nominal as tested mass' shall be no more than the lesser of ± 2.5% of the VUT maximum permitted mass or ± 500 kg

Verify the xy coordinates for the virtual front end and near side vehicle contour given by the manufacturer. When the coordinates given are within 10 mm of those measured by the test laboratory, the coordinates as provided by the manufacturer will be used. When the coordinates are not within 10 mm, the coordinates as measured by the laboratory will be used.

7 TEST PROCEDURE

7.1 VUT Pre-test Conditioning

7.1.1 General

A new vehicle is used as delivered to the test laboratory, however a vehicle may have been used for other Euro NCAP Safe Driving and Crash Avoidance tests.

If requested by the vehicle manufacturer and where not already performed for other tests, drive a maximum of 100 km on a mixture of urban and rural roads with other traffic and roadside furniture to ‘calibrate’ the sensor system. Avoid harsh acceleration and braking.

7.1.2 Brakes

Condition the vehicle’s brakes in the following manner (if it has not been done before for another test or in case the laboratory has not performed 100 km of driving) to ensure they are neither brand new nor corroded. Before commencing the next brake conditioning run, confirm the temperature of the hottest brake rotor is less than 400 °C, or wait a minimum of 120 seconds between runs to prevent brake overheating.

- Perform ten stops from a speed of 56 km/h with an average deceleration of approximately 0.2 to 0.3 g
- Immediately following the series of 56 km/h stops, perform three additional stops from a speed of 72 km/h, each time applying sufficient force to the pedal to operate the vehicle’s antilock braking system (ABS) for the majority of each stop
- Immediately following the series of 72 km/h stops, drive the vehicle at a speed of approximately 72 km/h for five minutes to cool the brakes

7.1.3 Tyres

Condition the vehicle’s tyres in the following manner (if it has not been done before for another test or in case the laboratory has not performed 100 km of driving) to remove the mould sheen.

- Drive around a circle of 100 m in diameter at a speed sufficient to generate a lateral acceleration of approximately 0.1 to 0.2 g for three clockwise laps followed by three anticlockwise laps
- Immediately following the circular driving, drive four passes at 56 km/h, performing ten cycles of a sinusoidal steering input in each pass at a frequency of 1 Hz and amplitude sufficient to generate a peak lateral acceleration of approximately 0.1 to 0.2 g
- Make the steering wheel amplitude of the final cycle of the final pass double that of the previous inputs

In case of instability in the sinusoidal driving, reduce the amplitude of the steering input to an appropriately safe level and continue the four passes.

7.1.4 System Check

Before any testing begins, perform a maximum of ten runs at the lowest test speed the system is supposed to work, to ensure proper functioning of the system.

7.2 Test Scenarios

7.2.1 General

The performance of the AEB VRU system is assessed in a range of pedestrian and bicyclist crossing and longitudinal scenarios and VUT near side turning scenarios.

For all testing scenarios except HBTA, assume a straight line path equivalent to the centreline of the lane in which the collision occurred, hereby known as the test path. Control the VUT with driver inputs or using alternative control systems that can modulate the vehicle controls as necessary to perform the tests.

See 7.2.6 for HBTA and trajectory coordinates illustrated in Annex B.

In case of the maximum vehicle operational speed being less than 90 km/h, the laboratory must test up to the maximum vehicle operational speed with a tolerance of -2 km/h.

7.2.2 Pedestrian Crossing and Longitudinal

For AEB Pedestrian the scenarios HPFA-50, HPNA-25, HPNA-75, HPNCO-50 and HPLA are considered as shown in Figure 7-1, Figure 7-2, Figure 7-3 and Figure 7-4 respectively.

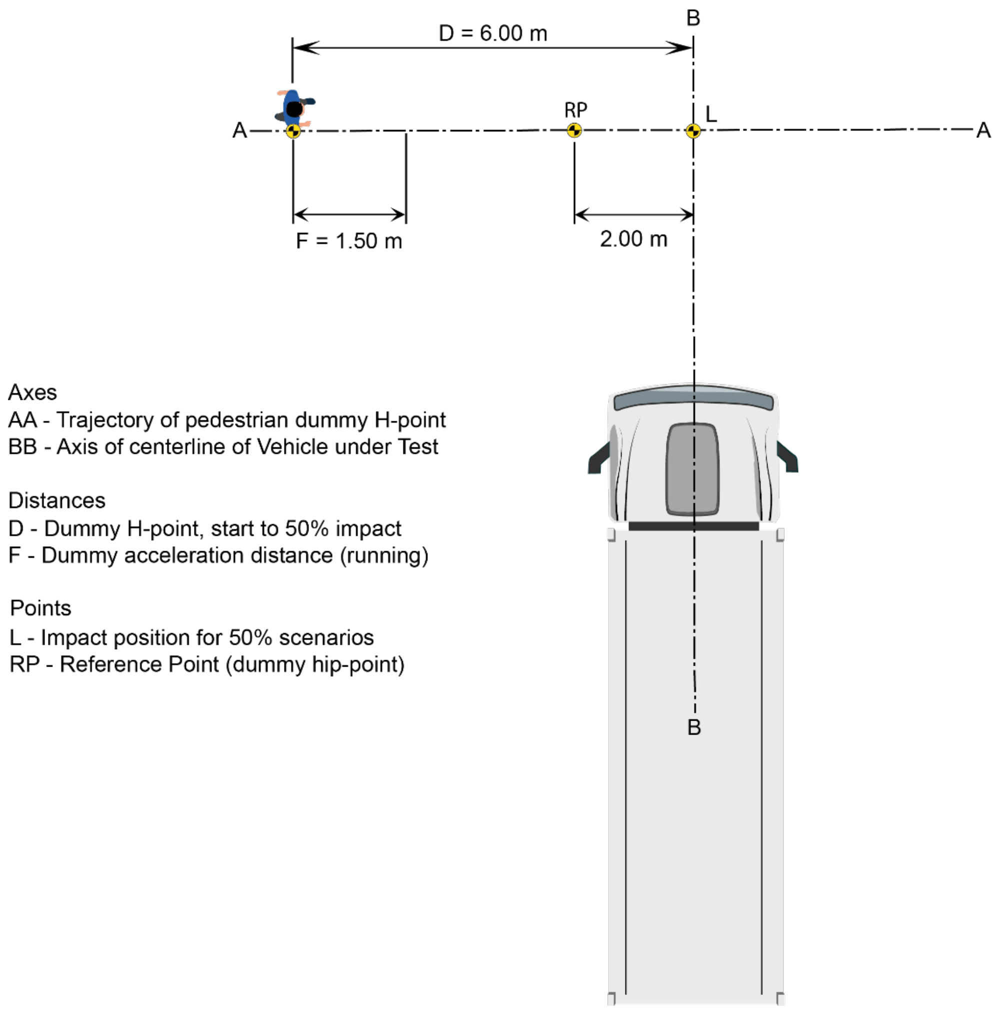
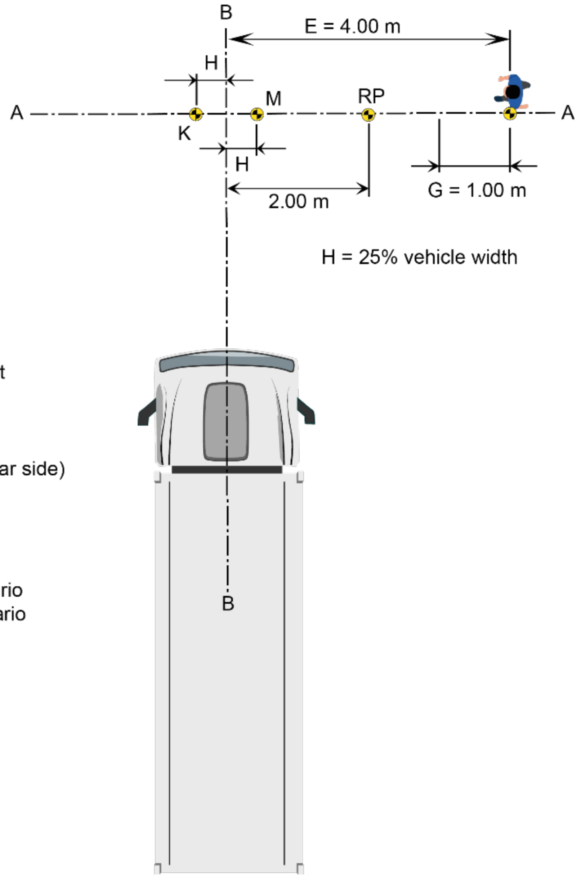


Figure 7-1 HPFA-50 scenario, running adult from far side

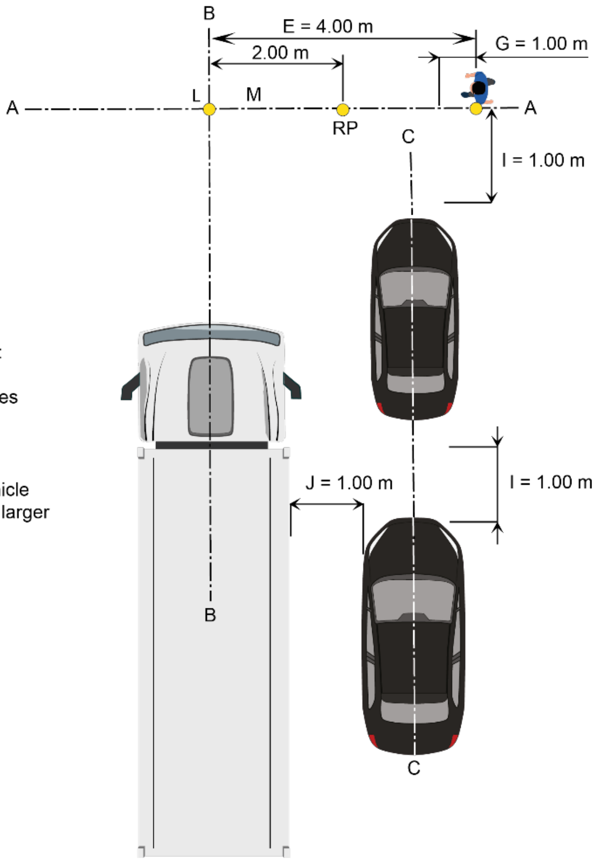


Axes
AA - Trajectory of pedestrian dummy H-point
BB - Axis of centerline of Vehicle under Test

Distances
E - Dummy H-point, start to 50% impact (near side)
G - Dummy acceleration distance (walking)
H - Impact point offset for 25% or 75%

Points
K - Impact position for 75% near-side scenario
M - Impact position for 25% near-side scenario
RP - Reference Point (dummy hip-point)

Figure 7-2 HPNA-25 & HPNA-75 scenarios, walking adult from near side



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

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

Points
L - Impact position for 50% scenarios
RP - Reference Point (dummy hip-point)

Figure 7-3 HPNCO-50 scenario, running child from near side from obstruction vehicles (see Annex A)

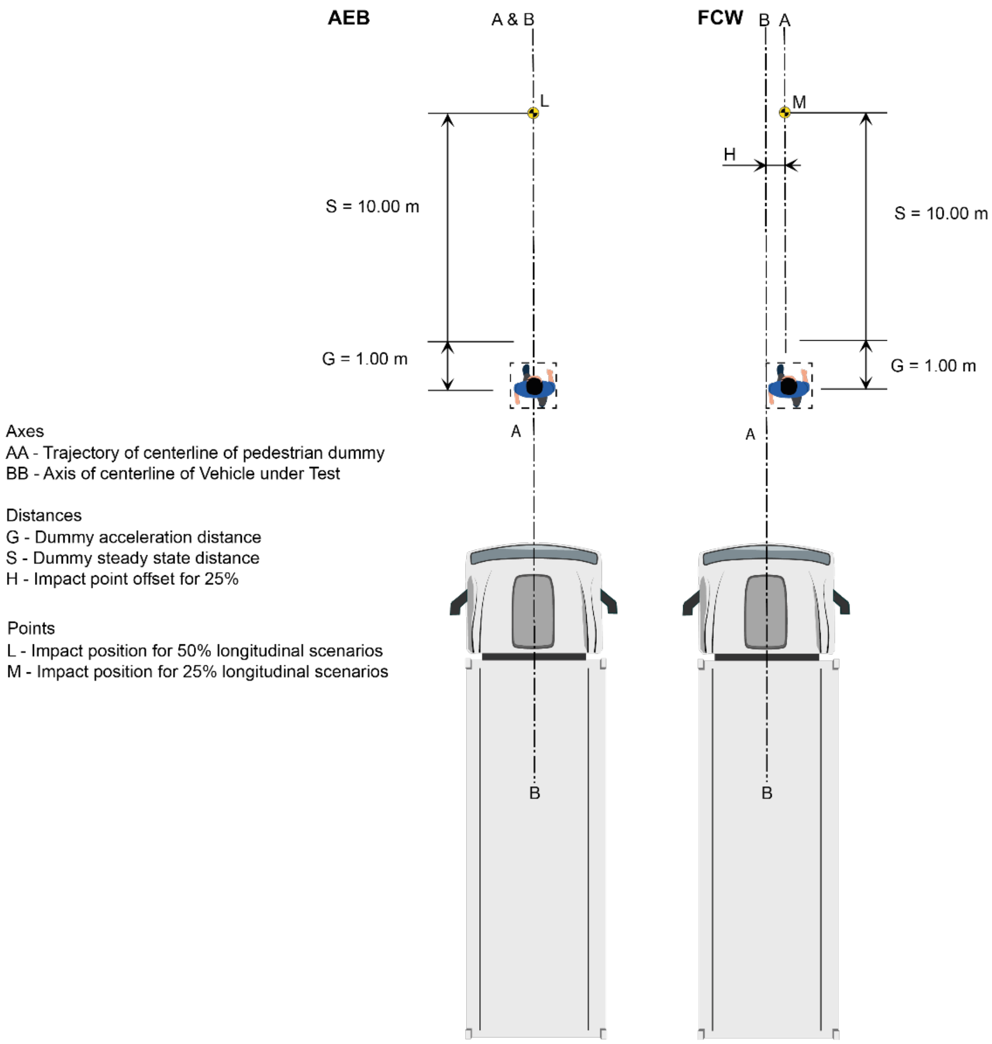


Figure 7-4 HPLA scenario, longitudinal walking adult (HPLA-50 AEB left and HPLA-25 AEB & FCW right)

All scenarios will be performed with 5 km/h incremental steps within the speed ranges as summarised in Table 7-1.

	HGV AEB Pedestrian						
	HPFA-50	HPNA-25	HPNA-75	HPNCO-50	HPLA-25	HPLA-50	HPLA-25
Type of test	AEB						FCW
VUT speed	10-50 km/h				20-60 km/h		50-90 km/h
Target speed	8 km/h	5 km/h					
Impact location	50 %	25 %	75 %	50 %	25 %	50 %	25 %
Lighting condition	Day						

Table 7-1 AEB pedestrian crossing and longitudinal test configurations

In case of the maximum vehicle speed being less than 90 km/h, the laboratory must test up to the maximum vehicle speed with a tolerance of -2 km/h.

7.2.3 Bicyclist Crossing and Longitudinal

For AEB Bicyclist the HBNA and HBLA scenarios are considered as shown in Figure 7-5 and Figure 7-6.

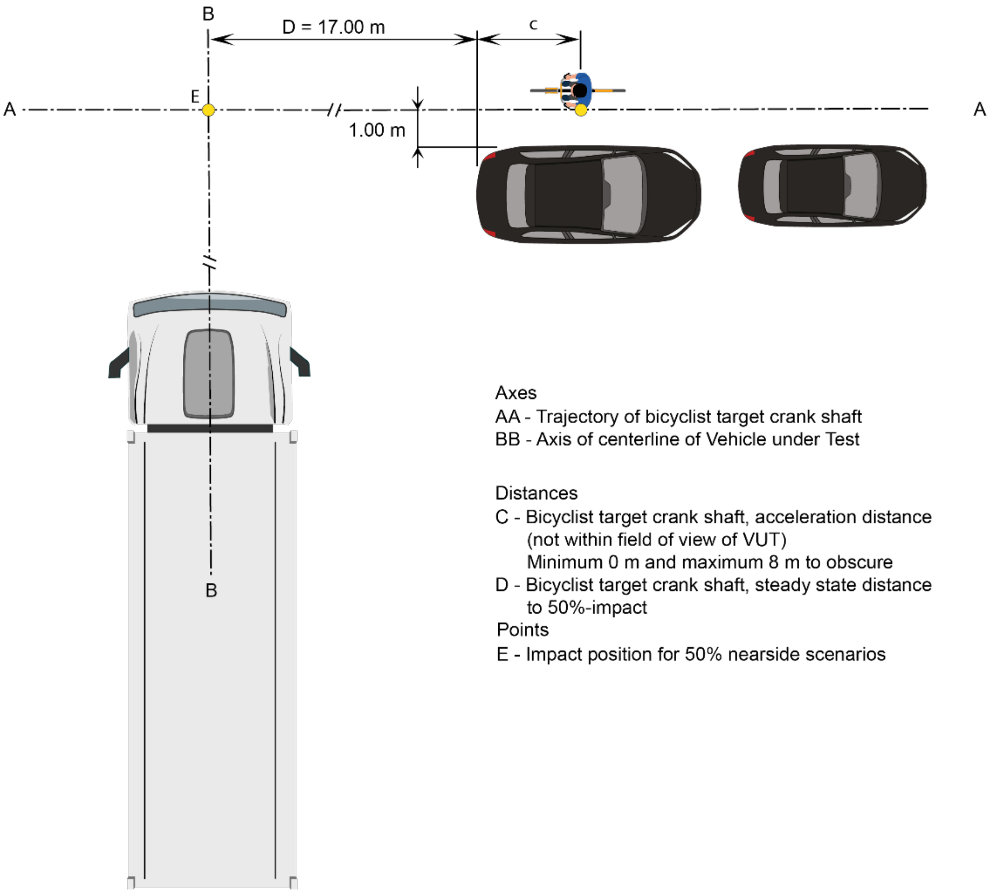


Figure 7-5 HBNA scenario, bicyclist from near side

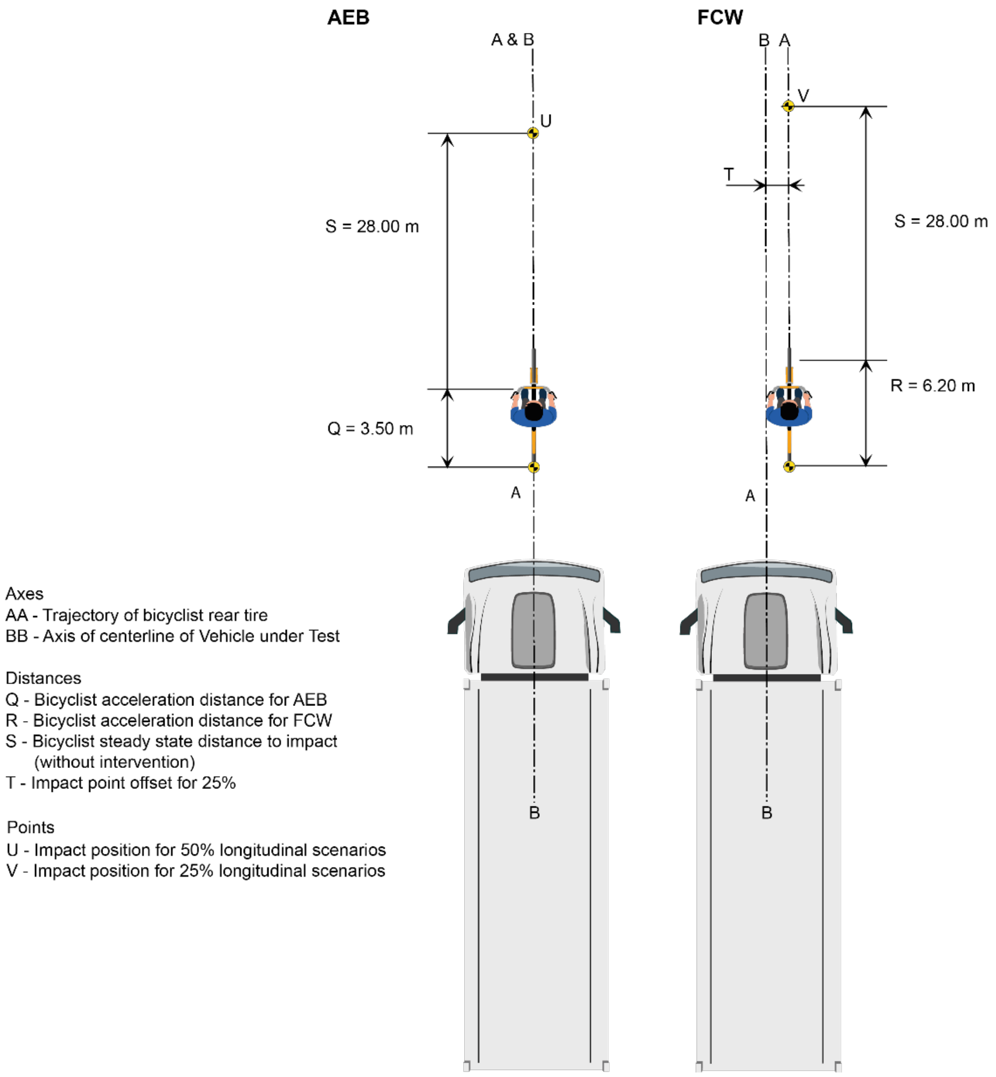


Figure 7-6 HBLA scenarios, longitudinal bicyclist (HBLA-50 AEB left and HBLA-25 AEB & FCW right)

All scenarios will be performed with 5 km/h incremental steps within the speed ranges as summarised in Table 7-2.

HGV AEB Bicyclist				
	HBNA-50	HBLA-25	HBLA-50	HBLA-25
Type of test	AEB			FCW
VUT speed	10 to 50 km/h	25 to 60 km/h		50 to 90 km/h
Target speed	15 km/h			20 km/h
Impact location	50 %	25 %	50 %	25 %
Lighting condition	Day			

Table 7-2 AEB bicyclist crossing and longitudinal test configurations

7.2.4 Bicyclist Near Side Turn

To be defined.

7.3 Test Conduct

7.3.1 General

Before every test run, drive the VUT around a full circular path, and then manoeuvre the VUT into position on the test path. If requested by the OEM 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.

Before commencing the next test run, confirm the temperature of the hottest brake rotor is less than 150 °C. It is acceptable to wait for brake cooling to occur between test runs. Forced cooling is permitted with ambient air only.

Between tests, avoid riding the brake pedal and harsh acceleration, braking or turning unless strictly necessary to maintain a safe testing environment.

7.3.2 Pedestrian and Bicyclist Crossing and Longitudinal

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 1000 at the test speed. If fitted, a speed limiting device or cruise control may be used to maintain the VUT speed (not ACC), unless the vehicle manufacturer shows that there are interferences of these devices with the AEB system in the VUT. Apply only minor steering inputs as necessary to maintain the VUT tracking along the test path.

7.3.3 Bicyclist Near Side Turn

To be defined.

7.4 Test Execution

Accelerate the VUT and EPT or EBT to their respective test speeds on their appropriate test paths.

The test shall start at T_0 (4 s TTC or start of trajectories for near side turn) and is valid when all boundary conditions are met between T_0 (for CPLA & CBLA-AEB T_0 - 1 s) and T_{AEB} and/or T_{FCW}, or any other system intervention:

- Speed of VUT (GPS-speed)
  - Crossing and longitudinal scenarios   Test speed + 1.0 km/h
  - Near side turn scenario   Trajectory speed ± 3.0 km/h
- Speed of EPT during steady state   ± 0.2 km/h
- Speed of EBT
  - o Crossing and longitudinal scenarios   ± 0.5 km/h
  - o Near side turn scenario   ± 1.0 km/h
- Lateral deviation from test path for VUT
  - Crossing and longitudinal scenarios   0 ± 0.10 m
  - Near side turn scenario   0 ± 0.50 m
- Lateral deviation from EPT and EBT test path
  - Crossing scenarios   0 ± 0.05 m
  - Longitudinal scenarios   0 ± 0.15 m
  - Turning scenarios   0 ± 0.05 m
  - Lateral velocity   0 ± 0.15 m/s
- Yaw velocity of VUT
  - Crossing and longitudinal scenarios   0 ± 1.0 °/s
- Steering wheel velocity
  - Crossing and longitudinal scenarios   0 ± 20.0 °/s
- Start of steady state
  - EPT near and far side   3.0 m from VUT centreline
  - EPT longitudinal   10.0 m from VUT impact point
  - EBT near side   17.0 m from VUT centreline
  - EBT longitudinal   28.0 m from VUT impact point
  - EBT near side turn   18.0 m from VUT impact point

In case of the unanticipated withdrawal of automatic braking during an AEB system test with a straight line approach, investigate the steering wheel velocity after T_{AEB}. If the steering wheel velocity exceeds the 0 ± 20.0 °/s limit after T_{AEB} repeat the test taking measures to maintain the steering wheel velocity within the limit until the end of the test. Note that other testing tolerances remain applicable from T_0 to T_{AEB} only.

The end of a test, where the AEB function is assessed, is considered when one of the following occurs:

- V_{VUT} = 0 km/h (crossing and near side turn) or $V_{VUT} = V_{EPT/EBT}$ (longitudinal)
- T_{impact} (crossing and longitudinal)
- In case of contact between the VUT and EBT (near side turn) contact plus a sufficient period of data to determine the area of intersection result
- EPT or EBT has left the VUT path or VUT has left the EPT or EBT path

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

- V_{VUT} = 0 km/h (crossing) or $V_{VUT} = V_{EPT/EBT}$ (longitudinal)
- T_{FCW} < 1.7 s TTC, after which an evasive action can be started

For manual or automatic accelerator control, it must be assured that during automatic braking the accelerator pedal does not result in an override of the system. There shall be no operation of other driving controls during the test e.g. clutch or brake pedal.

If during the execution of a test run it can be confidently predicted that V_{impact} would be in the red colour band for the test speed, it is permitted to end the test and take evasive action to avoid a collision in the interest of preserving the VUT, EPT and EBT.

7.4.1 Pedestrian and Bicyclist Crossing and Longitudinal

For AEB systems tests, commence testing at a test speed increment appropriate for evaluating the system performance. Whilst there is complete avoidance, continue testing in 10 km/h increments to evaluate system performance across the test speed range for the scenario. When there is contact, continue testing in 5 km/h increments to evaluate system performance across the test seed range for the scenario.

For relative test speeds up to and including 30 km/h (for crossing scenarios, this means the VUT test speed, and for longitudinal scenarios, this means the VUT test speed minus the VRU speed), stop testing if the VUT relative speed at impact is greater than 20 km/h for two consecutive test speeds.

For relative test speeds 35 km/h and above, stop testing if the VUT relative speed at impact is greater than 30 km/h.

For FCW systems tests, when the FCW is issued before 2.2 s TTC, the subsequent test speed for the next test is incremented with 10 km/h. When the FCW is issued after 2.2 s TTC, first perform a test at a test speed 5 km/h less than the test speed where this occurred. After this test continue to perform the remainder of the tests with speed increments of 5 km/h.

Stop testing when the manufacturer predicts that the FCW is not issued before 1.7 s TTC.

Where the predicted speed reduction in the tests above 40 km/h is at least 20 km/h (sufficient to score points), but the actual speed reduction measured in the test is between 15 and 20 km/h, the test shall be repeated a further two times and the middle value will be used in the assessment.

In case FCW triggers between 1.7 and 2.2 s TTC, the test shall be repeated a further two times and the middle value will be used in the assessment.

7.4.2 Bicyclist Near Side Turn

Test each trajectory, bicyclist lateral separation and impact position combination where intervention is anticipated. Where no intervention is anticipated, test select combination(s) to confirm.

7.5 System Deactivation

Where a means is provided for the driver to deactivate the AEB VRU system(s), investigate and record the method(s) of deactivating and reactivating the system.

APPENDIX A OBSTRUCTION DIMENSIONS

A.1 Smaller obstruction vehicle

The smaller obstruction vehicle shall be of the category Small Family Car and is positioned closest to the pedestrian path. The smaller obstruction vehicle shall be within the eometrical dimensions described in Table A-1 and must be in a dark colour.

Vehicle	Length (mm)	Width (excluding mirrors)	Height (mm)	Bonnet length (until A pillar)	Bonnet leading edge height (mm)
Minimum	4100	1700	1300	1100	650
Maximum	4400	1900	1500	1500	800

Table A-1 Smaller obstruction vehicle geometrical dimensions

A.2 Larger obstruction vehicle

The larger obstruction vehicle shall be of the category Small Off-road 4x4 and is positioned behind the smaller obstruction vehicle. The larger obstruction vehicle shall be within the geometrical dimensions described in Table A-2 and must be in a dark colour.

Vehicle	Length (mm)	Width (excluding mirrors)	Height (mm)
Minimum	4300	1750	1500
Maximum	4700	1900	1800

Table A-1 Larger obstruction vehicle geometrical dimensions

APPENDIX B NEAR SIDE TURN TRAJECTORIES

To be defined.