EURO NCAP
#FORSAFERTRUCKS

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Safe Driving
Vehicle Assistance

Adaptive Cruise Control

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 3,500kg.

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) E1136-10 (2010) standard reference test tyre, in accordance with ASTM Method E 1337-90 (reapproved 1996), at a speed of 64.4 km/h, without water delivery. Alternatively, the method as specified in UNECE R13-H.

Adaptive Cruise Control (ACC) – a system engaged by the driver which monitors the road and traffic environment and automatically adjusts speed to maintain a safe following distance

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.

ACC braking performance – the outcome of the automatically applied braking when ACC is operational along with AEB, in terms of whether the collision was avoided or the resultant (relative) impact speed.

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

HGV-to-Car Rear Moving (HCRm) – a scenario 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.

HGV-to-Car Rear Braking (HCRb) – a scenario 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.

Vehicle Under Test (VUT) – means 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, 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.

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

Time To Collision (TTC) – means 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_{ACC} – the time where the ACC 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_{impact} – the time at which the VUT hits the GVT.

V_{impact} – the speed at which the VUT hits the GVT.

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

1 INTRODUCTION

An analysis of European road traffic crash data (where at least one HGV was involved) revealed that Heavy Goods Vehicle (HGV) front-to-rear collisions account for 9 % of passenger car and Light Commercial Vehicle (LCV or van) occupant fatalities and 17 % of HGV occupant fatalities. Considering all injury severities, those figures increase to 20 % and 49 % respectively.

Typical incidents include the HGV colliding with the rear of slow moving or stationary traffic on highways at high relative speeds because of a range of factors including driver distraction, fatigue or misjudgement. Where the HGV collides with a light vehicle the large difference in weight means that the light vehicle sees almost all of the change in velocity putting the occupant(s) of that vehicle at very high risk. Where the collision partner is a heavy vehicle, the large collision energy presents a risk of serious injury to the HGV driver and the occupants of the struck vehicle(s).

Adaptive Cruise Control (ACC) is an increasingly available HGV feature which, similar to AEB, monitors the road and traffic environment. When engaged by the driver, it controls speed to maintain a safe following gap and can support avoiding collisions, albeit with more modest deceleration at comfort braking levels. Feeback from industry suggests this feature is commonly used by drivers and could potentially bring some safety benefits in certain circumstances by reacting to hazards ahead slightly earlier than might be the case for AEB.

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

2 REFERENCE SYSTEM

2.1 Convention

For both the VUT and the GVT 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 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- and right-hand drive vehicles tested, where in Figure 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.

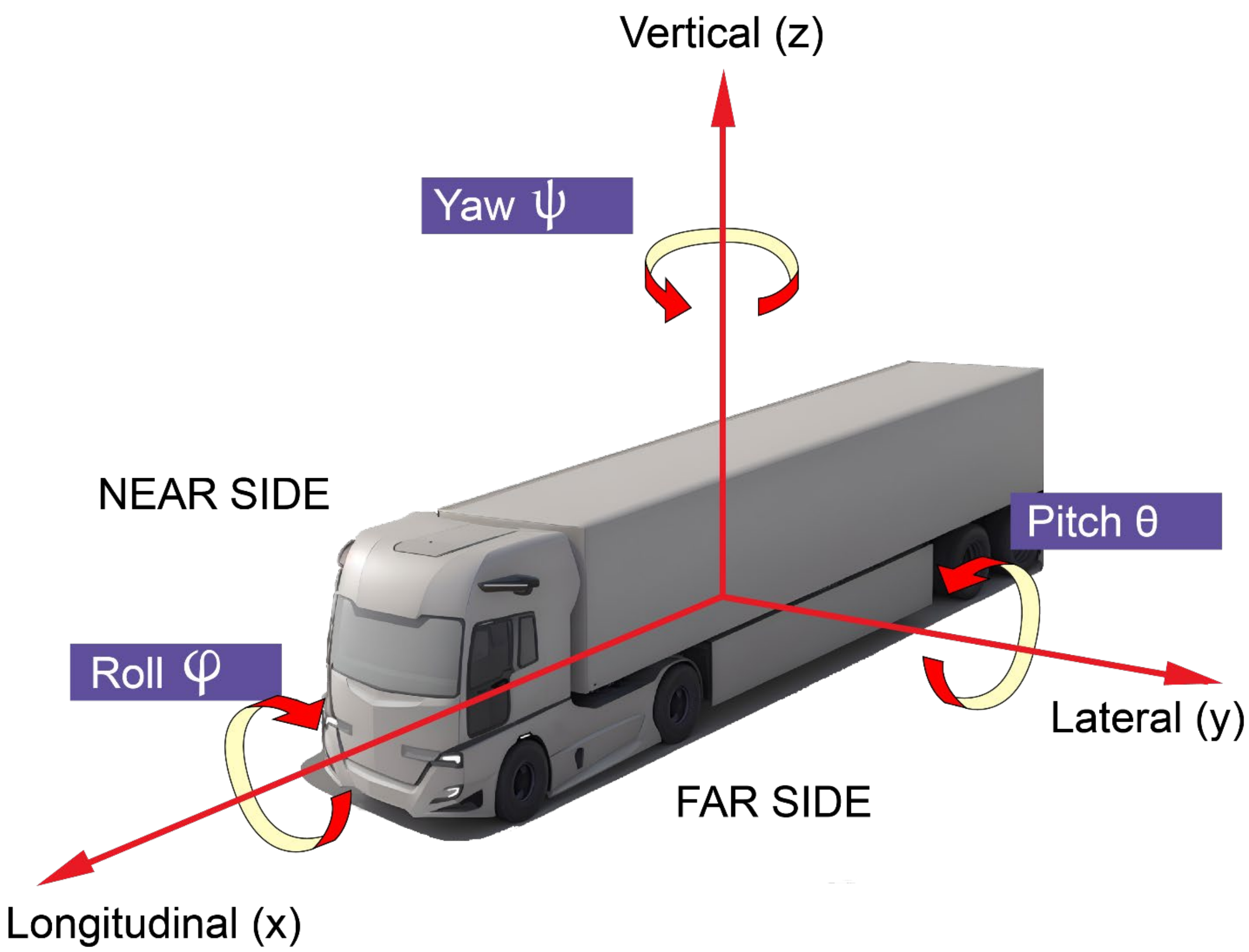

Figure 3-1 Coordinate system and notation

2.2 Lateral Path Error

The lateral path error is determined as the lateral distance between the centre of the front of the VUT and the centre of the rear of the GVT when measured in parallel to the intended straight-lined path as shown in the figure below.

$$\text{Lateral path error} = Y_{VUT}\ \text{error} + Y_{GVT}\ \text{error}$$

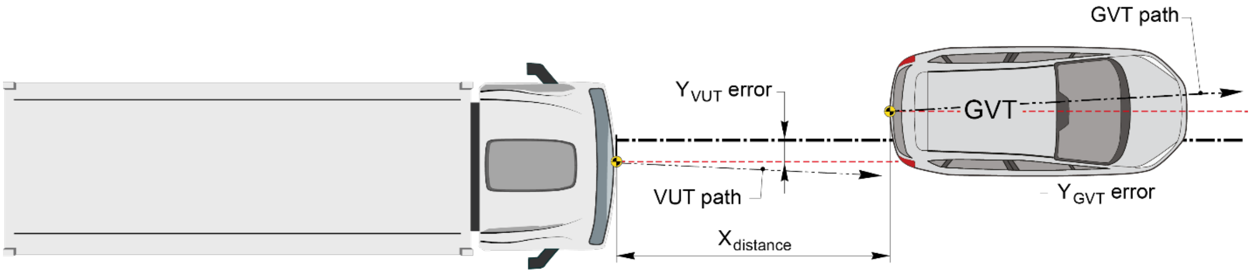

Figure 3-2 Lateral path error

2.3 Lateral Overlap

The lateral overlap is defined as a percentage of the width of the GVT overlapping the VUT, where the reference line for the overlap definition is the centreline of the GVT. In the case of 100% overlap, the centrelines of the VUT and GVT are aligned. In the case of 50% overlap, the centreline of the GVT is aligned with the outer edge as defined by the vehicle width.

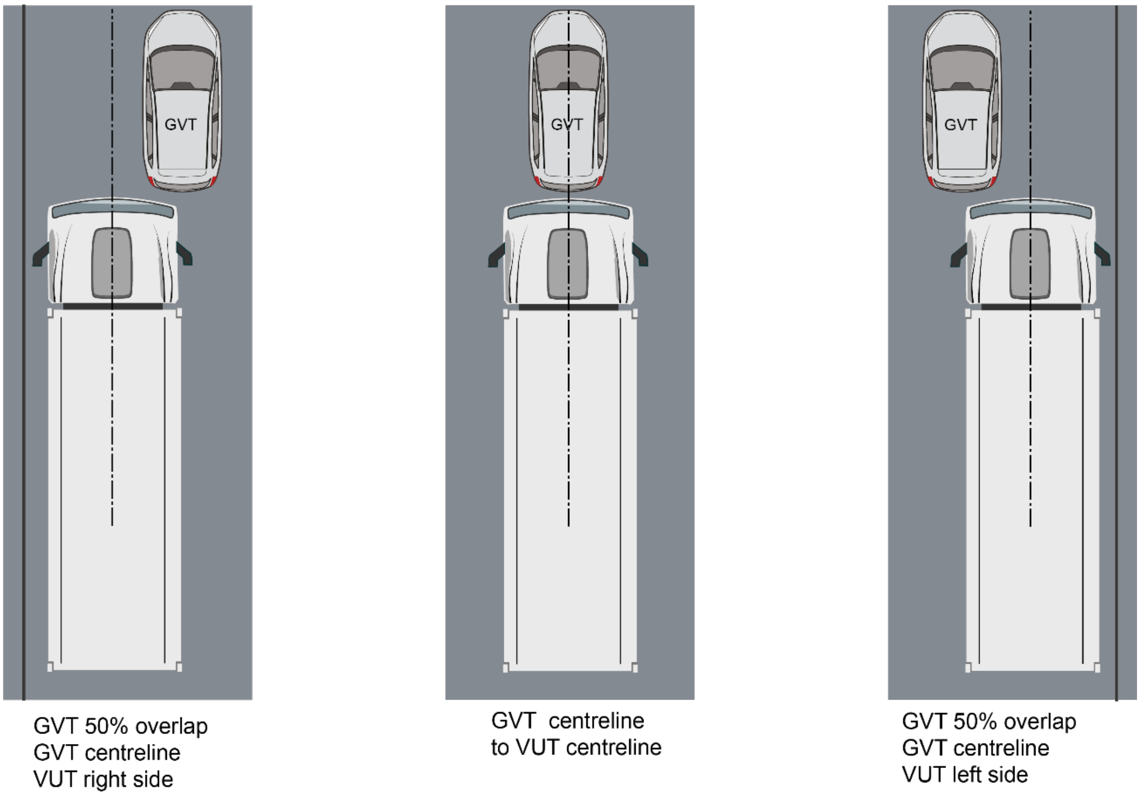

Figure 3-3 Lateral overlap

2.4 Profile for Impact Speed Determination

A virtual profiled line is defined around the front end of the VUT as shown in Figure 3 3. This line is defined by straight line segments connecting seven points that are equally distributed over the vehicle width minus [150] mm on each side. The theoretical x,y coordinates are provided by the manufacturer and verified by the test laboratory.

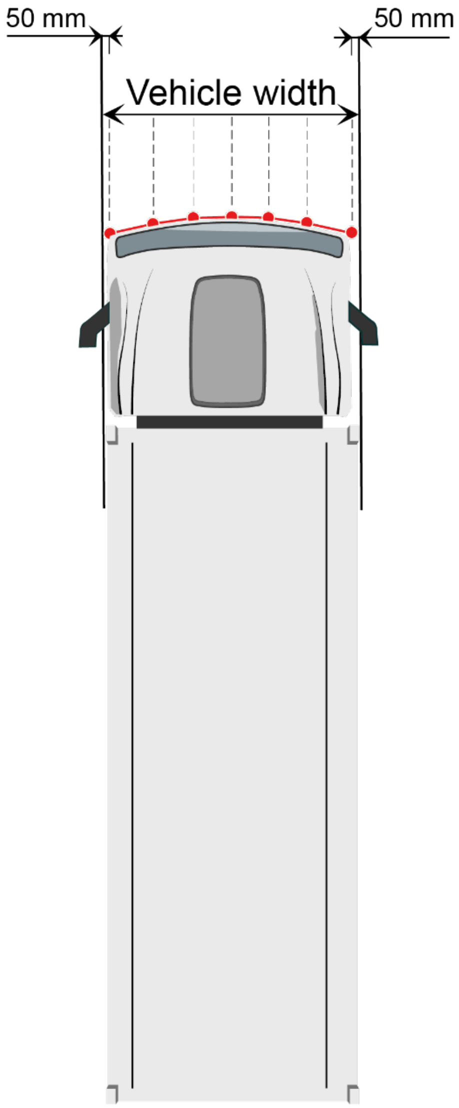

Figure 3-4 Virtual profiled line around the VUT front end

3 MEASURING EQUIPMENT

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

3.1 Measurements and Variables

Time	T
HCRs and HCRm: T_0 equals TTC = 4s	T_0
(HCRb: T_0 when GVT starts decelerating)	
T_{AEB}, time when AEB activates	$\mathbf{T}_{AEB}$
T_{impact}, time when VUT impacts GVT	$\mathbf{T}_{impact}$
Position of the VUT during the entire test	$\mathbf{X}_{VUT}$, $\mathbf{Y}_{VUT}$
Position of the GVT during the entire test	$\mathbf{X}_{GVT}$, $\mathbf{Y}_{GVT}$
Speed of the VUT during the entire test	$\mathbf{V}_{VUT}$
V_{impact}, speed when VUT impacts GVT	$\mathbf{V}_{impact}$
V_{rel_impact}, relative speed when VUT impacts GVT	$\mathbf{V}_{rel\_impact}$
Speed of the GVT during the entire test	$\mathbf{V}_{GVT}$
Acceleration of the VUT during the entire test	$\mathbf{A}_{VUT}$
Acceleration of the GVT during the entire test	$\mathbf{A}_{GVT}$
Yaw velocity of the VUT during the entire test	$\dot{\Psi}_{VUT}$
Yaw velocity of the GVT during the entire test	$\dot{\Psi}_{GVT}$
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 GVT longitudinal speed to 0.1 km/h
- VUT and GVT lateral and longitudinal position to 0.03 m
- VUT heading angle to 0.1°
- VUT and GVT yaw rate to 0.1°/s
- VUT longitudinal acceleration to 0.1 m/s2
- 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 Global Vehicle Target

Conduct tests in this protocol using the Global Vehicle Target (GVT) as shown in Figure 3 below. The GVT replicates the visual, radar and LIDAR attributes of a typical M_1 passenger vehicle.

Figure 4-1 Global Vehicle Target (GVT)

To ensure repeatable results the combination of the propulsion system and GVT must meet the requirements as detailed in ISO 19206-3.

Only equipment listed in the current version of TB 029 – Suppliers List may be used for testing. The current version can be found on the Euro NCAP website.

The GVT is designed to work with the following types of sensors:

- Radar (24 and 77 GHz)
- LIDAR
- Camera

When a manufacturer believes that the GVT 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 Manufacturer Supplied Data

The vehicle manufacturer is required to provide the Euro NCAP Secretariat with colour data (expected impact speeds are not required) detailing the ACC performance of the vehicle in the HCRs, HCRm and HCRb scenarios for all overlap and test speed combinations.

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

Data shall be provided for each grid point according to the following colour scheme:

- Avoided (green)
- Mitigated to reduced impact speed > 5 km/h(orange)
- No pre-collision speed reduction (red)

5.2 Absence of Manufacturer Data

In the absence of grid performance predictions, proceed with ACC HCR offset testing as follows:

- Randomly select the direction of offset and begin with the 50% GVT overlap 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 10 km/h. When there is contact, first perform a test at a test speed 5 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 5km/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.
- Continue with the centrally aligned test scenario. Commence testing at the lowest test speed for the scenario or highest 50% GVT overlap avoidance speed, whichever is greater. Increment subsequent test speeds as described in above.
- Where required, to ensure symmetry, retest the 50% GVT overlap two highest avoidance speeds on the other side. Where there is a difference in performance, perform all tests on the other direction of offset.

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 3.0 m to either side of the centre of the test lane and with a longitudinal distance of 30 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 3.0m either side. Lines or markings may cross the test path but may not be present in the area where ACC activation is expected.

6.1.2 Weather Conditions

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

No precipitation shall be falling and horizontal visibility at ground level shall be greater than 1 km. Wind speeds shall be below 10 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 (monitoring)
- Ambient illumination in Lux

6.1.3 Surroundings

Conduct testing such that there are no other vehicles, highway furniture, obstructions, other objects or persons protruding above the test surface that may give rise to abnormal sensor measurements within a lateral distance of 3.0m to either side of the test path during the full duration of the test starting at T_0 and within a longitudinal distance 30 m ahead of the VUT when the test ends.

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

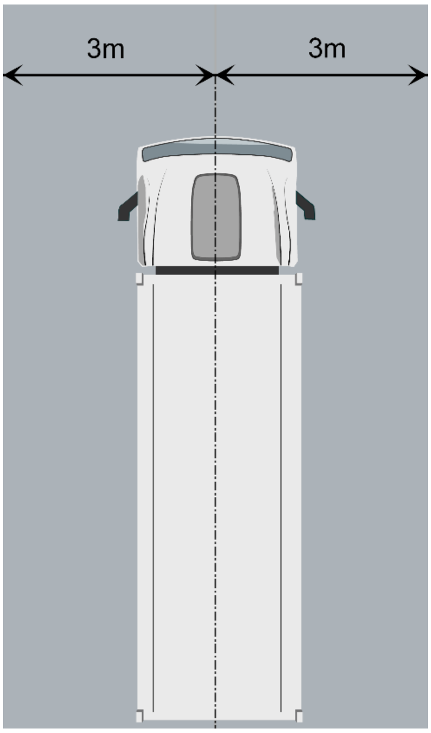

Figure 3-1 Free surroundings

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 the ACC configurable distance setting of the system to the closest distance setting. The AEB must remain active to avoid damage to the GVT.

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 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 approaching but not exceeding maximum permitted
- Of adequate gross trailer mass to fulfil the gross train mass of the VUT
- Box or curtain side body
- Equipped with disc brakes, category A Antilock Braking System (ABS) and an Electronic Braking System (EBS)

6.2.4 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. 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 6.1.3. 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 should 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 to represent typical category N vehicle operation, with 'as tested' mass as follows:

As tested mass = Unladen kerb mass + ((GVW – Unladen kerb mass)/2)

The procedure to prepare the VUT load requirement for testing is:

- Maintain adequate fuel in the vehicle to perform the testing
- Check the levels of all fluids and top up to their maximum levels if 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 and determine the total mass. The total mass is the 'unladen kerb mass' of the VUT. Record this mass in the test details
- Calculate the load mass required to achieve the 'as tested mass'. Note the 'as tested mass' will also account for nominal half fuelling where the fuel source affects the vehicle mass
- Apply the load mass to the vehicle comprising of the driver, test equipment (i.e. on-board test equipment and instrumentation, associated cables, cabling boxes and power sources) and ballast, with a tolerance of the lesser of [5% of the GVW or 1000kg]. 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. If water is used as ballast, it should be used in full containers to prevent the movement under acceleration
- Measure the VUT axle masses with the driver, test equipment and ballast on board and determine the 'as tested mass', confirming that individual axle weights do not exceed their permitted maximums

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 active safety 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 [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 [30 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 ACC system is assessed in the HCRs, HCRm and HCRb scenarios as shown in Figure 9, Figure 10 and Figure 11 respectively.

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

The vehicle sponsor will fund 10 verification tests per scenario, namely [5] tests in HCRs (10 to 90 km/h), [5] tests for HCRm (30 to 90 km/h). The HCRb scenario is tested in all four combinations.

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.

For testing purposes, 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.

7.2.2 HGV-to-Car Rear Stationary (HCRs)

The HCRs scenario is a combination of speed and overlap with 5km/h incremental steps in speed approaching a stationary GVT, centrally aligned and 50% GVT overlap, within the range illustrated in Figure 9 and Table 1.

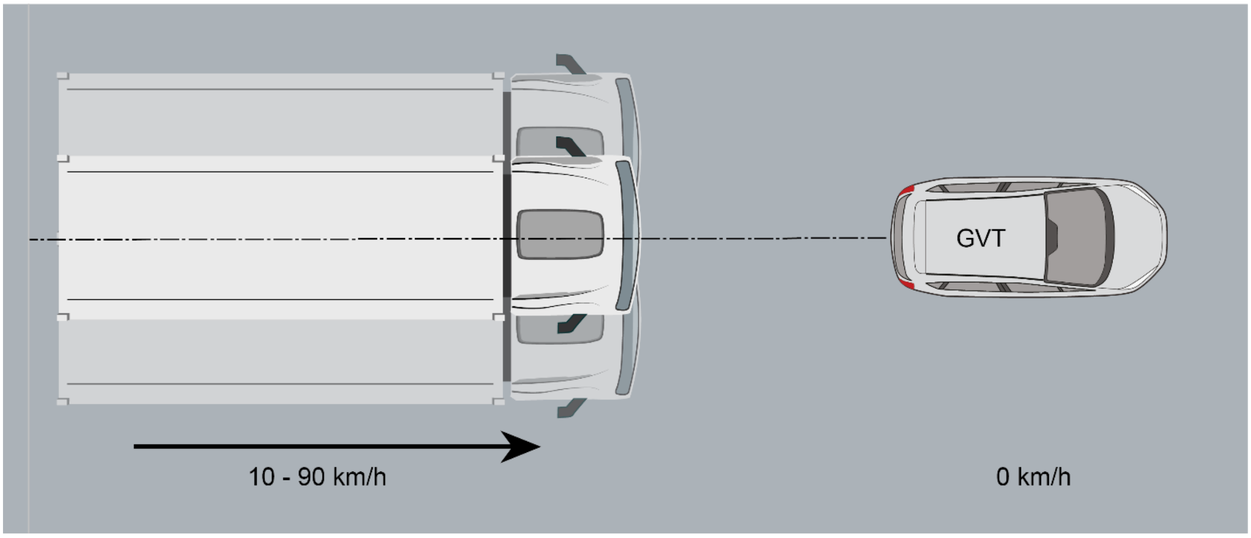

Figure 3-1 HCRs scenario

7.2.3 HGV-to-Car Rear Moving (HCRm)

The HCRm scenario is a combination of speed and overlap with 5km/h incremental steps in speed approaching a moving GVT travelling at 20km/h, centrally aligned and 50% GVT overlap, within the range illustrated in Figure 10 and Table 2.

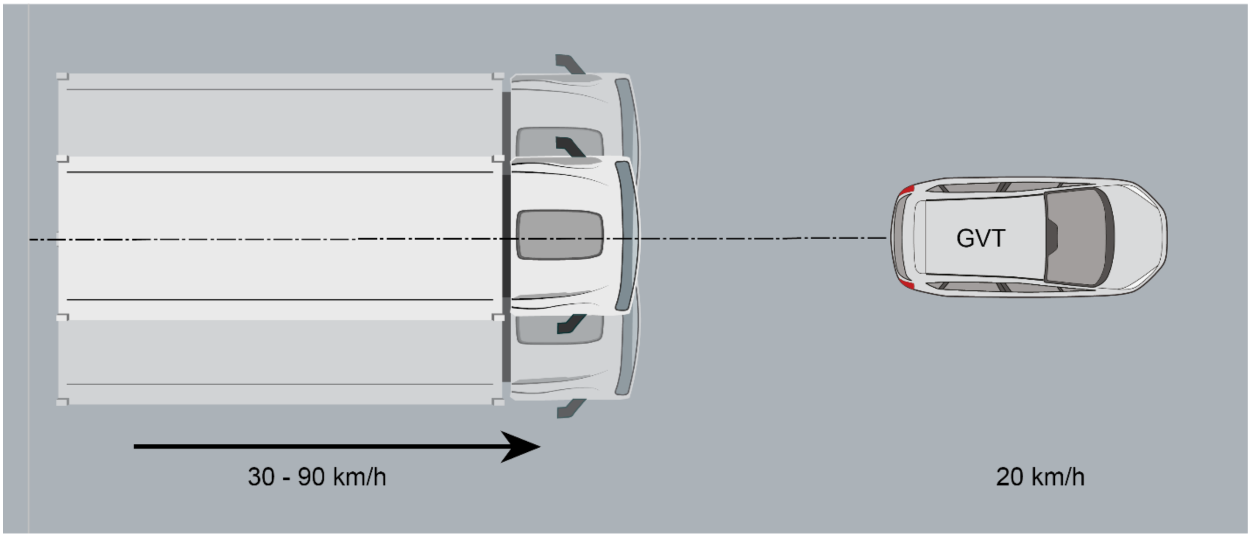

Figure 2: HCRm scenario

7.2.4 HGV-to-Car Rear Braking (HCRb)

HCRb tests will be performed at fixed speeds of 50 and 80 km/h for both VUT and GVT centrally aligned with all combinations of 2 and [6] m/s^2 deceleration. Two headways are used for each test speed, in the 50km/h tests headways are 12 and 40 m and in the 80 km/h tests headways are 30 and 50 m as illustrated in Figure 11 and Table 3. Different overlap situations may be tested for monitoring purpose at the end of the test program.

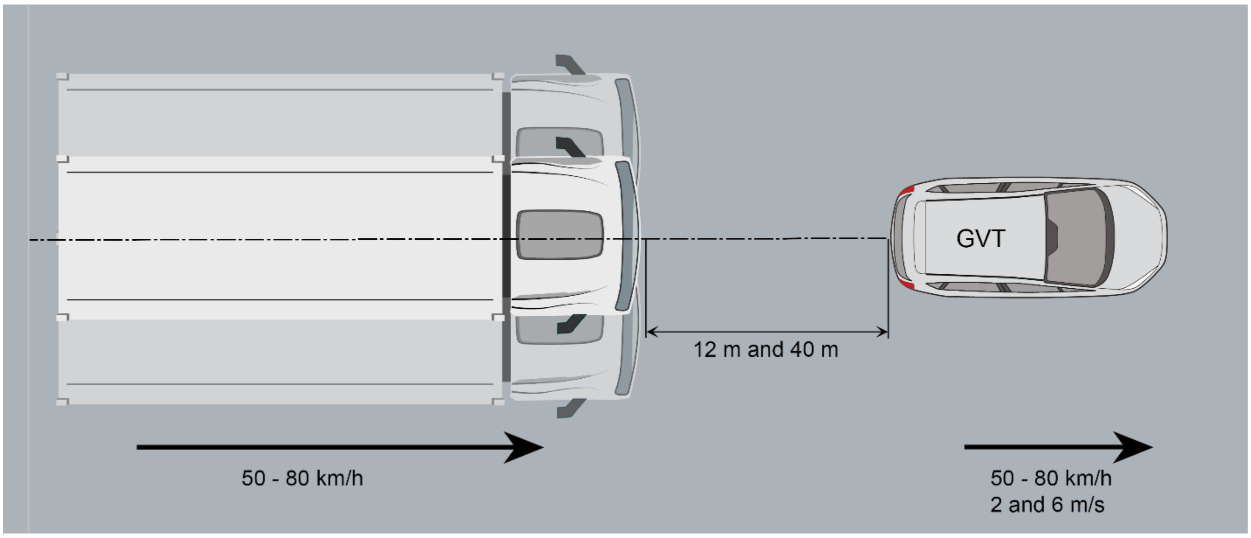

Figure 3-3 HCRb scenario

The desired deceleration of the GVT shall be reached within 1.0 seconds (T0 + 1.0s) which after the GVT shall remain within ± 0.5 km/h of the reference speed profile, derived from the desired deceleration, until the vehicle speed equals 1 km/h.

7.2.5 AEB Sensitivity to Driver Inputs

The ACC sensitivity to driver inputs is evaluated in an HCRs scenario with the VUT and GVT centrally aligned. The test laboratory shall select a VUT test speed at which full deployment of all stages of the AEB results in a collision with the GVT being avoided. The objective is to apply modest control inputs that indicate some level of driver activity, but which are of insufficient magnitude to avoid the imminent collision.

Determine T_{ACC} for the previously completed HCRs test at the selected test speed. Repeat the test, applying the following driver inputs individually at a time equivalent to T_{ACC} + [1.0] s to investigate their effect ACC system operation. Maintain other control inputs as per normal testing.

- Ramp steering wheel input in a randomly selected direction, starting from the current steering wheel position, [increasing at 30 °/s for a duration of 0.5 s and then holding the resultant steering wheel angle]
- Ramp accelerator pedal input, starting from the current pedal position, [increasing at 30 %/s of total travel for a duration of 0.5 s and then holding the resultant pedal position]
- Ramp brake pedal input, starting from the current pedal position, [increasing at 30 %/s of total travel for a duration of 0.5 s and then holding the resultant pedal position]

7.3 Test Conduct

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.

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. Apply only minor steering inputs as necessary to maintain the VUT tracking along the test path.

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

7.4 Test Execution

Accelerate the VUT and GVT to their respective test speeds.

The test shall start at T_0 (4s TTC) and is valid when all boundary conditions are met between T_0 and T_{ACC} or any other system intervention:

- Speed of VUT (GPS-speed)	Test speed + 1.0 km/h
- Speed of GVT (GPS-speed)	Test speed ± 1.0 km/h
- Lateral deviation from test path for VUT	0 ± [0.10] m
- Lateral deviation from test path for GVT	0 ± 0.05 m
- Relative distance between VUT and GVT (HCRb)	12m / 40m, 30 / 50 m ± 0.5m
- Yaw velocity of VUT	0 ± 1.0 °/s
- Yaw velocity of GVT	0 ± 1.0 °/s
- Steering wheel velocity	0 ± 15.0°/s

The end of a test is considered when one of the following occurs:

- V_{VUT} = 0 km/h
- $V_{VUT} < V_{GVT}$
- $A_{VUT} > -5\ m/s^2$
- Contact between VUT and GVT

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.