EUROPEAN NEW CAR ASSESSMENT PROGRAMME
(Euro NCAP)

TEST PROTOCOL – Lane Support Systems

Implementation 2023

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TEST PROTOCOL – LANE SUPPORT SYSTEMS

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1 INTRODUCTION

Road departure is one of the main causes of single vehicle and frontal crashes. By implementing lateral support systems, a significant amount of these accidents can be avoided.

Typical accidents are normally occurring due to unintentional lane departure where the driver drifts towards and across the line identifying the edge of the lane. Very often, the driver will be unaware that the car is in a potentially dangerous situation until the situation is critical: the wheels of the car may be on the grass or gravel at the side of the road, or, in extreme cases, the car may find itself in the path of an oncoming or overtaking traffic. This sudden, late realisation by the driver may prompt a panic response: the driver loses control of the car, and a crash is often the result. Injury severities are usually high, but this type of accident is relatively easy to avoid with a lateral support system resulting in potentially large safety improvements.

This protocol specifies the Lateral Support Systems test procedure, which are part of the Safety Assist assessment. Emergency Lane Keep Assist (default ON), Lane Keep Assist and Lane Departure Warning systems are tested, if applicable. To be eligible to score points for LSS, the vehicle must be equipped with an ESC system meeting the regulatory requirements.

2 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 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 64.4km/h, without water delivery. Alternatively, the method as specified in UNECE R13-H.

Emergency Lane Keeping (ELK) – default ON heading correction that is applied automatically by the vehicle in response to the detection of the vehicle that is about to drift beyond a solid lane marking, the edge of the road or into oncoming or overtaking traffic in the adjacent lane.

Lane Keeping Assist (LKA) – heading correction that is applied automatically by the vehicle in response to the detection of the vehicle that is about to drift beyond a delineated edge line of the current travel lane.

Lane Departure Warning (LDW) – a warning that is provided automatically by the vehicle in response to the vehicle that is about to drift beyond a delineated edge line of the current travel lane.

Vehicle under test (VUT) – means the vehicle tested according to this protocol with a Lane Keep Assist and/or Lane Departure Warning system.

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

Euro NCAP Motorcyclist Target (EMT) – means the Motorcyclist target used in this protocol as specified in the deliverable D2.1 of the MUSE project (Fritz and Wimmer 2019) which at time of publication is to be replaced with ISO 19206-5.

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

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.

Lane Edge – means the inner side of the lane marking or the road edge

Distance To Lane Edge (DTLE) – means the remaining lateral distance (perpendicular to the Lane Edge) between the Lane Edge and most outer edge of the tyre, before the VUT crosses Lane Edge, assuming that the VUT would continue to travel with the same lateral velocity towards it.

3 REFERENCE SYSTEM

3.1 Convention

3.1.1 For the VUT 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 3-1.

3.1.2 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.

3.1.3 This reference system should be used for both left and right hand drive vehicles tested.

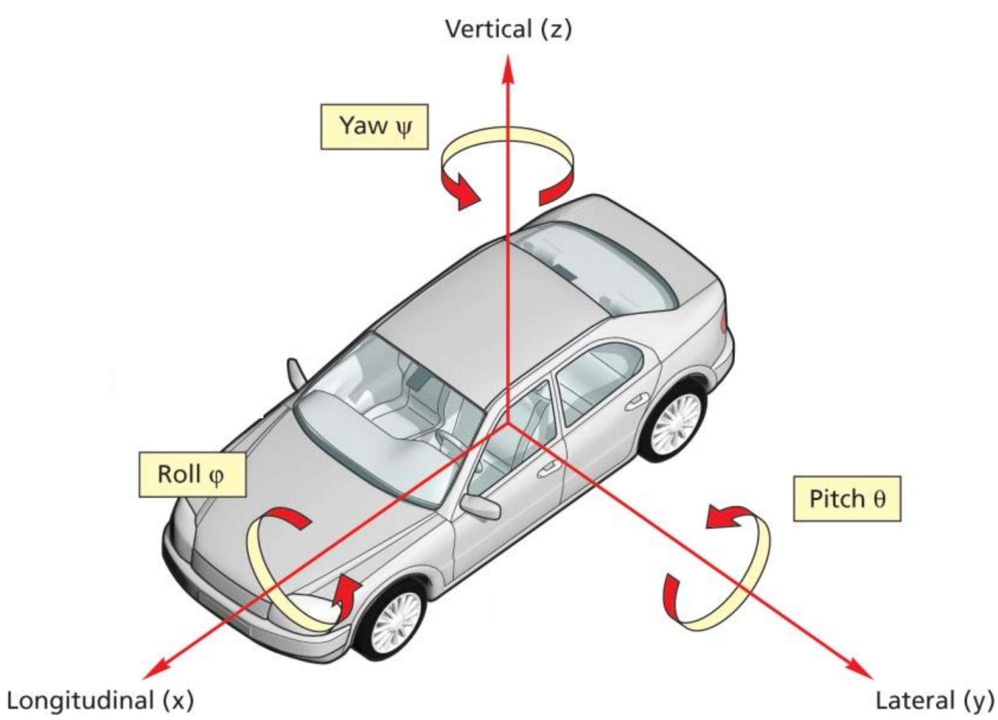

Figure 3-1: Coordinate system and notation

3.2 Lateral Path Error

3.2.1 The lateral path 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 the figure below. This measure applies during both the straight line approach and the curve that establishes the lane departure.

Lateral Deviation from Path = Y_{VUT} error

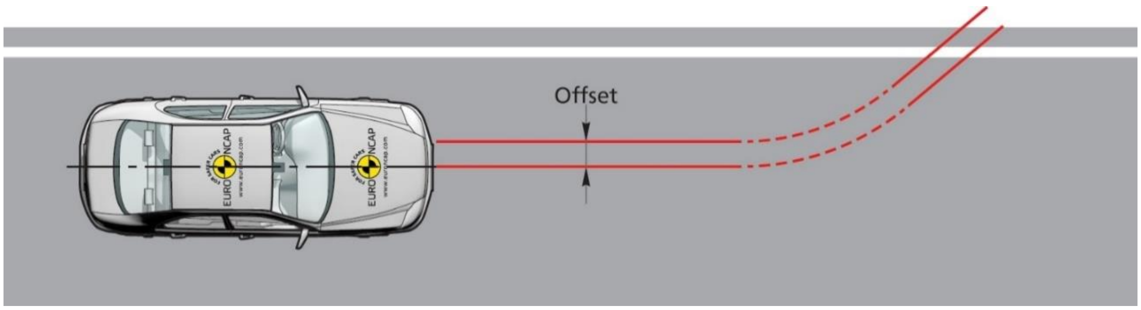

Figure 3-2: Lateral Path Error

4 MEASURING EQUIPMENT

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

4.2 Measurements and Variables

4.2.1	Time	**T**
	• T_0, time where manoeuvre starts with 2s straight path	$\mathbf{T}_0$
	• T_{LKA}, time where LKA activates (for calibration purposes only if required)	$\mathbf{T}_{LKA}$
	• T_{LDW}, time where LDW activates	$\mathbf{T}_{LDW}$
	• T_{steer}, time where VUT enters in curve segment	$\mathbf{T}_{steer}$
	• $T_{crossing}$, time where VUT crosses the line or road edge	$\mathbf{T}_{crossing}$
4.2.2	Position of the VUT during the entire test	$\mathbf{X}_{VUT}$, $\mathbf{Y}_{VUT}$
4.2.3	Position of the GVT during the entire test	$\mathbf{X}_{GVT}$, $\mathbf{Y}_{GVT}$
4.2.4	Speed of the VUT during the entire test	$\mathbf{V}_{long,VUT}$ $\mathbf{V}_{lat,VUT}$
4.2.5	Speed of the GVT during the entire test	$\mathbf{V}_{GVT}$
4.2.6	Yaw velocity of the VUT during the entire test	$\dot{\boldsymbol{\Psi}}_{VUT}$
4.2.7	Yaw velocity of the GVT during the entire test	$\dot{\boldsymbol{\Psi}}_{GVT}$
4.2.8	Steering wheel velocity of the VUT during the entire test	$\boldsymbol{\Omega}_{VUT}$

4.3 Measuring Equipment

4.3.1 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 0.1km/h;
- VUT and GVT lateral and longitudinal position to 0.03m;
- VUT heading angle to 0.1°;
- VUT and GVT yaw rate to 0.1°/s;
- VUT longitudinal acceleration to 0.1m/s^2;
- VUT steering wheel velocity to 1.0°/s.

4.4 Data Filtering

4.4.1 Filter the measured data as follows:

4.4.1.1 Position and speed are not filtered and are used in their raw state.

4.4.1.2 Acceleration, yaw rate, steering wheel torque and steering wheel velocity with a 12-pole phaseless Butterworth filter with a cut off frequency of 10Hz.

5 GLOBAL VEHICLE TARGET

5.1 Specification

5.1.1 Conduct the tests in this protocol using the Global Vehicle Target (GVT) as shown in Figure 5-1 below. The GVT replicates the visual, radar and LIDAR attributes of a typical M_1 passenger vehicle.

Figure 5-1: Global Vehicle Target (GVT)

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

5.1.3 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.

5.1.4 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.

6 TEST CONDITIONS

6.1 Test Track

6.1.1 Conduct tests on a dry (no visible moisture on the surface), uniform, solid-paved surface with a maximum slope of 1% in the longitudinal direction, < 2% for half a lane width either side of the centreline and < 3% for the outer half of the test lane in lateral direction.

6.1.2 The test surface shall have a minimal peak braking coefficient (PBC) of 0.9, 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 3.0m to either side of the centre of the test lane and with a longitudinal distance of 30m ahead of the VUT from the point after the test is complete.

6.1.3 Lane Markings and Road Edge

6.1.3.1 The tests described in this document require use of two different types of lane markings conforming to one of the lane markings as defined in UNECE Regulation 130 to mark a lane with a width of 3.5 to 3.7m when measured from the inside edge of the lane marking and a road edge:

1. Dashed line with a width between 0.10 and 0.25m (0.10 and 0.15m for centerlines)
2. Solid line with a width between 0.10 and 0.25m
3. Road Edge consisting of grass and/or gravel or any other approved surrogate

The inner edge of the lane marking shall be at 0.20 to 0.30m from the road edge (transition between paved test surface and road edge material), where applicable.
The lane markings and/or road edge should be sufficiently long to ensure that there is at least 20m of marking remaining ahead of the vehicle after the test is complete.

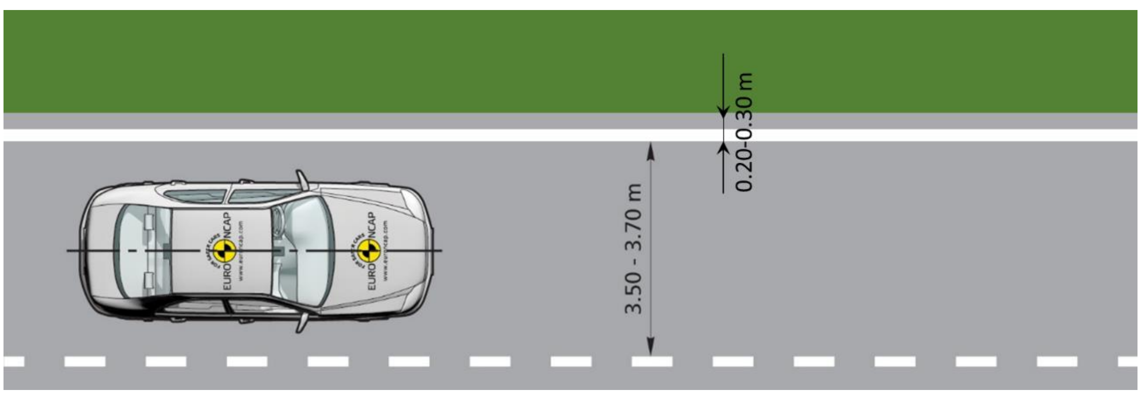

Figure 6-1: Layout of the lane markings

6.1.4 Weather conditions

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

6.1.4.2 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 VUT disturbance.

6.1.4.3 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. Ensure testing is not performed driving towards, or away from the sun when there is direct sunlight.

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

a) Ambient temperature in °C;
b) Track Temperature in °C;
c) Wind speed in m/s;
d) Wind direction in azimuth ° and/or compass point direction (monitoring);
e) Ambient illumination in Lux.

6.2 VUT Preparation

6.2.1 System Settings

6.2.1.1 Set any driver configurable elements of the system (e.g. the timing of the Lane Departure Warning or the Lane Keep Assist if present) to the middle setting or midpoint and then next poorer performing setting similar to the examples shown in Figure 4. Lane Centering functions should be turned OFF.

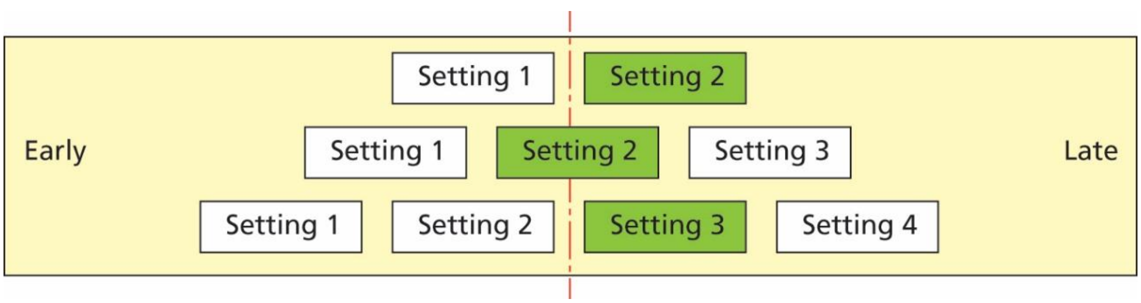

Figure 6-2: System setting for testing

6.2.2 Tyres

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

6.2.3 Wheel Alignment Measurement

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

6.2.4 Unladen Kerb Mass

6.2.4.1 If applicable, fill up the tank with fuel to at least 90% of the tank's capacity of fuel.

6.2.4.2 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.

6.2.4.3 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.

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

6.2.4.5 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.

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

6.2.5 Vehicle Preparation

6.2.5.1 Fit the on-board test equipment and instrumentation in the vehicle. Also fit any associated cables, cabling boxes and power sources.

6.2.5.2 Place weights with a mass of the ballast mass. Any items added should be securely attached to the car.

6.2.5.3 With the driver in the vehicle, weigh the front and rear axle loads of the vehicle.

6.2.5.4 Compare these loads with the 'unladen kerb mass'

6.2.5.5 The total vehicle mass shall be within ±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.

6.2.5.6 Repeat paragraphs 6.2.5.3 and 6.2.5.4 until the front and rear axle loads and the total vehicle mass are within the limits set in paragraph 6.2.5.5. 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.

6.2.5.7 Vehicle dimensional measurements shall be taken. For purposes of this test procedure, vehicle dimensions shall be represented by a two-dimensional polygon defined by the lateral and longitudinal dimensions relative to the centroid of the vehicle using the standard ISO 8855 coordinate system. The corners of the polygon are defined by the lateral and longitudinal locations where the plane of the outside edge of each tyre makes contact with the road. This plane is defined by running a perpendicular line from the outer most edge of the tyre to the ground at the wheelbase, as illustrated in Figure 6-3.

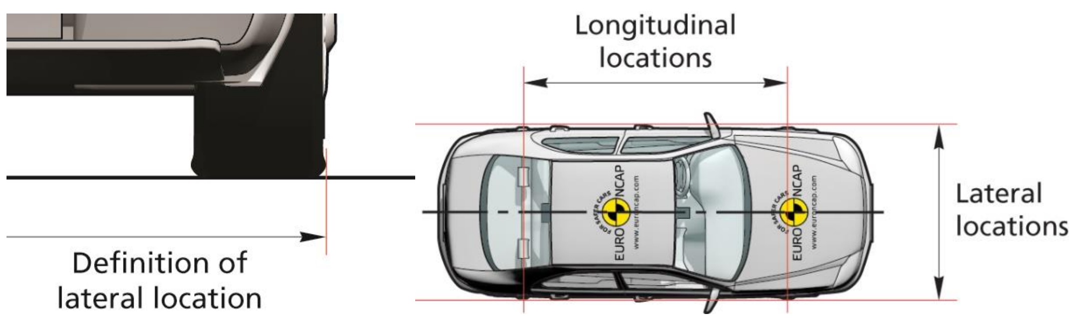

Figure 6-3: Vehicle dimensional measurements

6.2.5.8 The vehicle's wheelbase and the lateral and longitudinal locations shall be measured and recorded.

6.2.5.9 Requirements for Steering Robot friction levels should be checked prior to testing, as detailed in the Technical Bulletin TB 038.

7 TEST PROCEDURE

7.1 VUT Pre-test Conditioning

7.1.1 General

7.1.1.1 A new car is used as delivered to the test laboratory; however a car may have been used for other Euro NCAP active safety tests

7.1.1.2 If requested by the vehicle manufacturer and where not already performed for other tests, drive a maximum of 100km 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

7.1.2.1 Condition the vehicle's brakes in the following manner, if it has not been done before or in case the lab has not performed a 100km of driving:

- Perform twenty stops from a speed of 56km/h with an average deceleration of approximately 0.5 to 0.6g.
- Immediately following the series of 56km/h stops, perform three additional stops from a speed of 72km/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 72km/h stops, drive the vehicle at a speed of approximately 72km/h for five minutes to cool the brakes.

7.1.3 Tyres

7.1.3.1 Condition the vehicle's tyres in the following manner to remove the mould sheen, if this has not been done before for another test or in case the lab has not performed a 100km of driving:

- Drive around a circle of 30m in diameter at a speed sufficient to generate a lateral acceleration of approximately 0.5 to 0.6g for three clockwise laps followed by three anticlockwise laps.
- Immediately following the circular driving, drive four passes at 56km/h, performing ten cycles of a sinusoidal steering input in each pass at a frequency of 1Hz and amplitude sufficient to generate a peak lateral acceleration of approximately 0.5 to 0.6g.
- Make the steering wheel amplitude of the final cycle of the final pass double that of the previous inputs.

7.1.3.2 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

7.1.4.1 Before any testing begins, perform a maximum of ten runs, to ensure proper functioning of the system.

7.2 Test Scenarios

The performance of the VUT LSS is assessed in different scenarios that are applicable to the system:

- Emergency Lane Keeping (only when LSS system is default ON)
- Lane Keep Assist
- Lane Departure Warning
- Blind Spot Monitoring (BSM)

7.2.1 Tests in all scenarios (except BSM) will be performed with 0.1 m/s incremental steps within the lateral velocities specified for the test scenarios.

7.2.2 For testing purposes, assume an initial straight-line path followed by a fixed radius as specified for the test scenarios, followed again by a straight line, 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.

7.2.2.1 The vehicle manufacturer shall provide information describing the location when the closed loop path and/or speed control shall be ended so as not to interfere with the system intervention for each test. Otherwise for each lateral velocity, two calibration runs shall be performed in order to determine when the system activates. Compare steering wheel torque, vehicle speed or yaw rate of both runs and determine where there is a notable difference that identifies the location of intervention.

Run 1: Complete the required test path with the system turned OFF and measure the control parameter

Run 2: Complete the required test path with the system turned ON and measure the control parameter

7.2.2.2 Complete the tests while ending the closed loop control before system activation as defined in 7.2.2.1 In the case of calibration runs the release of steering control should occur on the test path and no less than 5m longitudinally before the location of intervention.

7.2.2.3 When the closed loop path ends, the driver's hands or the control will remain passive on the steering wheel without applying deliberate force but reflecting the behaviour of an inattentive driver holding the steering wheel.

7.2.3 The following parameters should be used to create the test paths:

$V_{lat,VUT}$ [m/s]	**R [m]**	**Ψ_{VUT} [°]**	**d1 [m]**	**d2 [m]**
0.2	1200	0.57	0.06	0.70
0.3		0.86	0.14	0.90
0.4		1.15	0.24	0.80
0.5		1.43	0.38	0.75
0.6		1.72	0.54	0.60
0.7		2.01	0.74	0.53
0.8		2.29	0.96	0.40
0.9		2.58	1.22	0.23
1.0		2.87	1.50	0.00

Where the lateral offset d from the lane marking or road edge:

$$d = d1 + d2 + \text{Half of the vehicle width (m)}$$

With:
d1: Lateral distance travelled during curve establishing yaw angle (m)
d2: Lateral distance travelled during V_{lat} steady state (m)

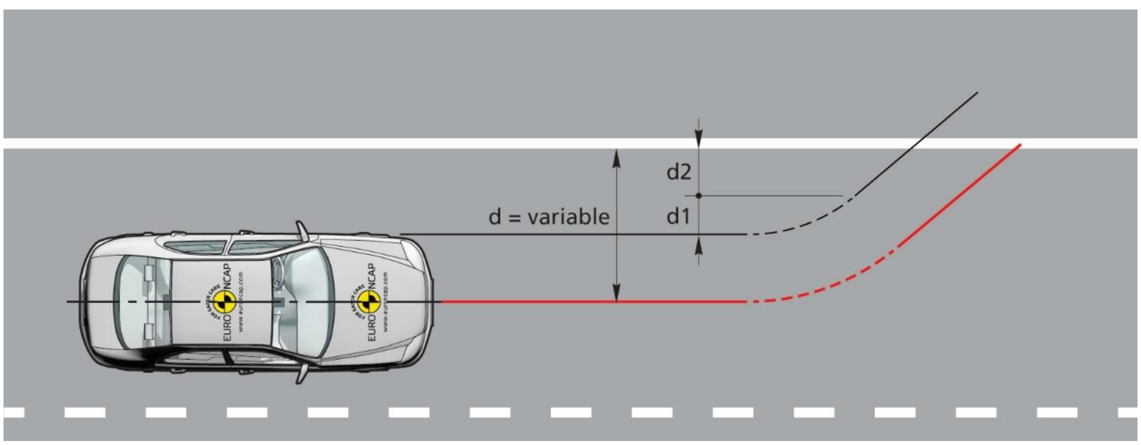

Figure 7-1: Vehicle paths definition

7.2.4 Emergency Lane Keeping tests

7.2.4.1 Road Edge tests

ELK Road Edge tests will be performed with 0.1 m/s incremental steps within the lateral velocity range of 0.2 to 0.6m/s for departures at the front passenger side only.

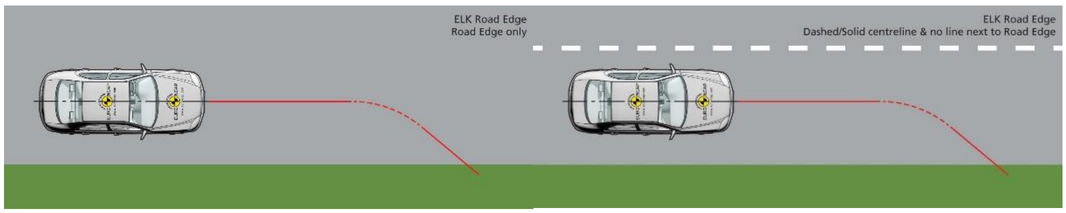

Figure 7-2: ELK Road Edge scenarios

7.2.4.2 Solid line tests

ELK Solid line tests will be performed with 0.1 m/s incremental steps within the lateral velocity range of 0.2 to 0.6m/s for departures at both sides of the vehicle in a fully marked lane. (The non-tested side can be solid or dashed)

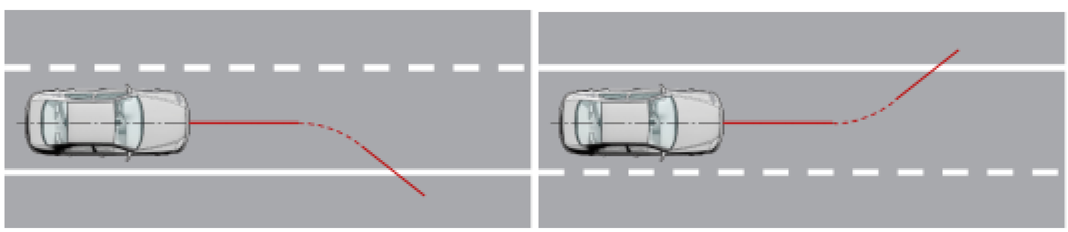

Figure 7-3: ELK Solid Line scenarios

7.2.4.3 Oncoming vehicle

7.2.4.3.1 For the oncoming scenario 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 target will be 1.5m from the inner side of the centre dashed lane marking of the VUT lane.

7.2.4.3.2 The paths of the VUT and target vehicle will be synchronised so that the front edges of the vehicle meet with a lateral position that gives a 10% overlap (assuming no system reaction) of the width of the VUT.

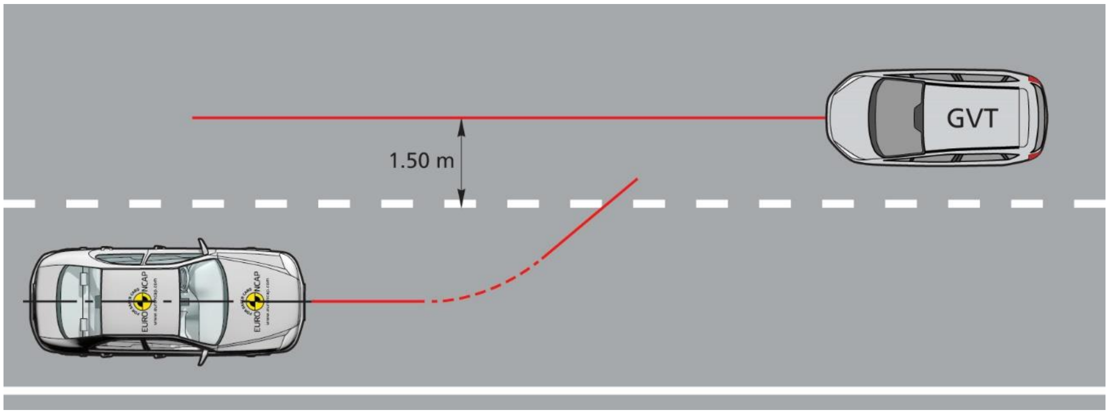

Figure 7-4: ELK Oncoming vehicle scenario paths

7.2.4.3.3 ELK oncoming vehicle tests will be performed with 0.1 m/s incremental steps within the lateral velocity range of 0.2 to 0.6m/s for departures at the driver side only.

7.2.4.4 <u>Overtaking vehicle</u>

7.2.4.4.1 For the overtaking scenario a GVT will follow a straight-line path in the lane adjacent to the VUT's initial position at the driver side, in the same direction as the VUT. The straight-line path of the target will be 1.5m from the inner side of the centre dashed lane marking of the VUT lane.

7.2.4.4.2 The paths of the VUT and target vehicle will be synchronised so that the longitudinal position of the leading edge of the target vehicle is equal to that of the rear axle of the VUT at the impact point (assuming no system reaction).

7.2.4.4.3 ELK overtaking vehicle tests will be performed with 0.1m/s incremental steps within the lateral velocity range of 0.2 to 0.6m/s for unintentional lane change and 0.5 to 0.7m/s for intentional lane changes for departures at the driver side only.

7.2.4.4.4 Both unintentional and intentional lane changes are tested in two situations:

- GVT and VUT travel at the same speed (no relative velocity)

7.2.4.5 GVT @ 80km/h is overtaking the VUT @ 72km/h (relative velocity of 8km/h)

7.2.4.5.1 The following parameters should be used to create the test paths for the intentional lane change tests where the turn signal is applied at 1.0s ± 0.5s before T_{STEER}:

$Vlat_{VUT}$ [m/s]	**R [m]**	**Ψ_{VUT} [°]**	**d1 [m]**	**d2 [m]**
0.5	800	1.43	0.25	0.75
0.6		1.72	0.36	0.60
0.7		2.01	0.49	0.53

Where the lateral offset d from the lane marking:

$$d = d1 + d2 + \text{Half of the vehicle width (m)}$$

With:
d1: Lateral distance travelled during curve establishing yaw angle (m)
d2: Lateral distance travelled during V_{lat} steady state (m)

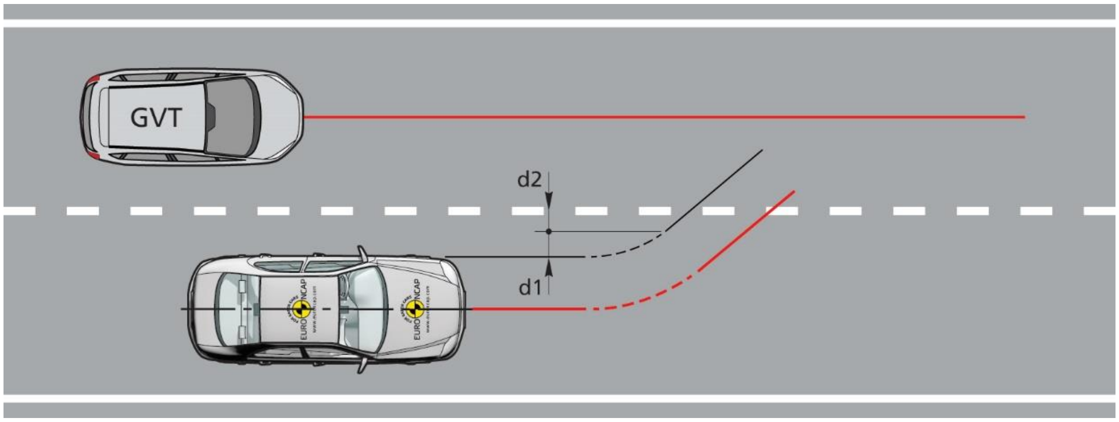

Figure 7-5: ELK Overtaking scenario

7.2.5 Lane Keep Assist tests

7.2.5.1 Dashed line tests

LKA Dashed line tests will be performed with 0.1 m/s incremental steps within the lateral velocity range of 0.2 to 0.6m/s for departures at both sides of the vehicle.

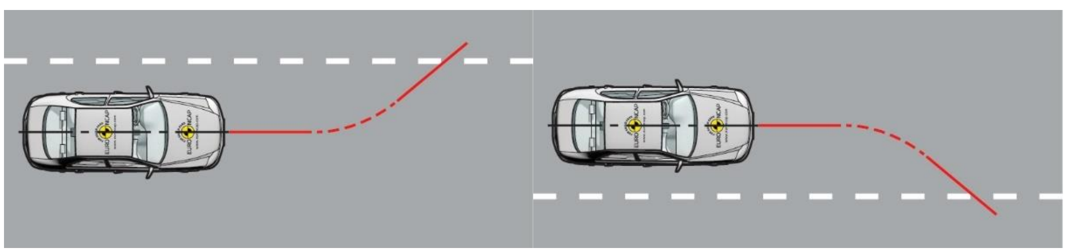

Figure 7-6: LKA Dashed line scenarios

7.2.5.2 Solid line tests

LKA Solid line tests will be performed with 0.1 m/s incremental steps within the lateral velocity range of 0.2 to 0.6m/s for departures at both sides of the vehicle.

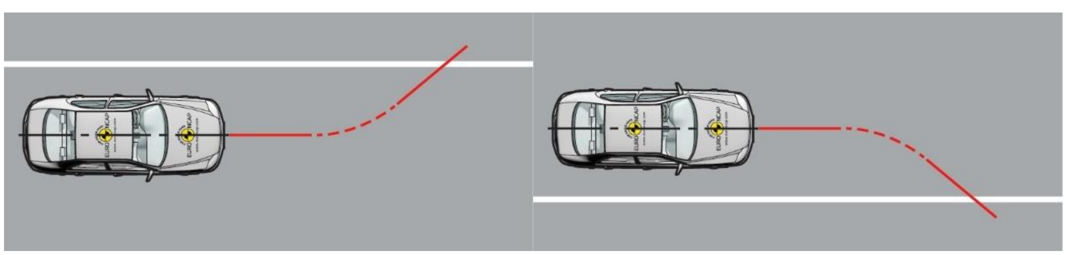

Figure 7-7: LKA solid line scenarios

7.2.6 Lane Departure Warning tests

In case of LDW only systems or systems where LDW can be used as a standalone function, perform the LKA single line tests within the lateral velocity range of 0.6 to 1.0m/s.

7.2.6.1 Alternative Method for Lane Departure Warning tests

As an alternative test method for $V_{lat,VUT} \geq 0.6$m/s, the manufacturer can request that the LDW tests are conducted by using a straight line vehicle path intersecting with a curved lane marking. The test laboratory will determine the intersecting points of a curved lane marking for each of the targeted $V_{lat,VUT}$, based on the yaw angles (Ψ_{VUT}) shown in 7.2.3.

7.2.7 Blind-Spot Monitoring Tests

7.2.7.1 For the Blind Spot Monitoring scenario, the target vehicle will follow a straight-line path in the lane adjacent to the VUT's initial position in the same direction as the VUT. The straight-line path of the target will be 1.5m from the inner side of the centre dashed lane marking (Figure 7-8).

7.2.7.2 The tests should be repeated with the test target to both the nearside and farside of the VUT.

7.2.7.3 The tests should be conducted with both the GVT and EMT (or a Real Motorcycle as an alternative test target).

7.2.7.4 The tests are conducted with a VUT speed of 72km/h and a target speed of 80km/h.

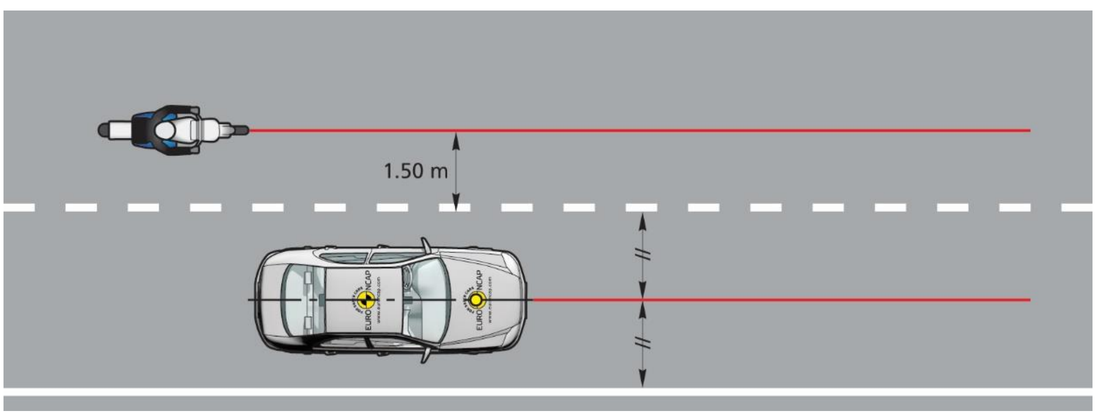

Figure 7-8 Blind-Spot Monitoring scenario

7.3 Test Conduct

7.3.1 Before every test run, drive the VUT around a circle of maximum diameter 30m at a speed less than 10km/h for one clockwise lap followed by one anticlockwise lap, 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.

7.3.2 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.

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.

7.4 Test Execution

7.4.1 Accelerate the VUT to 72 km/h.

7.4.2 Where applicable accelerate the target vehicle to 72km/h or 80km/h depending on the test scenario.

7.4.3 The test shall start at T_0 and is valid when all boundary conditions are met between T_0 and T_{LKA}/T_{LDW}:

ELK Road Edge, LKA, LDW and BSM scenarios:
- Speed of VUT (GPS-speed)72 ± 1.0km/h
- Lateral deviation from test path VUT0 ± 0.05m
- Steady state lane departure lateral velocity± 0.05m/s
- Yaw velocity of VUT (upto $T_{STEER)}$0 ± 1.0 °/s
- Steering wheel velocity (upto $T_{STEER)}$0 ± 15.0°/s

ELK oncoming scenarios:
- Speed of GVT (GPS-speed) from 4s TTC72 ± 1.0km/h
- Lateral deviation from test path GVT0 ± 0.30m

ELK Overtaking scenarios:
- Relative longitudinal speed0 or 8 ± 1.0km/h
- Relative longitudinal distance
  @ 0km/h relative velocity 0 ± [0.20]m
  @ 8km/h relative velocity x ± [0.20]m
  Lateral deviation from test path GVT0 ± 0.20m

7.4.3.1 Steer the vehicle as appropriate to achieve the lateral velocity in a smooth controlled manner and with minimal overshoot

7.4.4 The end of an LDW test is considered as when the warning commences.

7.4.5 The end of a BSM test is considered to be when the longitudinal distance between the VUT and test target =0m (i.e. when the front end of the VUT is aligned with the rear end of the test target).

7.4.6 The end of an LKA/ELK Road Edge test is considered complete 2 seconds after one of the following occurs:

- The LKA/ELK system fails to maintain the VUT within the permitted lane departure distance.
- The LKA/ELK system intervenes to maintain the VUT within permitted lane departure distance, such that a maximum lateral position is achieved that subsequently diminishes causing the VUT to turn back towards the lane.

7.4.7 The end of an ELK oncoming or overtaking test is considered as when one of the following occurs:

- The ELK system intervenes to prevent a collision between the VUT and target vehicle
- The ELK system has failed to intervene (sufficiently) to prevent a collision between the VUT and target vehicle. This can be assumed when one of the following occurs:
    - o The lateral separation between the VUT and target vehicle equal < 0.3m in the oncoming and overtaking scenario
    - o No intervention is observed at a TTC = 0.8s or a TTC submitted by the OEM

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

7.4.7.1 If the test ends because the vehicle has failed to intervene (sufficiently) or if the GVT has left its designated path by more than 0.2m, it is recommended that the VUT and/or GVT are steered away from the impact, either manually or by reactivating the steering control of the driving robot/GVT.

7.4.8 The subsequent lateral velocity for the next test is incremented with 0.1m/s.

ANNEX A: EURO NCAP TEST FACILITIES

Real Road Edges are to be used for Euro NCAP tests until an agreed artificial road edge for testing purpose is available.

A.1 Road Edges at the Euro NCAP laboratories

Road Edge examples