Automated Driving

Highway Assist Systems

Test & Assessment Protocol

September 2020

Version 1.0

Contents

Definitions

Throughout this protocol the following terms are used:

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

Global Vehicle Target (GVT) – means the vehicle target used in this protocol as defined in TB025 - Global Vehicle Target specification for Euro NCAP v1.0

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.

Speed Assist System (SAS) –a system that informs or warns the driver and/or controls the vehicle speed

Speed Limit Information Function (SLIF) – a function with which the vehicle knows and communicates the speed limit.

Speed Limitation Function (SCF) – a system which allows the driver to set a vehicle speed to which he wishes the speed of his car to be limited and above which he wishes to be warned.

Adaptive Cruise Control (ACC) – a system that controls the vehicle speed while maintaining a set distance to vehicles ahead

Intelligent Adaptive Cruise Control (iACC) – iACC is an ACC combined with SLIF, where the speed is set by the SLIF with or without driver confirmation.

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

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

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

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

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

Lane Support System (LSS) – a system that correct the vehicle heading to keep the vehicle within its driving lane and/or warns the driver

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.

1 Highway Assist systems

Euro NCAP released its first publication on Highway Assist systems in 2018. This protocol is developed to provide consumers with more detailed information on Highway Assist systems that are typically offered as an option and are as such not considered in the Euro NCAP star rating.

For Highway Assist systems, Euro NCAP focusses on two main areas: Assistance Competence, which is the balance between Vehicle Assistance and Driver Engagement, and Safety Backup. The sum of the scores in Assistance Competence and Safety Backup is used in a grading system, similar to the five-star safety rating.

This protocol describes the details of all scoring elements within Driver Engagement, Vehicle Assistance and Safety Backup.

1.1 Balance principle

The Assistance Competence score is the balance between Vehicle Assistance and Driver Engagement. The higher the level of assistance, the more the driver must be engaged by the system.

In principle, the Assistance Competence score equals the Vehicle Assistance score, but only when the Driver Engagement score (at least) matches Vehicle Assistance. Where Vehicle Assistance outscores Driver Engagement, the Assistance Competence score is limited to the Driver Engagement performance.

ASSISTANCE COMPETENCE	SCORE
Driver Engagement ≥ Vehicle Assistance	Vehicle Assistance
Driver Engagement < Vehicle Assistance	Driver Engagement

1.2 Grading

The sum of Assistance Competence and Safety backup determines the Grading:

GRADING	SCORE REQUIRED
VERY GOOD	≥ 160 points (≥ 80%)
GOOD	≥ 140 points (≥ 70%)
MODERATE	≥ 120 points (≥ 60%)
ENTRY	≥ 100 points (≥ 50%)

2 Assistance Competence – Driver Engagement

The Driver Engagement assessment consists of four elements:

- Consumer Information
- System Status
- Driver Monitoring
- Driving Collaboration

The following sections of the protocol describes the requirements and scoring for each of these elements.

2.1 Consumer Information

Drivers expectations of how much assistance the system will provide them will be influenced by information they are supplied prior to them operating the system. It should always be clear to any potential driver that the system is an assistance system only and that driver oversight is always required. This assessment is designed to examine the information supplied to the consumer relating to the assistance system.

2.1.1 System Name

When the vehicle manufacturer markets the longitudinal and lateral assistance systems under a single name, this name shall be used. If the vehicle manufacturer markets the longitudinal and lateral control systems separately, the name of each shall be assessed and the lowest of the two scores will be used.

A system name should contain the word "assistant", "assistance", "assist" or another variation of the term. If this is the case, 10 points are awarded.

The system name shall not contain the word "auto", "automatic", "automated", any other variation of the term or another term which is deemed to imply a level of automation higher than which the system is offering. E.g. "pilot", "self-drive", etc.

Where a system's name neither contains the term "assist" nor a variant of "auto" or "pilot", 5 points are awarded.

2.1.2 Marketing Material

Euro NCAP cannot monitor and assess every piece of marketing material related to the VUT in all countries where the system is sold. However, during the assessment, time will be taken to review publicly available marketing material, relating to the system assessed and published by the vehicle manufacturer. This will include, but is not limited to, television and radio advertisements, vehicle brochures and online information, i.e. the vehicle manufacturer website (search to include model and feature specific within the website and using the "build your vehicle" service).

Marketing material may not imply that the system offers a higher level of assistance than is provided. Examples of this include descriptions of the system as an automated system, a pilot or self-driving. Images of the driver with hands not touching the steering wheel or performing secondary tasks over and above those permitted during normal driving, whilst the vehicle is in motion, are another example.

Any feature describing higher function but clearly labelled as either "future tech" or "not available in this region" or similar is allowed unless deliberately misleading i.e. use of the function as a header.

In case marketing material correctly describes the system functionality, 5 points are awarded. When one or more violations are found, no points are scored.

2.1.3 Quick start guide

To be considered a "Quick start guide", information must be supplied to the consumer on the basic operation of the driving assistance system and system limits. This must be in a form supplementary to the vehicle handbook.

Typically, this will be a short document indicating position and function of controls, usage guidelines and system limitations. A tutorial video, which can be viewed through the vehicle infotainment system containing this information, is a suitable alternative to a paper document.

If a vehicle manufacturer has another means by which to supply the information to the consumer, they should liaise with the test laboratory and the Euro NCAP secretariat who will assess whether it meets the requirements.

Where a "Quick Start Quide" is available that meets the requirements, 5 points are scored.

2.1.4 Vehicle Handbook

The vehicle handbook should make it clear to the consumer that the system is an assistance system, and that driver engagement is always required. The handbook should detail operation of the system and controls. The handbook should detail intended use of the system and limits of the systems operation.

In case the vehicle handbook clearly described the system and its limitations, 5 points are awarded.

2.2 System Status

This assessment is designed to evaluate the information supplied to the driver on a continuous basis, confirming the level of driving assistance being provided by the system. This is anticipated to be visual information only.

This assessment is also designed to evaluate the information supplied to the driver in case the level of assistance by the system changes. This is anticipated to be visual, audible and/or haptic information or warnings.

If a manufacturer has a different method of system status indication to the driver, applied either continuously or momentarily at a change of assistance, the manufacturer should liaise with the test laboratory and the Euro NCAP secretariat who will consider if and how the indicator can be included in the assessment.

2.2.1 Preconditions

To be eligible for assessment, any system status indicators must be fitted to the vehicle as standard or fitted to the vehicle as part of the assistance system (i.e. it must not be possible to get an eligible assistance system without the indicator fitted).

To be eligible for assessment, it must not be possible for the assistance system to be used with the indicator disabled by the driver. This applies to any visual, audible or haptic indicator related to the system.

2.2.2 Continuous System Status Indicator Assessment

During this assessment, the vehicle should be driven in the manner required to achieve the correct level of assistance required for each part of the assessment. This means it should be driven at least once in:

- Manual mode (stand-by, no assistance)
- Longitudinal control only (e.g. ACC)
- Lateral control only (if available)
- Longitudinal and Lateral Control in combination.

If a system requires certain parameters for a level of assistance, the test laboratory should, within reason, meet those requirements.

Per system mode available in the vehicle 0.5 points are awarded for configurable status information, when they are always indicated and if the respective indication is distinguishable from other modes. In addition, 1.5 points per system mode are available for additional indicators in a head up display or another additional display in the driver's eye line.

When the status indication corresponds to general human factor guidelines and design principles, 0.25 are scored for each system mode.

The following questions are to be answered:

- Which of the following does the vehicle use to indicate the current level of assistance being provided by the respective system?

	Stand-by for Lat	Long only	Lat only	Long + Lat
Icon for status indication in the instrument cluster (always on)	☐	☐	☐	☐
Configurable status information in the instrument cluster	☐	☐	☐	☐
Other visual indicator (close to driver's expected line of sight in approx. +/- 15° from the driver´s normal forward view to the road scene, e.g. head up display)	☐	☐	☐	☐

- Is the system mode in primary status indicator always indicated (if system is switched on) and are indicators for different modes (e.g. ACC active, lateral control active, L2 active) distinguishable from each other?

	indicated at all times (always on)	distinguishable from other mode by colour and/or icon form
Stand-by for Lat	☐	☐
Long only	☐	☐
Lat only	☐	☐
Long + Lat	☐	☐
vehicle in lane ahead (when identified)	☐	☐

- Does the primary system status indicator in the instrument-cluster correspond to general human factors guidelines and design principles?

	Stand-by for Lat	Long only	Lat only	Long + Lat
Colour of indicator contrasts adequately from background colour (see Appendix 1, Table 1)	☐	☐	☐	☐
Colours conform to conventions or stereotypes (green related to “system active”; grey to “stand-by”; red to “warning or danger”)	☐	☐	☐	☐
Red/green and blue/yellow colour combinations are avoided (e.g. red icon on green background or green and red elements in one icon referring to different system modes)	☐	☐	☐	☐
Indicators are designed in accordance to the catalogue of so far accepted indicators (see Appendix 1, Table XY) to make underlying function and driver responsibility clear	☐	☐	☐	☐
No flashing indicators are used for continuous system status indication (standstill is considered discontinuous)	☐	☐	☐	☐

2.2.3 System Status Change Indicator Assessment

Euro NCAP does not specify how each change in system status should be achieved, as the conditions required can vary from vehicle to vehicle. The test laboratory conducting the assessment should meet the requirements of the system to achieve each change in system status, where possible without conducting manoeuvres largely different from normal driving. It is required that the test driver remains attentive throughout the transition, so changes in assistance given due to driver monitoring are not accepted as they are assessed elsewhere.

For each of the following transitions between levels of assistance being provided to the driver, record through which means the system indicates to the driver that the transition is taking place.

An audible and/or haptic warning to indicate a system change, scores 2 points. An extra 2 points are awarded when additional visual information is shown. In case this information meets the general human factors guidelines, 1 additional point is scored. Finally, 0.2 points per denied requested mode change are available for additional visual information.

The following questions are to be answered:

- Mandatory decreases in level of assistance provided, initiated by the system due to changes in environmental conditions or sensor degradation.
  Is the system status change indicated?

	Change in primary status indicator	Audible tone or noticeable haptic indication	Visual information (additional to primary indication, e.g. icon and/or text)
Long + Lat → Long only	☐	☐	☐

  Does the system status change indication correspond to general human factors guidelines and design principles?

	Long + Lat → Long only
Additional visual information is triggered as long as the driver is driving "hands-off"	☐
Additional audible information doesn't startle or annoy the driver (loudness between 50 and 90 dB recommended)	☐

- Mandatory increases in level of assistance provided, initiated by the system due to changes in environmental conditions. The indication of successful increase in level of assistance is given simultaneously to the system initiation:

	Change in primary status indicator
No assistance → Lat only	☐
Long only → Long + Lat	☐

- Driver requested increase in level of assistance provided – request accepted. The indication of successful increase in level of assistance is given simultaneously to the driver input:

	Change in primary status indicator
No assistance → Long only	☐
No assistance → Lat only	☐
No assistance → Long + Lat	☐
Long only → Long + Lat	☐
Lat only → Long + Lat	☐

- Driver requested increase in level of assistance provided – request denied (e.g. sensor is blocked, but driver tries to activate the system). Is the denied request indicated?

	No change primary in status indicator	Additional visual information (icon and/or text)
No assistance → Long only	☐	☐
No assistance → Lat only	☐	☐
No assistance → Long + Lat	☐	☐
Long only → Long + Lat	☐	☐
Lat only → Long + Lat	☐	☐

2.3 Driver Monitoring

The systems being tested are those that can be broadly grouped together as Highway Assist systems as defined by Euro NCAP, or as SAE Level 2. This means that the driver retains full responsibility and shares control with the vehicle. Both vehicle and driver share OEDR and the driver may not perform any secondary tasks over and above those permitted during normal driving.

2.3.1 Minimum Requirements (Whole Vehicle Type Approval)

Revision 4 of UN Regulation 79 defines a minimum requirement for interventions by the VUT when steering control is released by the driver with steering assist active, the important points to note are as follows:

- Optical warning within at least 15 seconds after steering control has been released.
- Acoustic warning & red optical warning within at least 30 seconds after steering control has been released
- System deactivated within 30 seconds of acoustic warning. An additional acoustic warning is required (different from the previous) for at least 5s.

The test house will run a confirmation test, to confirm that the driver monitoring system meets the R79 requirements as set out above. This test can be completed concurrently with the Unresponsive Driver Intervention assessment.

When the R79 compliance is confirmed, 10 points are scored.

2.3.2 Additional Monitoring

Direct Driver Monitoring systems that monitor driver engagement and cognitive workload using cameras and/or other sensors to check that the driver has “eyes-on” and / or “brain-on”.

Euro NCAP is developing test and assessment procedures for these Driver Monitoring systems. If a manufacturer already has a Direct Driver Monitoring system as integral part of the assistance system, the manufacturer should liaise with the test laboratory and the Euro NCAP secretariat who will consider if and how the monitoring system can be included in the assessment and are eligible of scoring 15 points.

2.4 Driving Collaboration

This assessment determines how the vehicle responds to a driver steering input, for example to avoid an obstacle within the lane of travel, when the steering assistance system is engaged.

2.4.1 Pothole Test

A direct torque measurement system is to be used in these tests, where all torque measurement data should have a [12-pole phaseless Butterworth filter with a cut off frequency of 10Hz] filter applied before maximum values are taken.

2.4.1.1 System On

Drive the VUT into a fully marked lane at an indicated 45mph (72km/h), using the ACC system with the continuous steering assistance system switched ON, and all other lateral support systems turned off where possible. Activate the continuous steering assist system and allow the system to take up a consistent position within the lane.

- Apply a full sine wave of steering angle to the VUT steering wheel, with an amplitude of 5 degrees and frequency of 0.25Hz.
- Record the maximum/peak steering torque required during the first half of the sign wave.
- Repeat the test three times and record the average maximum torque over the three runs.

2.4.1.2 System Off

Drive the VUT down the centre of a fully marked straight lane at an indicated 45mph (72km/h) using the ACC system with the continuous steering assistance system switched OFF, maintain a constant speed and central position within the lane.

- Apply a full sine wave of steering angle to the VUT steering wheel, with an amplitude of 5 degrees and frequency of 0.25Hz.
- Record the maximum/peak steering torque required during the first half of the sign wave.
- Repeat the test three times and record the average maximum torque over the three runs.

Both the override torque and override response are assessed based on the measurements and behaviour in the pothole test.

The difference between system percentage increase in torque (compared to system off) is compared:

OVERRIDE TORQUE	**Lane Change Manoeuvre GVT**			
	0-33%	**33-67%**	**67%-100%**	**100%+**
	5 points	3 points	1 point	0 points

For vehicles where the override torque <5Nm, 20 points are available for the reaction of the system during the pothole test:

- 20 points are awarded when the system provides continuous steering assistance throughout the manoeuvre and centres the vehicle in the lane afterwards
- 10 points are scored when the system cancels steering assistance during the manoeuvre but automatically reengages once the vehicle is centralised in lane again by the driver
- If a system cancels steering assistance during manoeuvre and requires a reactivation by the driver afterwards, no points are given

2.5 Driver Engagement Assessment

The Driver Engagement score is the sum of the scores of:

- Consumer Information
- System Status
- Driver Monitoring
- Driving Collaboration

For all three elements, the maximum available points for each subsection are detailed below.

2.5.1 Consumer Information

	Score
SYSTEM NAME System name	**10 points** 10 points
MARKETING MATERIAL Marketing material	**5 points** 5 points
QUICK START GUIDE Quick start guide availability	**5 points** 5 points
VEHICLE HANDBOOK Clear description of level of Assistance	**5 points** 5 points

2.5.2 System Status

	Score
CONTINUOUS STATUS INDICATOR Continuous system status indicator	**18 points** 18 points
STATUS CHANGE INDICATOR System status change indicator	**7 points** 7 points

2.5.3 Driver Monitoring

	Score
UNECE R79 COMPLIENCE UNECE R79 revision 4	**10 points** 10 points
DIRECT DRIVER MONITORING Direct Driver Monitoring	**15 points** 15 points

2.5.4 Driving Collaboration

	Score
OVERRIDE TORQUE	**5 points**
%-age increase in torque	5 points
OVERRIDE RESPONSE	**20 points**
Override torque	10 points
System response	10 points

3 Assistance Competence – Vehicle Assistance

The Vehicle Assistance assessment consists of three elements:

- Speed Assistance
- Adaptive Cruise Control Performance
- Steering Assistance

3.1 Speed Assistance

Using the camera and/or map data, vehicles can adopt the prevailing speed limit into the ACC system and/or display the speed limit for information or adoption by a secondary confirmation by the driver. A system with the capability to self-adjust or offer changes of the set speed can be referred to as iACC (intelligent Adaptive Cruise Control).

The VUT results of the Euro NCAP Speed Assist Systems assessment is used as basis and tests are to be performed as per the Euro NCAP Speed Assist Systems Test Protocols v2.0. Additionally, the VUT is assessed for its ability to recognise a change in speed limit and apply or offer that change in speed to the ACC.

Systems that can advise and make speed adjustments for upcoming road features shall be rewarded.

3.1.1 Score from Speed Assist Systems assessment

If a vehicle is presented for assisted driving assessment that hasn't already been through the NCAP rating scheme it is a requirement to carry out the Speed Assistance System tests as part of this assessment, following Euro NCAP Speed Assist Systems assessment as detailed in the Safety Assist – Assessment protocol v9.0.3.

It is likely that the optional Highway Assist systems comes with a higher performing SAS than the version with standard equipment only. In these cases, the SAS assessment also needs to be updated accordingly.

For the Highway Assist assessment, the normal SAS score is doubled.

3.1.2 Reaction to speed limit changes

To maintain law abiding driving, vehicles should have adapted their speed before they reach the sign indicating a change in speed limit, although in some EU countries there is an allowance of a certain distance before a prosecution can be made.

The vehicle manufacturer should provide the test laboratory and the Euro NCAP secretariat with information showing the vehicle response to speed limit changes for:

- Fixed speed limits
- Variable and temporary speed limits

The vehicle manufacturer must take the following into account when providing the information:

- Systems that automatically adjust the speed to the desired speed limit will be deemed to have adopted the speed limit in time if the vehicle speed is reduced to that of a lower speed limit [+2km/h] before the front axle of the vehicle passes the sign.
- Systems which offer adjustment to the new speed limit but require a manual action from the driver will be deemed to have adopted the speed limit in time if the vehicle speed is reduced to that of a lower speed limit [+2km/h] before the front axle of the vehicle passes the sign when the driver gives the confirmation action 1.5 seconds after the lower limit is offered.
- A system which only provides information about upcoming and current speed limits will be deemed to have provided the information in time if the lower speed limit information is displayed to the driver at a time which allows the driver to manually set the ACC to the lower speed limit and the vehicle speed is reduced to that of a lower speed limit [+2km/h] before the front axle of the vehicle passes the sign, when the driver starts this process 1.5 seconds after the information is given.

The test laboratory will perform a short road test on local highways to verify this function and to confirm that the VUT responds as indicated by the vehicle manufacturer.

3.1.3 Road Features

In addition to changing the ACC setting relative to the speed limit additional points are available for reducing speed when approaching the following road features:

- Corners
- Roundabouts
- Junctions

The test laboratory will perform a short road test on local roads to verify this function and to confirm that the VUT responds as indicated by the vehicle manufacturer.

3.2 Adaptive Cruise Control Performance

The Adaptive Cruise Control Performance assessment looks at how the longitudinal assist system fitted to the vehicle reacts to other vehicles during operation. For Highway Assist systems, only car-to-car performance is assessed.

3.2.1 ACC Car-to-Car tests

Only the capability of the ACC system is assessed in this section, where braking levels stay below approximately 5 m/s^2 and/or where it is confirmed that AEB did not intervene.

For each scenario and test speed, 1 point can be achieved where the ACC fully avoids the collision. Where the ACC intervenes and reduces the impact speed by more than 5 km/h before the AEB intervenes, 0.5 points are scored. Where the ACC does not reduce more than 5 km/h, no points are awarded.

The ACC Car-to-Car assessment contains different scenarios when driving at highway speeds:

ACC CAR-TO-CAR	VUT	GVT
CCRS – STATIONARY TARGET **(straight and curved road)**	70 km/h 80 km/h 90 km/h 100 km/h 110 km/h 120 km/h 130 km/h	
CCRM – MOVING TARGET	80 km/h 90 km/h 100 km/h 110 km/h 120 km/h 130 km/h 80 km/h 90 km/h 100 km/h 110 km/h 120 km/h 130 km/h	20 km/h 20 km/h 20 km/h 20 km/h 20 km/h 20 km/h 60 km/h 60 km/h 60 km/h 60 km/h 60 km/h 60 km/h
CCRB – BRAKING TARGET ACC-mode closest	55 km/h	50 km/h
CUT-IN Cut-in @ TTC = 0.00 Cut-in @ TTC = 1.50	50 km/h 120 km/h	10 km/h 70 km/h
CUT-OUT Cut-out @ TTC = 3.00 Cut-out @ TTC = 3.00	70 km/h 90 km/h	50 km/h 70 km/h

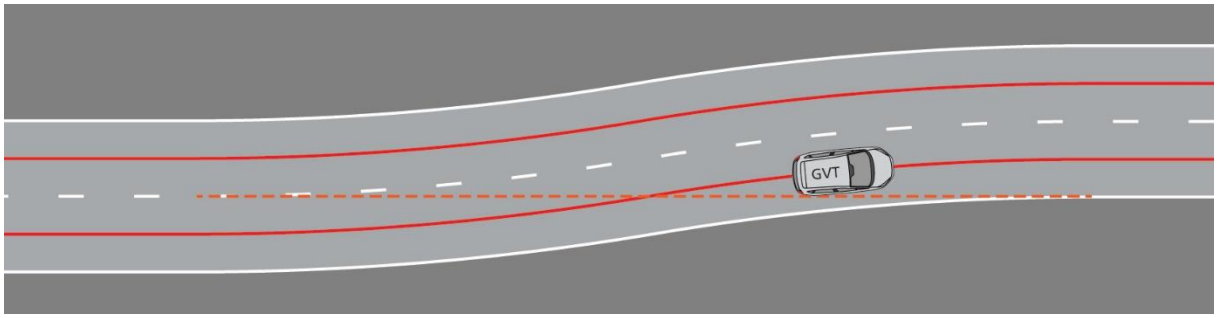
3.2.1.1 ACC Car-to-Car tests

All ACC Car-to-Car tests are performed as per Euro NCAP AEB Car-to-Car test protocol v3.0.2. For each test, the vehicle should be driven in a fully marked lane with the ACC set with the indicated speed set to the desired test speed. The ACC should be set to the closest following distance for all tests. Lateral assistance should be engaged and used to control the VUT's position with the lane. Both the ACC and Steering assist must be active before the lower of 10s TTC or 250m relative longitudinal distance.

For CCRs on a curved road and the Cut-in and Cut-out scenarios, additional details are given in the following paragraphs.

3.2.1.2 CCRs on curved road

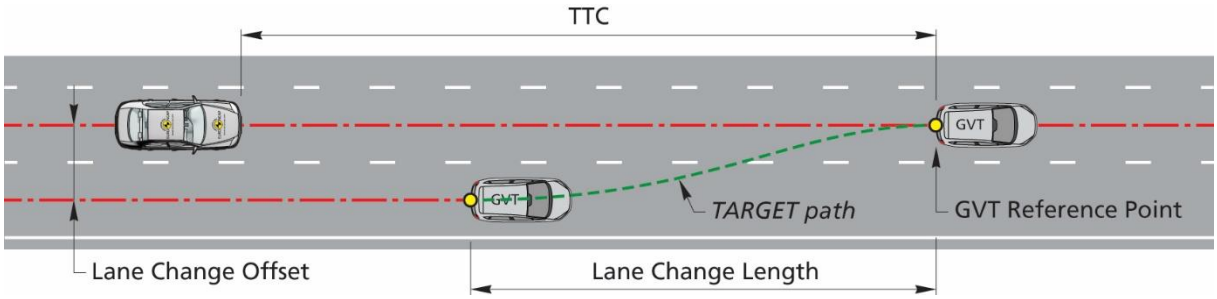
For tests on a curved section of road, the first turn of the S-Bend as required for the Steering Assistance assessment is used where the GVT should be positioned such that it is central in lane around the first bend so that the rear corner is touching the extrapolated line as if the straight were continue (as shown in the picture below).



3.2.1.3 Cut-in tests

In the Cut-in tests, the GVT on the adjacent lane will perform a full lane change (3.5m lateral displacement) into the lane of the VUT. The indicated TTC is defined as the TTC at the point in time that the GVT has finished the lane change manoeuvre, where the rear centre of the GVT is in the middle of the VUT driving lane.

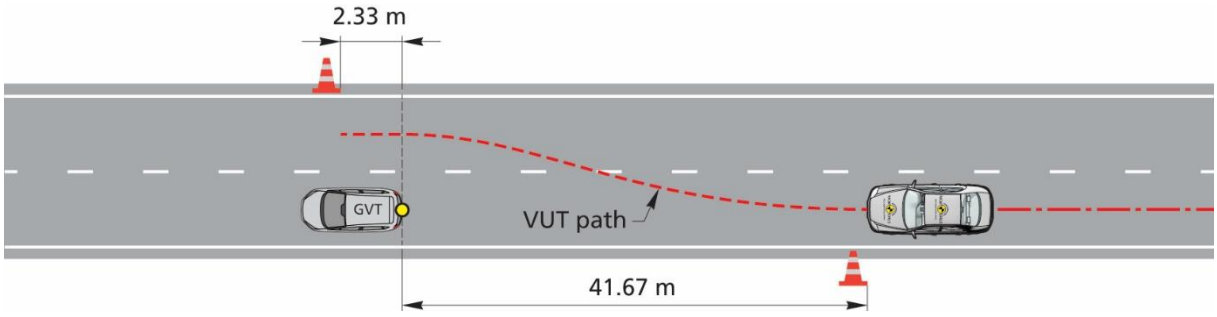
ACC CUT-IN	VUT	GVT	Lane Change Manoeuvre GVT		
			Lateral Acceleration	Change Length	Radius of turning segments
Cut-in					
Cut-in @ TTC = 0.00	50 km/h	10 km/h	0.5 m/s^2	14.5 m	15 m
Cut-in @ TTC = 1.50	120 km/h	70 km/h	1.5 m/s^2	60.0 m	250 m

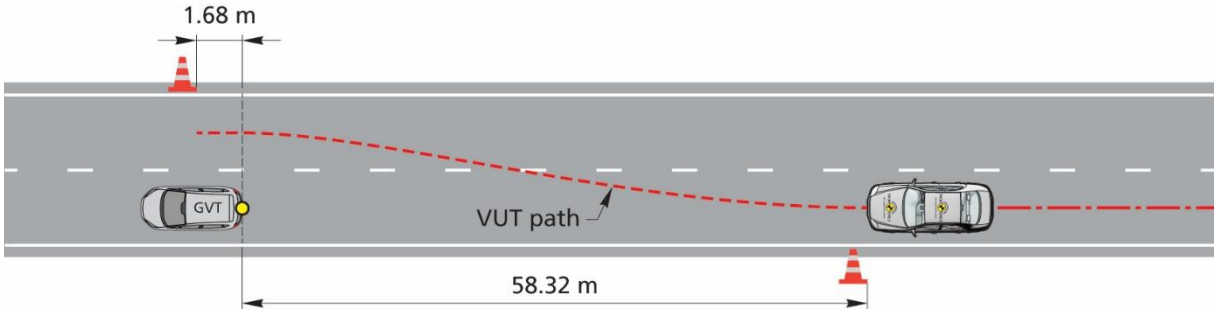


3.2.1.4 Cut-out tests

The Cut-out test must be performed using a real car for the lead vehicle and not a robot-controlled platform. The vehicle cutting out will perform a full lane change (3.5m lateral displacement) into the adjacent lane to avoid the stationary GVT. The indicated TTC is defined as the TTC of the lead vehicle to the GVT when the lead vehicle will start the lane change.

ACC CUT-OUT	VUT	Lead Vehicle	Lane Change Manoeuvre of lead vehicle		
			Lateral Acceleration	Change Length	Radius of turning segments
Cut-in					
Cut-out @ TTC = 3.00	70 km/h	50 km/h	1.5 m/s^2	44.0 m	130 m
Cut-out @ TTC = 3.00	90 km/h	70 km/h	1.5 m/s^2	60.0 m	250 m





3.2.2 Undertake prevention

In most European countries it is only permissible to overtake a slower moving vehicle, in free-flowing traffic, in a lane to one side of the slower moving vehicle. Therefore, an assisted driving system should not overtake a vehicle on the incorrect side in this scenario. For this highway-based assessment, it may be that the system is geofenced and it will be a requirement for the OEM to inform the test laboratory of the function of the system.

The manufacturers handbook or supplied information will be used to assess the performance of the system, with its operation confirmed by the test house where possible.

The longitudinal control system should prevent the VUT from overtaking a slower moving vehicle in an adjacent lane on the incorrect side for that country when travelling in free-flowing traffic at a minimum speed of 90km/h.

Note: If the vehicle ahead in adjacent lane brakes with a deceleration greater than the maximum design deceleration for the VUT's ACC system then it is acceptable that the VUT would perform the undertake as this is not the intended scenario for this test.

3.2.3 ACC Auto-Resume

This assessment looks at the strategy to resume the ACC after the vehicle has come to a full stop. To be eligible for assessment, the VUT must be capable of coming to a complete stop under ACC control when the traffic in front stops while also maintain steering assistance.

<table>
<tr><th>ACC AUTO-RESUME</th><th>Within 5s</th><th>After 5s</th></tr>
<tr><td rowspan="3">10 points</td><td>Automatic resume</td><td>Driver input</td></tr>
<tr><td colspan="2">Eyes-on road</td></tr>
<tr><td colspan="2">Confirm surrounding with external sensors</td></tr>
<tr><td>7 points</td><td colspan="2">Driver input</td></tr>
<tr><td>3 points</td><td colspan="2">Automatic resume</td></tr>
</table>

The Euro NCAP test laboratory will conduct a confirmation test based on the information provided by the vehicle manufacturer. If there are any features available on the VUT other than the one detailed below, then the vehicle manufacturer must inform the test laboratory how to test this feature.

3.2.3.1 Coming to a complete stop and resume within the maximum hold time

Drive the vehicle within a fully marked lane, following another vehicle driving at a constant 20km/h. Activate the longitudinal and lateral control system in the VUT with the following distance set to minimum distance and ACC set to a maximum speed of 30km/h or the minimum set speed of the system if this is higher than 30km/h.

After the vehicle has settled in a constant position within the lane and a constant distance behind the lead vehicle, gradually bring the lead vehicle to a halt with a deceleration not more than [-3m/s^2]

Hold the lead vehicle stationary for a time less than the max hold time of the VUT and then resume driving of the lead vehicle. Confirm that the VUT resumes driving as expected.

3.2.3.2 Coming to a complete stop and resume after the maximum hold time

Repeat the test as per 3.2.3.1 then hold the lead vehicle stationary for a time greater than the max hold time of the VUT and then resume driving of the lead vehicle. Confirm that the VUT does not resume driving without driver interaction as expected.

3.2.3.3 Coming to a complete stop and utilising external sensors

If the system utilises advanced sensors (such as ultrasonic parking sensors) to detect obstacles in between the VUT and the lead car to prevent pulling away if, for example, a pedestrian has appeared in the gap then test this using a pedestrian dummy entering the gap between the lead car becoming stationary and the max hold time for this scenario as per the following instructions:

- The lead vehicle and the VUT should stop equidistant across the path of the pedestrian dummy +/-0.5m. The dummy should then approach from the nearside at 5km/h as per CPNA AEB tests but with a trigger of when the VUT becomes stationary and then stop at the midpoint (50%) of the VUT.
- Once the pedestrian dummy is stationary between the vehicles, resume driving the lead vehicle to confirm that the VUT will not resume driving into a pedestrian.
- After a 5s delay remove the pedestrian from the headway of the VUT by continuing across the road at 5km/h.
- Upon the VUT resuming driving once the pedestrian (or obstacle) has passed it must be confirmed that the driver monitoring escalation strategy remains active during the hold time. For example, if no hands are detected on the steering wheel at the resumption of driving the 1st audible and visual warnings for "hands-off" should start before the VUT has reached 10km/h, it is not sufficient to assume that the vehicle being in motion will engage the driver.

3.2.3.4 Coming to a complete stop and utilising Driver Monitoring sensors

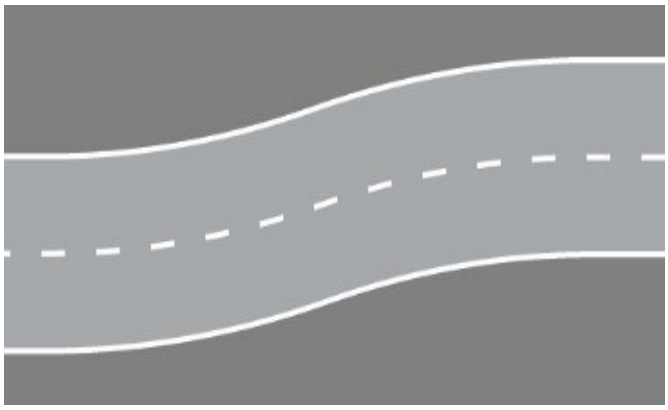
If the system utilises "eyes-on" monitoring to determine driver gaze during the hold period, then confirm this function by looking elsewhere during the hold period and confirming that the VUT no longer pulls away to follow the lead vehicle.

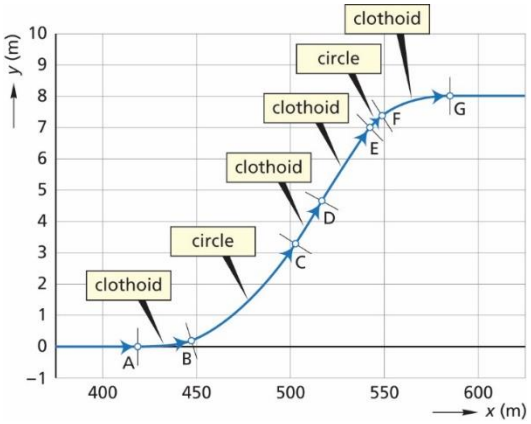
3.3 Steering Assistance

A steering assistance function should support the driver to keep the vehicle in lane, not only on straight roads. If a car departs from its lane there is an increased risk of collision. Euro NCAP does not expect vehicles to stay in the centre of the lane in all corners, but expects the vehicle to always support the driver by directing the vehicle to the correct heading. Euro NCAP tests the steering assistance in a so called S-Bend.

STEERING ASSIST	80 km/h	100 km/h	120 km/h
VUT stays in lane in both turns	10	10	10
VUT stays in lane in the 1st turn and redirects the vehicle in the 2nd turn	7.5	7.5	10
VUT stays redirects in the 1st turn	2.5	5	7.5

3.3.1 S-Bend dimensions





The approximate dimensions of the S-Bend is defined as:

- Left turn of radius 930m for an angle of 6 degrees
- Right turn of radius 500m and an angle of 6 degrees

More detailed, the S-Bend parameters are:

S-BEND	Clothoid parameter	Radius	Length
1st Turn	153.7		30.0
	-	787 m	57.1
	105.0		14.0
2nd Turn	98.6		26.0
	-	374m	5.1
	120.8		39.0

It is permissible for an S-Bend to be used with the turn directions mirrored as long as the same geometry is maintained.

3.3.2 Test Method

The capability of the steering assist system is tested at ACC indicated vehicle speeds of 80km/h, 100km/h and 120km/h. Where possible, all other lane support systems should be switched off for the duration of the test.

The vehicle should be driven along the straight section of the fully marked lane at a constant speed with the steering assist system on for enough time for the steering assist system to take up a constant position within the lane, prior to the start of the S-Bend.

The driver should make every effort not to add any input into the steering system which can affect the path of the vehicle once it has entered the S-Bend section. It is permissible for the test driver to remove their hands from the steering wheel. However, the driver may need to keep their hands on the wheel or provide a different input to prevent the actions of the vehicle being dictated by the systems recognition of an inattentive driver.

The driver should allow the vehicle to maintain a continuous maximum ACC speed as set throughout each test run. It is permissible for the vehicle system to reduce the driven speed in response to the road geometry, and this reduction in speed should not be overridden by the test driver. It may also be the case that the curvature tested would cause the vehicle to slow sufficiently to remain within lane if it were on a mapped location (real world driving); if this is predicted to be the case the OEM should advise the laboratory carrying out the test and confirm a suitable location to prove that the vehicle can slow and remain in lane.

3.4 Vehicle Assistance Assessment

The Vehicle Assistance score is the sum of the scores of:

- Speed Assistance
- Adaptive Cruise Control Performance
- Steering Assistance

For all three elements, the maximum available points for each subsection are detailed below. Where the raw score needs to be scaled, two columns are used. One showing the raw score and the amount of points available per scenario. In the column next to it, the maximum scaled score for each element is shown.

3.4.1 Speed Assistance

	Score
SPEED ASSIST SYSTEM	**6 points**
Speed Assist System	6 points
REACTION TO SPEED LIMIT CHANGES	**12 points**
Fixed speed limits	6 points
Variable and temporary speed limits	6 points
Road features	**7 points**
Corners	3 points
Roundabouts	2 points
Junctions	2 points

3.4.2 Adaptive Cruise Control Performance

	Raw Score	Score
ACC CAR-TO-CAR	**31.000**	**25 points**
CCRs – Stationary target	7.000	
CCRs – Stationary target in a curve	7.000	
CCRm – Moving target	12.000	
CCRb – Braking target	1.000	
Cut-in	2.000	
Cut-out	2.000	
UNDERTAKE PREVENTION		**5 points**
Undertake prevention @ speeds > 90 km/h		5 points
ACC AUTO-RESUME		**10 points**
ACC Auto-Resume		10 points

3.4.3 Steering Assistance

	Score
STEERING ASSISTANCE	**30 points**
S-Bend @ 80 km/h	10 points
S-Bend @ 80 km/h	10 points
S-Bend @ 80 km/h	10 points
LANE CHANGE ASSIST	**5 points**
Lane change assist	5 points

4 Safety Backup

The Safety Backup assessment consists of three elements:

- System Failure
- Unresponsive Driver Intervention
- Collision Avoidance

4.1 System Failure

In real world driving, it is anticipated that the sensors involved with the Driver Assistance System (Radar, LiDAR, or camera) may either deteriorate by age or damage or become blocked in adverse weather conditions. Having a blocked or deteriorated sensor may reduce the competency of the system. It is important that the system does not operate with reduced competency and that the driver is aware of the reason that the system becomes unavailable.

It is believed that all current systems will see some reduction in competency when a sensor fails, but there may be redundancy built into the system or multi-function sensors used to mitigate the effects to the performance of the system if a single sensor fails.

4.1.1 Pre-Test

Due to the complex nature of current systems and sensors the vehicle manufacturer will be required to fill in a questionnaire prior to the test taking place to detail the anticipated effect of blocking the sensors involved in providing the assistance in relation to each system.

4.1.2 Test

The test will assess all individual sensors systematically in three different scenarios:

- Sensor blocked at vehicle start up.
- Sensor becomes blocked when vehicle is moving but Driver Assistance System not activated.
- Sensor becomes blocked when vehicle is moving with the Driver Assistance System active and engaged.

For each sensor that forms part of the assistance system, the assessment is the same.

4.1.2.1 Sensor Blocked at Start-up

With the VUT switched off, cover the sensor under test with a material that will prevent the sensor receiving a signal. Typically, radar absorbing material is used to cover the radar.

Once the material is in place start the car and drive up to the minimum speed to activate the assistance system as detailed in the VUT handbook. Attempt an activation as soon as possible. If the assistance system can't be engaged after a 5 minute drive, then the VUT scores 8 points and is eligible for a further 2 points if a visual warning is displayed within 5 minutes of driving above the minimum speed following this activation attempt. If the control system can be activated at this time the VUT scores 0 points.

4.1.2.2 Sensor Blocked with VUT in motion, System not active

Drive the VUT with the assistance system not activated at the minimum speed [or 30km/h minimum speed, whichever is lowest] required to activate the system for 1 minute. Then, without slowing below this speed, cover the sensor with the same material that was used in the above test and attempt a system activation after 5 minutes.

If the system cannot be engaged, then the VUT scores 4 points and is eligible for a further 1 point if a visual warning is displayed within 5 minutes of driving above the minimum speed following this activation attempt. If the assistance system can be activated at this time, the VUT scores 0 points.

4.1.2.3 Sensor Blocked with VUT in motion, System active

Drive the VUT with the assistance system activated at the minimum design speed for the system [or 30km/h minimum speed, whichever is lowest]. Then, without stopping, cover the sensor with the same material that was used in the above test.

If the system cancels within 2 minutes of the material covering the sensor then the VUT scores 8 points and is eligible for a further 2 points if a visual warning is displayed within 5 minutes of driving following the covering of the sensor. Any other time before the system cancels will score 0 points.

If the OEM has declared that the system suffers no loss in performance when a sensor is blocked, then, with that sensor covered, the test house should confirm this by repeating, either

- the CCRs test from ACC Performance at highest speed that was avoided by the VUT in case the sensor becoming blocked is declared to have no effect on longitudinal control.
- the Steering Assistance test at the highest speed that the VUT remained in lane, in case the blocked sensor is declared to have no detriment to lane guidance. If the vehicle does not remain in lane at any of the test speeds, repeat the 80km/h test and accept a deviation no greater than 0.25m from the original path.

If the OEM declaration is confirmed by this/these test(s), the VUT scores 20 of the available points for this sensor. It must then provide a visual message to the driver that the sensor has become blocked, this can be at any time but must be displayed no later than the beginning of the next drive as defined by an ignition cycle, the display of the visual message scores the VUT an additional 5 points for this sensor and it is added to the total score equation in section 3.

If the VUT fails the confirmation test, then 0 points are scored for that sensor.

4.2 Unresponsive Driver Intervention

This assessment is designed to test the ultimate reaction of the vehicle to a driver who remains unresponsive after the cascade of warnings and attempts re-engage the driver. This test can be run concurrently with the Driver Monitoring assessment.

It is anticipated that many of these systems may be geo-fenced to work only on highways. It is permissible and recommended that the VM has the test labs test track assigned as a highway on their test vehicle.

This test must be performed in a minimum two-lane straight road with a length of at least 1.6km (1 mile) not including acceleration and braking zones. The near side most lane must have a solid white line with enough space for a safe harbour (hard shoulder or none running lane) across from the driving lanes.

Affix onboard cameras to monitor the Instrumentation of the vehicle at the minimum and it is recommended to mount at least one additional camera monitoring the interior / driver cockpit.

4.2.1 80km/h Test

With no other vehicles on the track, and the VUT in the second driving lane, accelerate up to test speed and engage ACC and continuous steering assistance system.

Allow the system to take up a consistent position within the lane and then release the controls "hands off". For ease of video review, use a trigger such as saying the phrase "hands off" at the moment of releasing the steering wheel.

Observe and if required make verbal comments on the vehicle's response.

The test is considered complete when either:

- The vehicle comes to a complete stop.
- The warning escalation ends.
- Both the longitudinal and steering assistance systems switch off.
- There is no response from the car and the test driver has to stop at the end of the test track section.

A vehicle that maintains steering control and brings the vehicle to a controlled stop or reduces its speed to crawling speed is awarded 20 points. An additional 5 points are reserved for a more advanced response in case of an incapacitated driver. However, current regulations restrict the vehicle taken other measures like changing lanes and stopping on the hard shoulder.

4.3 Collision Avoidance

The aim of the ACC Performance assessment is to assess only how the longitudinal assist system fitted to the vehicle reacts to other vehicles during operation. At this stage, the system is only being assessed for performance when driving on a highway, therefore only car-to-car performance is assessed. In this assessment "Collision Avoidance" the capability of the vehicle

to avoid a collision using both assisted driving systems and emergency systems combined is assessed.

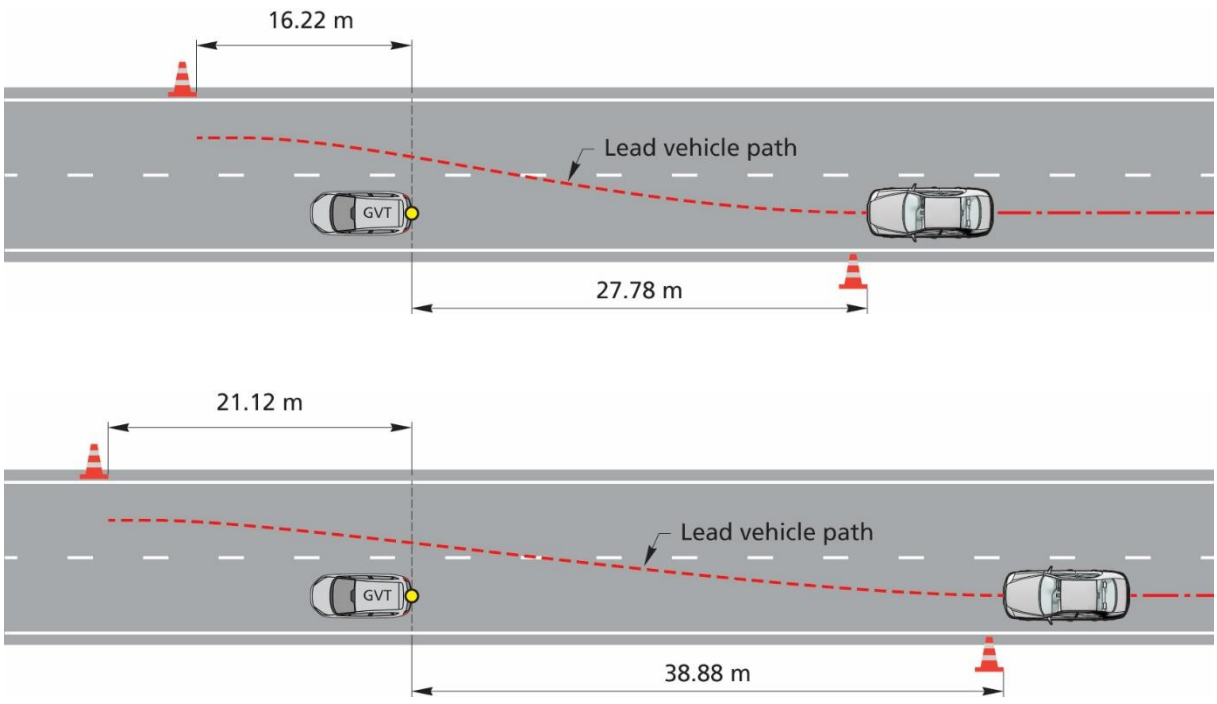
For each scenario and test speed, 1 point can be achieved where the ACC and/or AEB fully avoids the collision. Where the ACC and/or AEB intervenes and reduces the impact speed by more than 5 km/h, 0.5 points are scored. Where the ACC and/or AEB system does not avoid the collision, but an FCW is issued at a TTC >1.5s an additional 0.25 points are awarded for that scenario.

For CCRs, CCRm and CCRb, the same test speeds are used as for the ACC Performance assessment. For Cut-in and Cut-out additional and more critical set-ups are used to verify the Safety Backup.

AEB CAR-TO-CAR	**VUT**	**GVT**
Cut-in		
Cut-in @ TTC = -1.50	50 km/h	10 km/h
Cut-in @ TTC = 0.50	120 km/h	70 km/h
Cut-out		
Cut-out @ TTC = 2.00	70 km/h	50 km/h
Cut-out @ TTC = 2.00	90 km/h	70 km/h

4.3.1.1 Cut-out tests

The additional Cut-out tests for Safety Back-up must also be performed using a real car but the lead vehicle will cut-out at a TTC of 2s instead of 3s as in ACC Performance.



4.3.2 Lane Support System – S-Bend

The lane support system – S-bend is designed to determine the ability of the vehicle to stay in lane or alert the driver to a lane departure on a curved section of road using both the AD system and the emergency LSS systems such as ELK, LKA and LDW.

This section is based on the same test scenarios and test speeds as the Steering Assistance section. For each test speed at which the vehicle remained in lane during the Steering Assistance assessment, the points for Collision Avoidance are automatically awarded.

For each test speed at which the vehicle did not remain in lane during steering assistance tests, repeat the test, as per Steering Assistance with all additional LSS systems switched on.

Where an LKA intervention prevents the VUT from crossing the lane marking by more than 0.4m, 5 points are awarded. Where there is no intervention by the system, but an audible or haptic LDW is provided before the vehicle has left the lane by more than 0.3m, 2.5 points are scored.

4.3.3 Lane support system - Lane change with overtaking vehicle

The lane change section of the collision avoidance system is to assess the vehicles ability to stop the vehicle changing lane into the path of a vehicle travelling in the adjacent lane. Both ELK systems and Blind Spot Monitoring with active torque systems fitted as part of the driver assistance pack which can change the vehicles heading to prevent a collision are considered beneficial in this scenario.

Only the Intentional Lane change with overtake tests from the Euro NCAP LSS Test Protocol v3.0.2 are to be performed. If the vehicle has already been assessed by Euro NCAP, these results can be carried over.

In case all intentional lane change tests are passed, 10 points are awarded.

4.4 Safety Backup Assessment

The Safety Backup score is the sum of the scores of:

- System Failure
- Unresponsive Driver Intervention
- Collision Avoidance

For all three elements, the maximum available points for each subsection are detailed below. Where the raw score needs to be scaled, two columns are used. One showing the raw score and the amount of points available per scenario. In the column next to it, the maximum scaled score for each element is shown.

4.4.1 System Failure

	Score
SYSTEM FAILURE	**25 points**
Sensor blocked at Start-up	10 points
Sensor blocked with VUT in motion, System inactive	5 points
Sensor blocked with VUT in motion, System active	10 points

4.4.2 Unresponsive Driver Intervention

	Score
UNRESPONSIVE DRIVER INTERVENTION	**25 points**
Controlled stop	20 points
Headroom for more advanced solutions	5 points

4.4.3 Collision Avoidance

	Raw Score	Score
ACC/AEB CAR-TO-CAR	**35.000**	**25 points**
CCRs – Stationary target	7.000	
CCRs – Stationary target in a curve	7.000	
CCRm – Moving target	12.000	
CCRb – Braking target	1.000	
Cut-in	4.000	
Cut-out	4.000	
LSS		**25 points**
S-Bend		15 points
Intentional lane change with overtake		10 points