**EURO NCAP'S FIRST STEP TOWARDS SCENARIO-BASED ASSESSMENT BY COMBINING AUTONOMOUS EMERGENCY BRAKING AND AUTONOMOUS EMERGENCY STEERING**

**Richard Schram**
European New Car Assessment Programme
Belgium

on behalf of the Euro NCAP Working Group on AEB/AES

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## ABSTRACT

Following the implementation of Autonomous Emergency Braking in the overall safety rating in 2014, Euro NCAP is making its first step towards a scenario-based approach by allowing a driver initiated steering intervention as an alternative to the driver responding to a Forward Collision Warning (FCW) by braking. With this first step, Euro NCAP is acknowledging that there are multiple responses possible to the same threat and that steering, in some cases, may be a better crash avoidance strategy than braking.

Within the Euro NCAP Working Group on AEB/AES, Euro NCAP members, test centers and the automotive industry represented by the ACEA, JAMA, KAMA and CLEPA associations, the first protocols are developed for both AEB Car-to-Car (C2C) and AEB systems, responding to vulnerable road users (VRU). The procedures are an extension to the current AEB C2C and AEB VRU test and assessment protocols, with expected adoption in the rating in 2020. This paper describes both the test and assessment protocols.

## BACKGROUND

In 2009, Euro NCAP introduced the overall rating scheme, which allows new technologies to be implemented in the safety assessment of a new vehicle. The new rating scheme consists of four areas of assessment, also called boxes, which together result in a single overall safety rating. The four areas of assessment are Adult Occupant Protection (AOP), Child Occupant Protection (COP), Pedestrian Protection (PP) and Safety Assist (SA).

Over the last few years, the car industry has taken their responsibility and are now fitting active safety systems like AEB as standard on nearly all new models released on the European market.

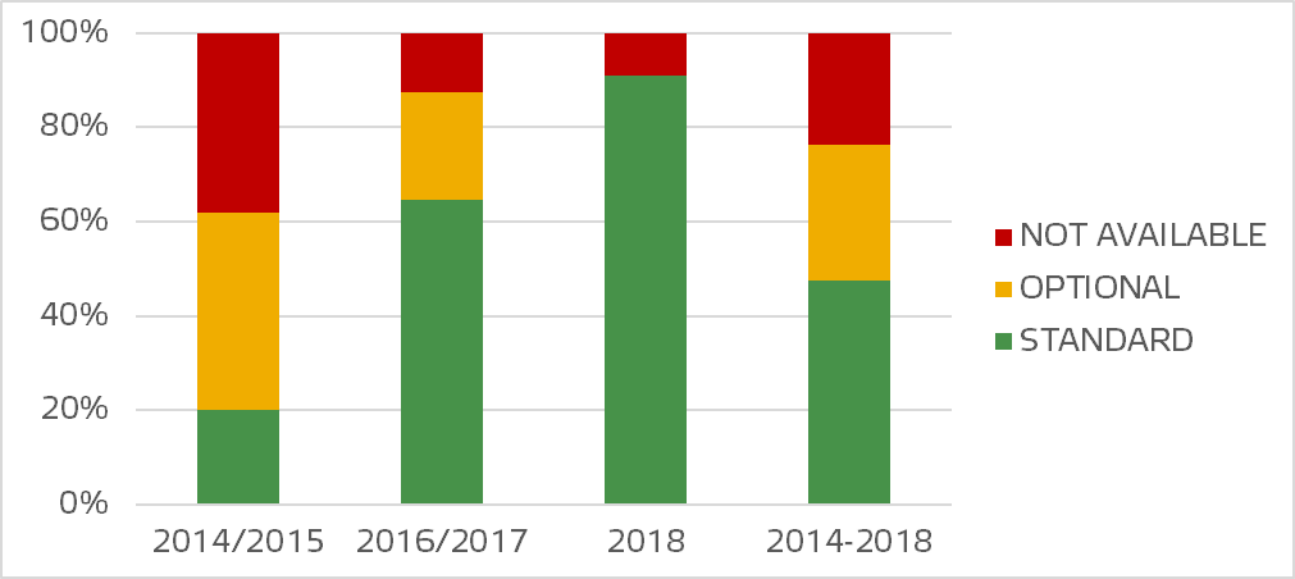


**Figure 1. AEB fitment distribution for Euro NCAP tested models**

As also the hardware and performance of these safety systems has evolved rapidly, Euro NCAP is now in the position to look for further use cases. With the inclusion of more complex scenarios, a scenario-based assessment instead of a system based assessment seems to be a logical next step in allowing the industry to decide themselves what is the most efficient strategy to avoid or mitigate any critical situation, while at the same time balancing the risk at possible false interventions.

As a first step, Euro NCAP will award so-called Emergency Steering Support (ESS), driver initiated systems that can steer away from a potential impact. The focus is on scenarios where responding to the FCW by steering is seen to be the better solution than hard braking to avoid a possible collision.

As for all Euro NCAP protocols, the development of the test procedure and assessment criteria was done within a collaborative Working Group. The Euro NCAP working Group on AEB/AES involves Euro NCAP members and laboratories, representatives from the car industry and suppliers, and was given the task to deliver extended AEB protocols for both Car-to-Car and Vulnerable Road Users by the end of 2018, for implementation in 2020. The work of the group took advantage of and brought together the results delivered by several research initiatives in Europe that where looking into extending the scope of AEB systems.

## EURO NCAP WORKING GROUP

**Initiatives**

In Europe, several initiatives led by Euro NCAP members and/or laboratories have been running in parallel, all with the same goal of developing test procedures for extended AEB scenarios for both AEB C2C, AEB VRU: INTERSECTION, PROSPECT, MUSE and CATS.

The INTERSECTION project, led by BASt and IDIADA has been specifically set up to develop test procedures for AEB C2C scenarios at intersections, which could be adopted in consumer testing. Accident analysis and driving studies are performed to understand the trajectories and scenario details of accidents between cars occurring on intersections. The group is supported by car manufacturers and suppliers and liaises closely with the PROSPECT project in terms of the intersection layout.

The European Commission sponsored FP8 project PROSPECT (Proactive Safety for Pedestrian and Cyclists) led by IDIADA had the overall objective is to provide a better understanding of VRU-related accidents and to develop, demonstrate and test innovative, (pro) active safety systems for protecting VRUs. The project partners consisted of research institutes, car manufacturers and suppliers, three of which were Euro NCAP laboratories: BASt, IDIADA and TNO. The PROSPECT project ran from 2015 until 2018.[1]

The results of the initiative CATS (Cyclist-AEB Testing System) were already implemented in the 2018 Euro NCAP update when AEB Cyclist scenarios were introduced. Additional scenarios that were judged to be too challenging for 2018 introduction are now added to the list of test scenarios in AEB VRU. The project was supported by another Euro NCAP test laboratory, BASt as well as car manufacturers and suppliers. The additional scenarios will be described in further detail within this paper.

UTAC is leading an initiative looking into specific scenarios for car-to-motorcycle accidents. In addition, the project will develop the necessary test equipment to be able to realistically assess the performance of AEB systems responding to motorcycles. This project is also supported by car manufacturers, suppliers and Euro NCAP laboratories ADAC, BASt, CSI and Thatcham Research. The results of this project will be useful for Euro NCAP planned update in 2022.

The outcome and deliverables of all these initiatives were and will be extensively discussed within the working group and formed the basis for the decision on test scenarios and targets used.

## TEST SCENARIOS AND TARGETS

The Euro NCAP 2025 Roadmap indicates several updates in the field of AEB C2C and AEB VRU. With the roadmap as a basis and based on the work done in the different initiatives, some updated and new scenarios are selected for implementation in 2020, and 2022 Euro NCAP rating updates. The sections below will explain the updates in the different areas including a first step into a so-called scenario-based assessment.

**AEB Car-to-Car**

For Car-to-Car scenarios, the roadmap picks up on the latest technological developments and scheduled for inclusion of a turn across path scenario in 2020 and general crossing scenarios for 2022.

The Car-to-Car Front turn-across-path (CCFtap) scenario represents the case where a driver intends to cross the oncoming lane and either misses or misjudges the speed of an oncoming vehicle. These accidents typically happen in a city environment and at relatively low ego speeds of the vehicle making the turn. In the first step, this scenario is tested at three different test speeds for the VUT (10, 15 and 20km/h) and three speeds for the GVT (30,45 and 55 km/h). Avoidance in these cases can only be reached by a late and harsh intervention of the AEB system as there is not enough time to warn the driver. In 2022, additional crossing scenarios will be added for which the details are being developed in the INTERSECTION project.

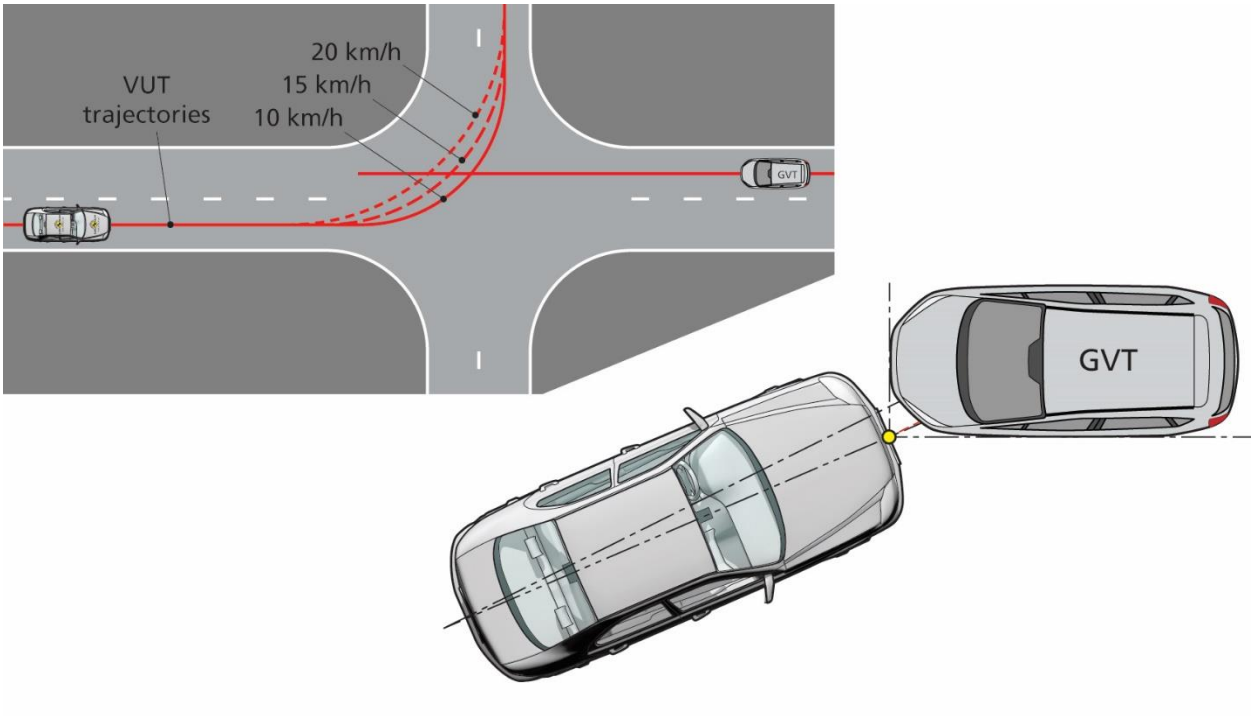


**Figure 2. AEB Car-to-Car turn-across-path scenario, CCFtap**

**AEB Bicyclist**

Two additional AEB Bicyclist scenarios are added to the test suite; Car-to-Bicyclist Farside (CBFA) and Car-to-Bicycle Nearside Obstructed (CBNAO). The challenging part of these scenarios, and the reason for implementation in 2020 instead of 2018, is the higher bicycle speed in the CBFA scenario and short detection time for the CBNAO.

In the CBFA scenario, tested at 10-60km/h, the bicycle speed is 20 km/h, which means that the opening angle of the forward-looking sensor(s) has to be increased to be able to detect the bicyclist in due time.

The obstruction in the CBNOA is blocking the sensors to see the cyclist only just before the impact, which means that the AEB system has very little time to respond to the critical situation. As the obstruction, the Euro NCAP WG decided to use two vehicles as a pragmatic method already used in the AEB child scenario.

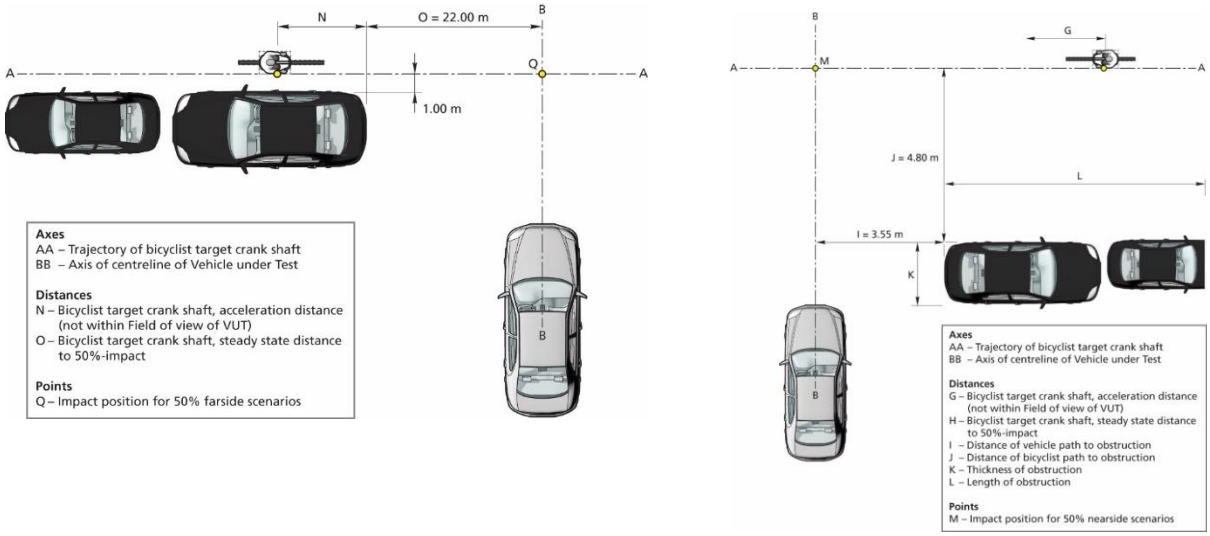


**Figure 3. AEB Car-to-Bicycle Farside (CBFA) and Car-to-Bicycle Nearside Obstructed (CBNAO) scenarios**

### AEB Pedestrian

Rear AEB for cases where a pedestrian is overrun by a vehicle backing up is now also included in the Euro NCAP tests for AEB Pedestrian. Both moving and stationary cases are included where additional rearward sensing hardware is required to be able to detect the pedestrian walking or standing behind the vehicle. The test speeds are very low, 4 and 8 km/h, and the only assessment criteria is full avoidance. To incentivize this technology sufficiently, Euro NCAP awards these tests with two points out of nine points available for AEB Pedestrian.

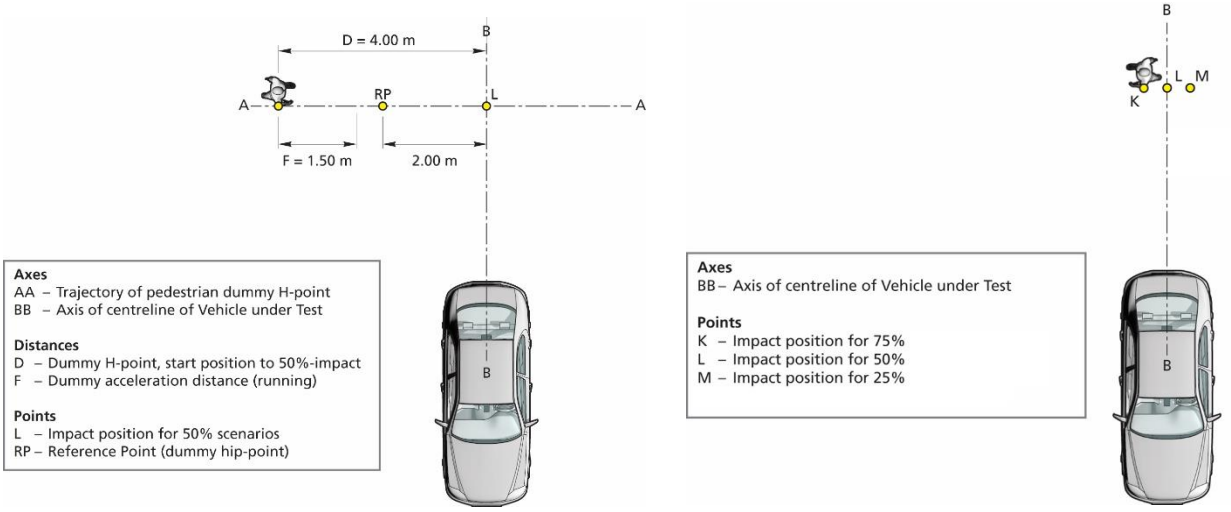


**Figure 4. AEB Car-to-Pedestrian Rearside (CPRA) moving and stationary scenarios**

Another new scenario in the AEB Pedestrian area is the Car-to-Pedestrian Turning scenarios (CPTA). As mainstream technology expected in 2020 is still limited in its field of view, only cases where the pedestrian walks from the opposite direction are included in the first step. Vehicle turns to both left and right at various speeds are included as shown in Figure 4. The exact specifications of the path relative to lane markings is required to facilitate different lane width's that may be present at the test laboratories.

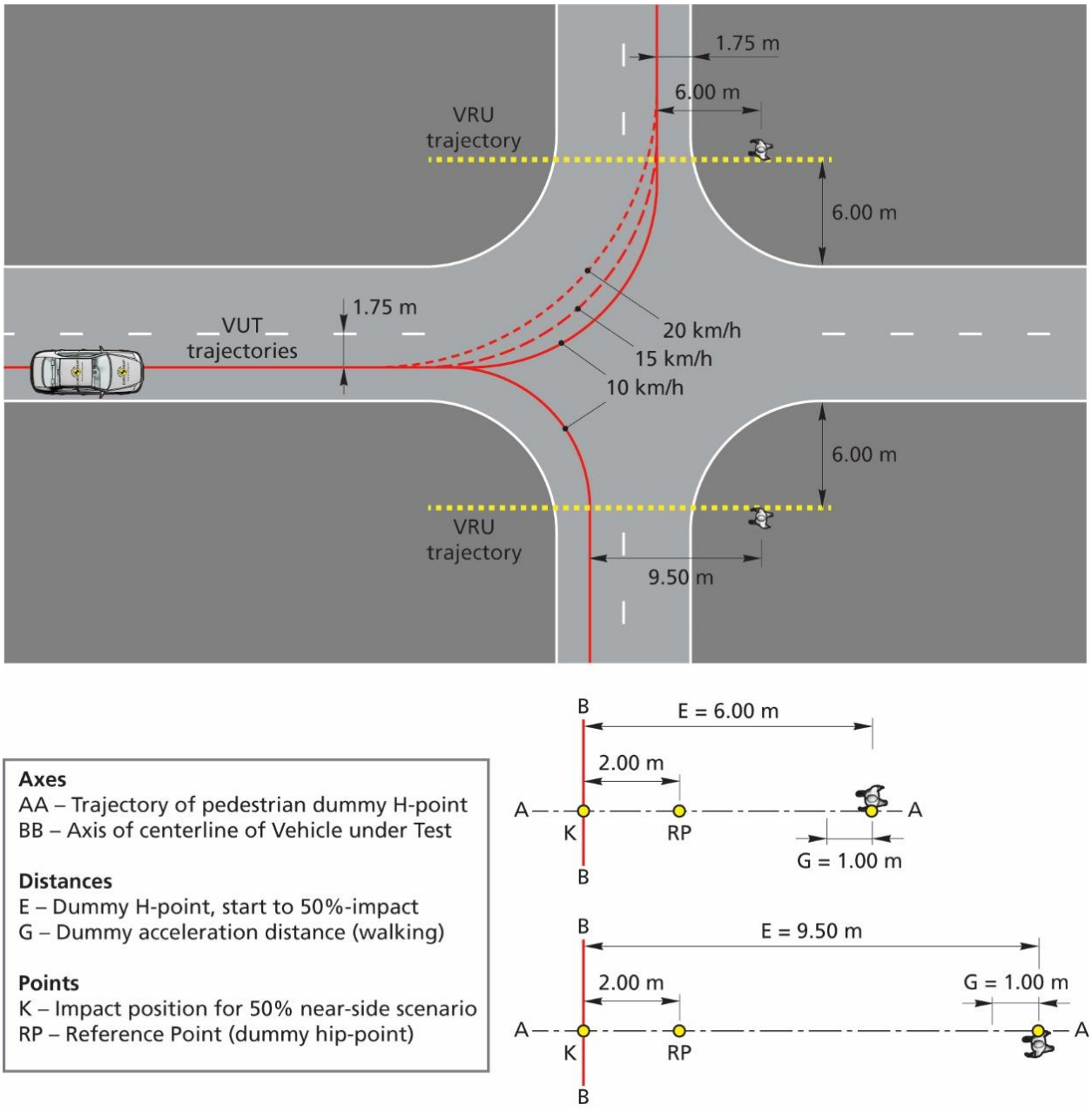


**Figure 5. AEB Car-to-Pedestrian Turning (CPTA) scenarios**

**Emergency Steering Support**

The already included Car-to-Car Rear stationary (CCRs) scenario is one of the cases where Emergency Steering Support is recognized as one of systems that help the driver avoiding the crash when responding to the FCW. As steering is most effective in lower overlap cases where minor lateral displacement is enough to avoid the collision, Euro NCAP only allows ESS in the low overlap cases.

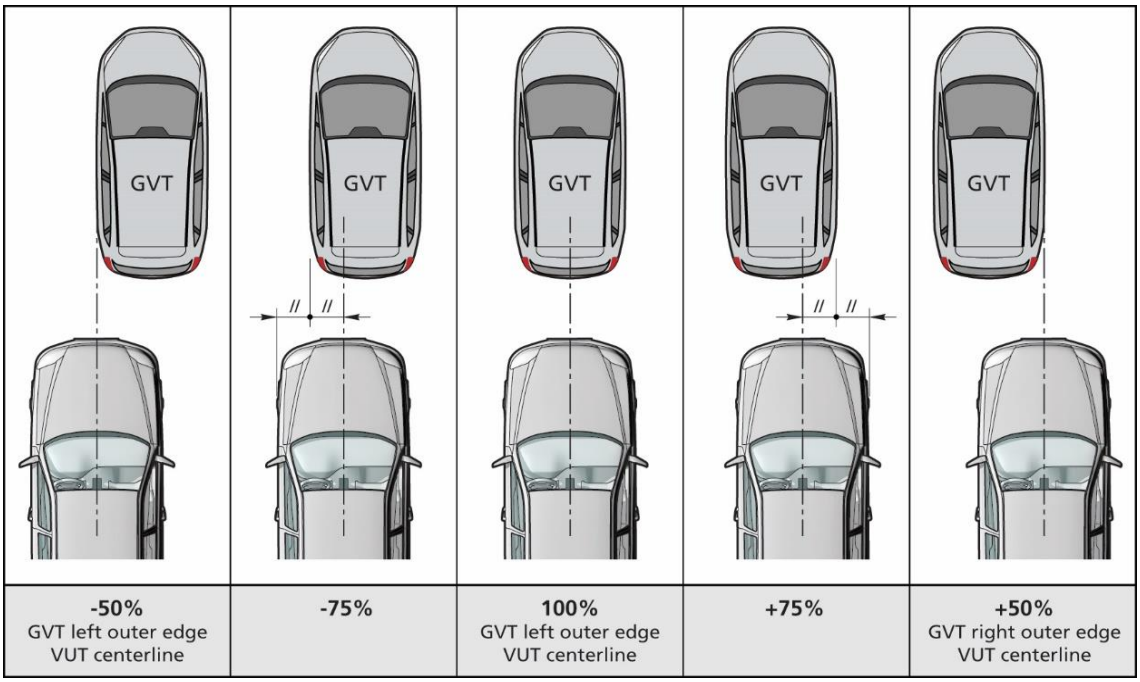


**Figure 6. AEB Car-to-Car Rear stationary scenario where ESS is allowed in the -50% overlap case**

Emergency Steering Support is allowed in both the longitudinal scenarios of Car-to-Pedestrian and Car-to-Bicyclist at small overlap situations. In these specific scenarios, a small lateral movement is the most adequate intervention to avoid the collision.

A specific test procedure has not been developed yet due to lack of experience with these systems and the large variety in logic within the limited amount of systems currently available on the market. At the moment, Euro NCAP will ask the car manufacturer wishing to have their ESS system performance assessed and included, to show the technical details and provide evidence that in cases of late driver steering intervention, the system will still be able to support the driver by optimizing or guiding the steering maneuver.

## DISCUSSION

Test scenarios used for AEB/AES systems are a simplified and standardized representation of accident scenarios to ensure repeatable and reproducible test results. A significant correlation between the test track performance and the performance of the technology in real-life is not guaranteed. Requirements and possible sub optimization need to be constantly reviewed to ensure robust performance that will ensure continuous development of these live saving systems. On the other hand, more complex and more realistic test tools are required to ensure that the test environment are the best possible representation of situations occurring on real roads.

For the longer term, Euro NCAP is working on a more general scenario based approach where as part of the vehicle assessment, the car manufacturer would be asked to provide a performance prediction for all of the (critical) scenarios in a defined database with more complex and more realistic scenarios. To be able to validate the OEM performance, a combination of Vehicle in the Loop tests and simplified tracks would be required.

## CONCLUSION

Euro NCAP puts more emphasis on extended capability and robustness of safety assist systems within its 2020 and 2022 rating schemes. Additional scenarios are added to cover a larger portion of accidents happening on the roads.

With the implementation of a combined AEB/AES assessment within the overall safety rating, Euro NCAP takes a first step towards a scenario-based assessment. This will offer the car manufacturer maximum flexibility to develop their active safety systems. With the upcoming General Safety Regulation, Euro NCAP keeps on pushing the performance of these live-saving systems, well beyond regulatory requirements in the years ahead.

## REFERENCES

[1] Proactive Safety for Pedestrians and Cyclist, FP8-project PROSPECT, http://www.prospect-project.eu/