Understanding Euro NCAP - Setting the Standard for AEB Performance Validation

By Jacob Miller

The pathway to automated feature enablement in series production vehicles begins with ADAS, specifically active systems that support lateral and/or longitudinal control for safety purposes. These safety systems form the basis of L1 automation that rely on sensors and sophisticated algorithms. These systems have been around for close to ten years and are rapidly appearing on production cars because of their safety benefits.

One of these safety features is automatic emergency braking (AEB) for pedestrians and bicyclists, also referred to as vulnerable road users (VRUs). Collisions with pedestrians are one of the leading causes of death among automobile accidents, which is why AEB systems play such a key role in vehicle safety. For safety-critical systems such as AEB, it is vitally important to test such systems and validate the safety for both the driver and VRUs. Euro NCAP has created AEB VRU testing standards that can evaluate the safety and functionality of AEB systems from all different vehicle manufacturers, creating a level playing field and informing consumers on the safety of each vehicle provides.

This report summarizes test conditions, procedures, and scenarios of Euro NCAP's AEB VRU testing. It also discusses the challenges and the outlook of Euro NCAP testing for more advanced active safety systems.

Background of Euro NCAP

Euro NCAP has become a highly reputable source when it comes to safety test results in the automotive industry because of their well-developed safety tests and standardized rating system. These standardized safety tests give automakers and suppliers a specific goal to reach with their safety systems. Since these test results are published for consumers to see, automakers strive for a higher rating in hopes of increasing sales.

The ultimate goal of Euro NCAP is to reliably inform consumers about the safety of the vehicles on the market. With automobile accidents not only resulting in the tragic loss of lives but also millions of dollars in damages, safety in the automotive industry has been an area of utmost importance. Providing consumers with accurate and unbiased safety test results on the vehicle they are buying not only allows them to make more informed decisions, but it also pushes automakers to enhance their vehicles' safety systems.

Each car assessed receives a rating between one and five stars. Stars are awarded not only for good test performances, but also for the availability of safety features. A vehicle that meets minimal legal safety standards would receive zero stars but is not necessarily unsafe to drive – it merely would not include additional safety features.

Euro NCAP tests the safety of systems including adult occupant protection, child occupant protection, pedestrian protection (AEB VRU), and safety assist (driver assistance and crash avoidance technologies). Some vehicles have a dual rating from Euro NCAP; the lower rating is for the base model and the higher rating includes added safety features that come optional with the vehicle. Some examples of 5-star rated models for 2019 include the Tesla Model 3, Volkswagen T-Cross, Mazda 3, Toyota Corolla and RAV4, and the Audi e-tron.

Euro NCAP began exploring the testing of the first AEB systems in 2013 before including the test results in their five-star rating system the following year. The first AEB testing standards only tested crash avoidance between two vehicles until Euro NCAP first introduced their AEB pedestrian testing in 2016. Bicyclist were later added to the testing suite in 2018, transitioning the name to vulnerable road user AEB systems. The following table shows the results of AEB VRU testing for 2019.

Brand/Model	System Name	Results (Out of 12 pts)	Operational From
VW T-Cross	Front Assist	11.6	4 km/h
Mercedes-Benz B-Class	Active Brake Assist	11.6	7 km/h
Tesla Model 3	Collision Avoidance Assist	11.6	8 km/h
Toyota Corolla, RAV4	Pre-Collision System as part of Toyota Safety Sense	11.3	10 km/h
Lexus UX	Pre Crash System as part of Lexus Safety System +	11.3	10 km/h
Renault Clio	Active Emergency Braking System	11.2	7 km/h
Skoda Scala	Front Assist	11.1	10km/h
Mercedes-Benz GLE	Active Brake Assist	11.1	7 km/h
Seat Tarraco	N/A	11.1	n/a
Mercedez Benz G-Class	Active Brake Assist	10.4	10 km/h
Audi e-tron	Audi pre sense	9.7	10 km/h
Mazda 3	Smart Brake Support	8.6	10 km/h
Honda CR-V	Collision Mitigation Brake System	7.8	5 km/h
Range Rover Evoque	Emergency Braking	6	5 km/h

AEB VRU Test Procedures

Targets

One important aspect of AEB VRU testing that must remain consistent between all tests is the pedestrian and bicyclist targets. Euro NCAP targets must be designed to replicate the attributes of real people and be able to work with camera, radar (both 24 and 77 GHz), and LiDAR, creating an equal playing field for whatever sensor configuration a vehicle may come equipped with. The targets are required to be dressed in certain clothes (blue trousers and a black shirt) and must not cause significant damage when impacted by a vehicle. The test scenarios described in [NCAP's documentation] include tests with an adult pedestrian, a child pedestrian, and a bicyclist. Since the test scenarios require the target to be moving laterally or longitudinally with the vehicle, each target must include the proper equipment for movement. Pedestrian targets have a maximum speed of 8 kilometers per hour while bicyclist targets have a maximum speed of 20 kilometers per hour.

Images of Euro NCAP compliant adult, child, and bicyclist targets shown left to right (Source: Euro NCAP AEB document)

Test Conditions

A large section of Euro NCAP's documentation for AEB VRU testing is dedicated to test conditions. These detailed test conditions cover requirements for the test track, the weather and lighting, the surroundings, and vehicle under test (VUT) preparations. Standardizing the test conditions ensures that each test is consistent, even when performed on different days or in different testing locations, so the results can be properly compared.

The test track must be a dry, uniform, solid-paved surface with minimal slope and a minimal peak braking coefficient of 0.9. Surface irregularities are not allowed, as they may cause abnormal sensor behavior. Lane marking must be parallel to the VUT's direction of travel in the area where AEB is intended to be activated.

When testing the AEB VRU systems, the ambient temperature must be between 5°C (41°F) and 40°C (104°F) and there must not be any precipitation. The maximum allowable wind speed is 10 m/s since high winds could disrupt AEB systems. The ambient illumination must be above 2000 lux, and Euro NCAP's documentation provides further stipulations for ambient lighting for night testing. Euro NCAP standards also require measurements of the ambient temperature, track temperature, wind speed and direction, and ambient lighting at the commencement of every test or every 30 minutes.

The area surrounding the testing site must be clear of other vehicles, highway infrastructure, or any other obstructions that may lead to erroneous sensor behavior. Euro NCAP also stipulates the size of the required free area in each direction for each test. The vehicle is not allowed to pass underneath overhead signs, bridges, or other structures during the testing, and there must be nothing in the background that would cause abnormal sensor behavior during the test, such as a highly reflective object.

Euro NCAP also documents specific preparations that must be followed for the VUT. These preparations include configuring AEB to the middle setting, deactivating any deployable VRU protection system, conditioning the tires, checking the wheel alignment and oil levels, filling up the gas tank to at least 90%, and many more. Essentially, these extensive VUT preparations ensure that the vehicle is in proper condition and is in a state most similar to what these vehicles would be like on the road.

Test Procedure & Execution

Prior to testing the AEB VRU systems, certain pre-test conditions must be met. Euro NCAP requires that the testing be done on a new vehicle that was delivered to the testing facility. A maximum of 100 km of driving is allowable for fine tuning the system. Before testing begins, the brakes and the tires are to be broken in by following specific driving patterns, which can be found in the Euro NCAP documentation. Finally, once the vehicle is tuned and broken in, a maximum of ten low-speed AEB tests can be run.

Throughout the execution of tests, Euro NCAP also stipulates specific procedures to be followed. Maximum errors for the VUT speed, VUT lateral deviation, VRU target lateral deviation, yaw velocity, steering wheel velocity, and VRU target speed. If there is a larger error in any of these measurements, the test is considered invalid. When assessing the AEB system, the test concludes when the VUT comes to a stop (or matches the VRU target speed in a longitudinal test), the VUT strikes the VRU target, or the VRU target path is no longer in the VUT's path. NCAP's documentation also describes how to increment the VUT velocity for the next test depending on the success of the previous test. Following each of the test procedures makes certain that each AEB system is tested in an equal and consistent manner.

Test Scenarios

Euro NCAP defines nine scenarios to be tested for AEB VRU systems. They are compiled in the chart below with descriptions of the target configuration for each test scenario.

Test Name	Pedestrian / Bicyclist Target	Longitudinal / Nearside / Farside	Adult / Child Target	Vehicle Width Impact %
Car-to-Pedestrian Farside Adult 50% (CPFA-50)	Pedestrian	Farside	Adult	50
Car-to-Pedestrian Nearside Adult 25% (CPNA-25)	Pedestrian	Nearside	Adult	25
Car-to-Pedestian Nearside Adult 75% (CPNA-75)	Pedestrian	Nearside	Adult	75
Car-to-Pedestrian Nearside Child 50% (CPNC-50)	Pedestrian	Nearside	Child	50
Car-to-Pedestrian Longitudinal Adult 25% (CPLA-25)	Pedestrian	Longitudinal	Adult	25
Car-to-Pedestrian Longitudinal Adult 50% (CPLA-50)	Pedestrian	Longitudinal	Adult	50
Car-to-Bicyclist Nearside Adult 50% (CBNA-50)	Bicyclist	Nearside	Adult	50
Car-to-Bicyclist Longitudinal Adult 25% (CBLA-25)	Bicyclist	Longitudinal	Adult	25
Car-to-Bicyclist Longitudinal Adult 50% (CBLA-50)	Bicyclist	Longitudinal	Adult	50

Conclusion

Providing robust and repeatable testing standards is vital for evaluating the safety of new ADAS features, which is exactly what Euro NCAP accomplishes with their AEB VRU system testing standards. The scope of the testing, however, is limited because of the strict set of conditions and procedures that must be followed for these tests. Because the tests need to be consistent and repeatable, the test conditions often tend towards the ideal situations that may occur for these ADAS systems, leaving it somewhat uncertain how the system might act differently in more variant real-world situations. Unfortunately, there is no way around this dilemma when designing testing standards. Euro NCAP has done well to outline various hypothetical scenarios in which AEB would be used, but the true performance of these systems cannot be fully evaluated without real-world use cases.

In addition to adding new and challenging tests for existing safety systems, Euro NCAP is trying to keep up with the development of ADAS. Euro NCAP began testing Level 2 autonomous features that they call Highway Assist systems in 2018. These tests focus primarily on adaptive cruise control (ACC) and lane centering (LC) features, trying to find test cases that challenge current systems such as approaching a stopped vehicle or slowing down for a vehicle cutting into the lane. As the complexity of these autonomous systems grow, so does the complexity of the tests required to evaluate performance. NCAP does not yet include the results of these tests in their safety ratings, but as they continue to explore how these systems work and the safety benefits of such systems, they will likely begin to be incorporated into a broader vehicle safety rating. It is yet to be seen how entities such as Euro NCAP will test higher level autonomous systems, but this will be an important trend to watch in order to grow public confidence in a crowded industry.

About VSI Labs

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