

IMPLEMENTATION OF EQUITABLE OCCUPANT PROTECTION IN THE EURO NCAP CONSUMER RATING SCHEME

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ABSTRACT

As vehicle safety research progresses, the scope with which injury risks are identified, quantified and addressed widens. While earlier efforts have addressed the most common and straightforward impact scenarios, further improvements in occupant protection now require the incorporation of real-world variations, such as occupant characteristics and system robustness. These developments benefit all road user groups allowing for greater fidelity when evaluating the level of safety offered by a vehicle. Real-world crash data continues to highlight a number of areas that should be addressed to reduce risks posed to certain groups of vehicle occupant. Euro NCAP has adopted test methods aimed at evaluating and promoting safety technology through the use of updated test equipment, assessment criteria and virtual testing techniques.

For assessments in 2026, revised rating, test and assessment protocols were developed with the aim of promoting more robust restraint systems. These revisions included new approaches that complement the existing crash test procedures to evaluate the vehicle's ability to offer equitable protection to occupants of differing age and sex across a broader range of impact severities and occupant statures. In addition to full scale crash test methods, sled and virtual assessment techniques have been combined with revised biomechanical criteria to help improve the safety offered to the elderly population.

The aim of this paper is to present the changes introduced in Euro NCAP's Crash Protection test and assessment procedures for 2026, and to outline future priorities that will shape the 2029 protocols. Euro NCAP will continue to develop methods that encourage advancements in occupant protection and promote safer vehicle design. Further steps are already under development for implementation in the 2029 assessment. This will build upon the aim of equitable protection to develop a rating that promotes more robust safety technology for all vehicle occupants.

INTRODUCTION

In November 2022, Euro NCAP published its roadmap detailing the strategic goals for the period up to 2030 [1]. This vision outlines measures that aim to continue the vast improvements already made in vehicle safety since Euro NCAP published its first test results in 1997. Road crashes remain a leading cause of death for people of all ages, accounting for some 2.7% of all deaths worldwide. This is more than Malaria, TB, HIV and many other diseases. In 2016, road crashes were the leading cause of death for children and young adults 5-29 years of age [2].

Euro NCAP Vision 2030 identified three periods for the implementation of new test and assessment procedures, the first applicable in 2026, the second in 2029 and a third in 2032. It is with the use of updated and improved assessment methods that Euro NCAP will continue its contribution over the upcoming years to the pursuit of Vision Zero.

Improvements in the rating scheme contributing towards addressing the global burden from road deaths were implemented by Euro NCAP in the beginning of 2026 and saw the introduction of significantly updated test procedures. The previous rating scheme, introduced in 2009, consisted of four assessment areas titled Adult Occupant Protection (AOP), Child Occupant Protection (COP), Vulnerable Road User (VRU) Protection and Safety Assist (SA). This combined the test performance in those four assessment areas into a combined star rating, and a similar approach was adopted in 2026. The 2026 rating scheme comprises four stages of injury prevention in a vehicle crash which is inspired by the work of Dr William Haddon, who introduced an epidemiological approach towards injury prevention. Four new assessment areas, or stages, are being evaluated and are termed Safe Driving (SD), Crash Avoidance (CA), Crash Protection (CP) and Post-crash Safety (PC).

In addition to changes in the 2026 rating scheme, the tests within the Crash Protection stage have been expanded to help address real-world variations in road accidents. These include crash scenarios, occupant characteristics such as age and anthropometry, injury assessment criteria, and restraint system robustness. Both low and high severity impact scenarios have been introduced, and greater use is made of the current Anthropometric Test Devices (ATD). Sled and Virtual Testing (VT) techniques have also been introduced to both the frontal and far side occupant assessments to provide a broader evaluation of restraint system performance and to ensure that safety is provided beyond the occupant statures used in regulation.

This paper highlights some of the changes implemented in the Crash Protection test and assessment procedures introduced for 2026 and the motivation for these updates. It also outlines future priorities under consideration for adoption in 2029. Across both development timelines, particular focus is given to implementing equitable occupant protection across different ages, sexes and anthropometries. Updated assessments have also been introduced in the Safe Driving and Crash Avoidance stages to incorporate advanced occupant monitoring and sensing system robustness. Although not covered in this paper, this information can be found in paper number 26-0290 [3].

2026 EURO NCAP RATING SCHEME

The overall rating adopted in 2026 is composed of individual scores achieved in the four stages. The score in each stage is based on the vehicle performance in the multiple tests and assessments within that stage. Each test is allocated a maximum score, and the total score for each stage is the sum of the individual test scores, with a maximum of 100 for each stage. The distribution of rewards in the 2026 rating is detailed in Table 1.

Table 1: Euro NCAP 2026 Rating Scheme

Safe Driving		Crash Avoidance		Crash Protection		Post-Crash	
Occupant Monitoring	30	Frontal Collisions	60	Frontal Impact	40	Rescue Information	40
Driver Engagement	30	Lane Departure Collisions	20	Side Impact	35	Post-Crash Intervention	25
Vehicle Assistance	40	Low Speed Collisions	20	Rear Impact	5	Vehicle Extrication	35
				VRU Impacts	20		
Total	100	Total	100	Total	100	Total	100

Each level of star rating, from one to five, has a minimum number of points associated with each stage in the assessment. The final star rating is based on the score achieved in the lowest performing stage. Additional constraints, known as backstops, have also been implemented to limit the overall star rating under certain circumstances, even if the point scores satisfy the thresholds. In the case of crash protection, backstops are applied to critical body regions such as the head, neck, chest and abdomen, none of which may score zero points. Body regions that score zero points will preclude the award of a fifth star. Further details of this can be found in the Overall Rating Scheme protocol [4].

All full-scale impact testing is conducted under the Crash Protection area of assessment and, in addition to the establishment of the four stages, an entirely new method of score calculation was developed for the individual tests. The individual tests that make up the Crash Protection assessment are detailed in Table 2. In addition, a shifting of a certain number of points among Safe Driving and Crash Avoidance, as well as Crash Avoidance and Crash Protection is allowed due to the fact that good performance in one can compensate for a shortfall in a neighbouring stage.

In Crash Protection, the 2026 rating evaluates the protection offered in each occupant seating position and awards a score accordingly based on the ATD performance recorded in that position be it adult or child. This differs from the previous assessment method that, for adult occupant protection, based the score on the worst performing body region between the driver and passenger. This new principle was necessary to allow for the assessment of different statures on one seating position, but it also gives greater fidelity in the overall assessment as several tests are carried out with different dummies on the same seating position.

Table 2: Crash Protection Rating

Crash Protection	Points
Frontal Impact	40
Offset – 50km/h Mobile Progressive Deformable Barrier Test	20
Full Width – 35km/h Deformable Barrier Test	10
VT & Sled – Validation sled tests and virtual testing	10
Side Impact	35
MDB – 60km/h Advanced European Mobile Deformable Barrier Test	15
Pole – 32km/h Oblique Pole Impact Test	10
Far side – Sled tests and virtual testing	10
Rear Impact	5
Front occupant – Static and dynamic measurements	4
Rear occupant – Static measurements	1
Vulnerable Road User Impact	20
Head impact – Subsystem impactor tests	10
Pelvis & Leg impact – Subsystem impactor tests	10

Predicted Data

In 2013, Euro NCAP adopted a grid approach for the assessment of pedestrian headform to vehicle impacts. This approach utilised predicted performance data given by the OEM, either in the form of HIC values or the colour band, representing good to poor protection, in which the expected results would be. Physical tests are performed to ‘verify’ the accuracy of the OEM prediction. This approach allowed for more detailed mapping of the protection offered by the vehicle front during head impacts. The use of a tolerance on the colour bands gives some allowance of the potential differences between the results expected by the vehicle manufacturer and those obtained in the official Euro NCAP tests.

This approach has been extended to the full-scale tests in 2026, whereby the vehicle manufacturer may provide Euro NCAP with the predicted performance of the ATD parameters in the test. This prediction may be a particular ATD value or the colour band in which the performance is expected to lie. The predicted level of protection offered by the vehicle is then verified by Euro NCAP with the use of the full-scale tests. The difference between the predicted data and that recorded in the official test must be within 25% of the colour band width for each assessment. When a measured ATD parameter performs better or worse than predicted, but within the tolerance, the predicted result is used in the rating. When a measured ATD parameter performs better or worse than predicted and is outside the 25% tolerance, the measured value shall be used in the rating. As with passive Vulnerable Road User (VRU) safety assessment, the provision of predicted data is not mandatory. Therefore, where the OEM provides no predicted data (or only partial data), the vehicle rating is based purely on the measured results obtained in the official tests for *all* areas of the assessment. This step was taken to avoid discussions caused by the scattering of the test and ATD, as well as the need to combine crash data with that of the sled and virtual assessments.

2026 CRASH PROTECTION

Equity in Crash Protection

Over the years, a number of studies have been performed to investigate if the protection offered to vehicle occupants has increased, and how consumer rating programmes reflect the outcomes observed on the road. In general, it is accepted that that vehicle crashworthiness has improved over the last few decades [5]. Although some areas have seen more improvement than others, developments in new and improved technology, such as adaptive restraint systems and centre airbags, are increasing in popularity throughout the vehicle fleet.

Recent real-world crash studies have highlighted some areas where disparity exists between particular areas of the population, for example in terms of age and sex [6], [7], [8] and while all vehicle occupants have benefited from safer vehicles, there remain further areas where improvement is needed [9]. Crash severity is only one aspect affecting the injury outcome of an impact, the broad spectrum of human characteristics also being an influencing factor. With the strategy outlined in the Vision 2030 roadmap, the Working Groups for Frontal and Side impact protection began work on revised tests and assessment procedures that take into account some of these characteristics.

From the first iteration of the Euro NCAP rating scheme in 1997, some consideration was given to occupants of differing stature. The knee impact assessment is expanded from that of the 50th percentile occupants used in the test to cover small females and large males. Although limited in scope, this approach has been built upon over the years and was expanded to other areas of occupant protection. In January 2015, Euro NCAP introduced the Hybrid III 5th percentile ATD in a new full-width rigid barrier test aimed specifically at evaluation of the restraint system in both front and rear seating positions. As new tools and techniques become available, Euro NCAP has continued to expand the scope of the assessments promoting equitable protection for all occupants.

Frontal Impact

To address the different occupant demographics and crash severities encountered in the real world, Euro NCAP's frontal tests were updated and complemented with data from both sled and virtual testing. Vehicle restraint systems are primarily designed to protect the mid-sized male occupant, as this is the only requirement of legislation. Euro NCAP's 2026 assessment sees more evaluations of adult occupants of different statures and ages in different seating positions. Although it is not possible for full-scale crash testing to replicate the full diversity of occupant demographics, impact severities and seating position observed in real-world conditions, this is another step towards evaluating a broader range of these parameters. Details of the 2026 load cases are given in Table 3.

Table 3: Stature & severity matrix

		Low 35km/h	Mid 50km/h	High 56km/h	
95 th Male	Driver			Validation 2	
	Passenger		Validation 1	Robustness 3	
50 th Male	Driver	Robustness 1	MPDB		
			Validation 1		
			HBM		
	Passenger	Robustness 2	FWDB		
5 th Female	Driver	FWDB		Robustness 3	
		Robustness 2			
	Passenger	Robustness 1	MPDB	Validation 2	
	Rear passenger	FWDB			

Key

Full scale test
Sled test
Virtual testing

Particular focus of the assessment is on two areas: small females and low severity impacts. Research by Forman et al. and Östling et al. has shown that small females are at higher risk of lower extremity injury [7] and that a significant proportion of injuries occur in relatively low severity crashes [10]. The risk is further increased when considering elderly occupants. Although elderly occupants are less frequently injured, their risk of injury is approximately twice that of younger occupants. It is also important to remember that a greater proportion of the population is represented by the 50th percentile than by the 5th or 95th percentile occupants. Furthermore, restraint systems must become adaptive to ensure that they offer protection to all sizes and statures, particularly under the more demanding loading conditions encountered with the 95th percentile occupants.

The 50km/h MPDB test remains unchanged in term of test parameters, but the Test device for Human Occupant Restraint (THOR) 50th male driver is now accompanied by a Hybrid III 5th female in the front seat row. Child ATDs, Q6 and Q10, remain passengers in the second seat row. This test incorporates a compatibility assessment as well as a revised ATD assessment. A 35km/h full width deformable barrier test has been introduced and replaces the 50km/h full width rigid wall test now mandatory in regulation. In this low severity test, the driver will be a Hybrid III 5th female and the front seat passenger a THOR 50th male. A Hybrid III 5th female will be a passenger in the second seat row. The introduction of this test aims to build upon the improvements already made in rear restraint performance by creating an incentive for adaptive restraint systems that can protect a range of occupant sizes and offer benefits in lower severity crashes. Owing to the costs associated with full scale vehicle testing, further variations in the matrix (Table 3) have been addressed with the use of physical sled testing and virtual test data.

Virtual testing in frontal impact scenarios has been incorporated into the 2026 Euro NCAP assessment for the first time. Using the same methodology undertaken by the VTC Working Group for the development of a far side impact assessment [11], the group conducted a series of frontal impact sled testing to prove the concept could be adopted. The sled tests provide a basis for validation of simulations models which, in combination with ATD certification procedures and other model controls, allow for the use of virtual models to be included in the assessment. The work undertaken in the development of frontal impact virtual testing procedures was detailed by Klug et al. [12]. A qualification procedure for the HIII virtual models was developed. The qualified HIII models are then used to run simulations in the vehicle sled simulation model where two of them are later compared with the laboratory sled tests to validate that the simulation models are of sufficient quality to be used within the virtual testing procedure. If so, the simulation results of the remaining load cases are considered in the robustness scores.

Two sled tests performed by the OEM contribute to both variation in the matrix as well as validation of the virtual robustness tests. The first sled test, validation 1, uses the established scenario of a 50km/h MPDB impact with a 50th percentile driver. A 95th percentile passenger is also included to provide an assessment for large stature occupants along with validation for virtual robustness test 3. To ensure that any restraint system also protects in the most demanding circumstances, a worst-case scenario was introduced in the form of sled test validation 2 with a 95th percentile male driver and a high severity (56km/h) impact. The 5th percentile passenger is also included to provide validation of for virtual robustness test 1.

Virtual robustness tests 1, 2 and 3, validated where possible by the full-scale tests and sled tests, then offer the final aspects of the test and severity matrix. As is the case for sled tests, the robustness tests evaluate the performance of the restraint systems to encourage protection for a range of occupant sizes in crashes of varying severity.

Finally, Human Body Model (HBM) simulations have been introduced in 2026 as a monitoring evaluation. Although not currently used in the rating, they enhance the coverage of the assessment procedures and act as data collection to ensure that the entire industry is ready for their application as a scoring aspect in the vehicle rating from 2029 onwards. Data will be collected using the mid severity pulse with a 50th percentile driver to enhance model capabilities and enhance understanding of how these tools can be implemented in future ratings. To be eligible for full robustness scores, HBM simulations with qualified HBMs must be submitted. Qualification covers a wide range of Post Mortem Human subject (PMHS) load cases which have to be run and are compared to the PMHS load cases with objective metrics. Even if a model has been already qualified before, comparability load cases have to be run to ensure that the HBM works as intended with the specific solver version and control cards used by the vehicle manufacturer [13].

Injury criteria

In addition to the extension of test procedures adopted for 2026 assessments, the working group reviewed injury criteria and biomechanical limits. Particular attention was given to the thorax as this body region provides the greatest opportunity for evaluating restraint system performance for different statures, and encouragement for adaptive restraint systems. No anthropometric test devices (ATD) are available that measure all the potential risks

of injury to humans or assess protection for different sizes of occupant in different seating positions. To compensate for this, the assessments have typically accounted for other occupant characteristics such as age or stature by using occupant kinematics, interior contact points and particular injury risk curves.

From the first Euro NCAP ratings, Euro NCAP adopted the lower performance limits (LPLs) in frontal and side impacts that were developed for legislation by the European Experimental Vehicles Committee (EEVC). The EEVC limits were set to provide a basic minimum level of protection and only protect in a moderate proportion of accidents. However, the LPLs were not sufficiently demanding to adequately identify best practice in vehicle and restraint design. Therefore, higher performance limits (HPL) were also established to differentiate between vehicles and encourage improvements in occupant protection.

As already mentioned, a greater proportion of vehicle occupants, and in particular elderly occupants, are injured in frequently occurring, low severity crashes. To complement the variation in crash severity and occupant stature adopted for 2026 testing, age-based assessment criteria have also been applied to the different statures and test severities to further broaden the evaluation of restraint performance within the Euro NCAP rating. The thorax assessment is one area where this approach is applied, and the assessment limits are detailed in Table 4. It is acknowledged that this is only the first step to address occupant diversity and age, the group will endeavour to review all available data and continue to identify sound foundations for biomechanically based assessment criteria. Additionally, the sensitivity of certain ATD in low severity impacts also have to be taken into account when defining the assessment limits. More advanced chest assessment criteria are still in focus for 2029 but, before they can be implemented, ATD issues, such as certification, and repeatability and reproducibility, need to be addressed.

Table 4: Thorax assessment

Criterion	Severity	HIII 5 th		HIII 50 th		THOR 50 th		HIII 95 th	
		HPL - LPL	Capping	HPL - LPL	Capping	HPL - LPL	Capping	HPL - LPL	
D _{chest compression}	mm	35km/h	18 - 34 ³	34	20 - 42 ³	42	29 - 54 ³	54	-
		50km/h	18 - 34 ³	34	20 - 42 ³	42	35 - 60 ¹	60	28 - 55 ²
		56km/h	22 - 42 ¹	42	-	-	-	-	28 - 55 ²
V _{viscous criterion}	m/s	0.5 - 1.0	1.0	0.5 - 1.0	1.0	-	-	0.5 - 1.0	
D _{abdomen compression}	mm	-	-	-	-	88	-	-	

Biomechanical limits applicable to LPL only - 45 year old¹, 50 year old², 65 year old³

Taking the thorax compression assessment as an example, Euro NCAP used the Hybrid III (HIII) 50th percentile ATD with injury risk curves detailed by Mertz et al. [14]. The higher and lower performance limits of 22mm and 50mm represented a 5% and 50% risk of injury \geq AIS 3. These limits were used until 2015 where the LPL was reduced to 42mm representing a 25% risk of injury \geq AIS 3. For 2026, the 42mm LPL is used alongside a 20mm HPL for the HIII 50th.

The HIII 5th percentile occupant was first introduced in 2015 assessments as a driver and rear seat passenger in the full-width rigid wall test. The thorax compression HPL of 18mm was established by scaling the 22mm HPL of the HIII 50th. The LPL was reduced in 2023 from 42mm to 34mm to align with that used in UN regulation No. 137, where 34mm gives a 50% risk of AIS3+ injury for a 65 year old. For the 56km/h test, the original HIII 50th percentile limits of 22-42mm were adopted for the HIII 5th percentile.

The chest assessment was the only criterion where an age difference was apparent between 45 year old and 65 year old occupants. Accident data has shown that the elderly are more at risk in low speed impacts compared to younger occupants, so the 35km/h FWDB was considered to address this issue. The starting point was the UN regulation with the LPL of 34mm, when taken into consideration with existing values the decision for the HPL was to continue with the 18mm limit. To maintain current stringency in this area, these compression values were adopted in the MPDB test. At 56km/h, the range of 22mm to 42mm aligns with the injury risk of a 45 year old, which are applied to both Hybrid III 5th and 50th percentile dummies.

The HIII 95th percentile occupant thorax limits are based on scaling of the original risk curves given by Mertz, additional tests showed that the thoracic response has a degree of scattering. This led to the need for less stringent

requirements and instead of using the thoracic injury risk functions for 45YO, wider limits from 28mm to 55mm were adopted.

When the MPDB test procedure adopted the THOR 50th percentile ATD, the Rmax criterion with limits of 35mm to 60mm were adopted. In the absence of reliable injury risk curves, these limits were largely based upon the relative stiffness of the THOR ribcage compared with that of the HIII. There is some uncertainty regarding the injury risk curves that currently exist for the THOR, owing to a different definition of the number of fractured ribs compared to that used for the HIII injury risk curves.

Other criteria such as TIC and PCscore, which are considered more biofidelic chest injury criteria [15], were reviewed by the group but have not been adopted due to persistent variability in the individual thoracic rib performance. An improved methodology in certification, using a wedged impactor, is expected to reduce ATD variation and offer a more reproducible response allowing for the adoption of improved chest injury criteria.

Child occupant protection

In the 2026 rating, child occupant protection is assessed in the frontal MPDB and side AE-MDB impacts. The score is based purely on the dynamic performance recorded by the dummies in the tests and contributes to the score of those individual tests. For example, a total of 20 points (maximum) is awarded to the MPDB test, with 5 points being awarded to each occupant: THOR 50th driver, Hybrid III passenger, Q6 child and Q10 child. The dynamic assessment criteria of the child dummies has remained unchanged from the previous assessment. The Vehicle Based Assessments (VBA) and Child Restraint System (CRS) assessments are still performed in 2026; but have been incorporated into the assessment in the form of a prerequisite score that must be achieved in order to obtain full points in the Crash Protection area. This revised methodology was developed to align with the overall philosophy of the 2026 assessment where a score is generated based on the ATD performance in individual vehicle seating positions.

The VBA evaluates the vehicle's provisions for the safe carriage of children. This includes the provision of i-Size seating positions or other vehicle attachment points, the integrity of ISOFIX anchorages and the ability to install different ISO fixtures (R3 and B2). The CRS installation evaluates how well the vehicle accommodates a variety of child restraints. The VBA and CRS assessments are then combined, with a minimum score required to qualify for full points in the overall Crash Protection score. The prerequisite number of points required in the vehicle provisions assessment is 7.0 points in 2026 and 2027, rising to 8.0 points from 1st January 2028 onwards. This offers a soft landing for the first two years of implementation, while the increased requirement in later years aims to ensure that child safety provisions are not reduced.

Where the prerequisite score is *not* met, the Crash Protection score will be reduced by the difference between the prerequisite limit (e.g. 7 points in 2026), and the number of points scored in the Vehicle Provisions assessment. For example:

- a) Scoring 6.5 points in the Vehicle Provisions assessment will mean that the Crash Protection score will be reduced by 0.5 points from a total of 100.
- b) Scoring 6.0 points in the Vehicle Provisions assessment will mean that the Crash Protection score will be reduced by 1.0 points.

In addition to a revised child protection assessment, the Euro NCAP Child Occupant Protection Working Group focused on updates needed in both ATD hardware and assessment criteria. A compression based assessment for the thorax has been under consideration since 2014, and with the adoption of the Q6 and Q10 ATDs in 2016, these ATDs have the opportunity to replace the criterion based on thorax resultant acceleration.

The Q6 chest deflection limits (30-42mm) were implemented in 2018 as a pragmatic combination of the various efforts undertaken by the European Enhanced Vehicle-safety Committee (EEVC) [16]. It is important to note that in adults, chest deflection strongly correlates with the risk of rib fracture. However, children, particularly pre-pubescent, rarely sustain rib fractures because their ribcage is highly compliant; the cartilage has not yet calcified, making it much more flexible. Therefore, a more cautious approach should be taken when using chest deflection limits for children that were scaled down from adult values as the injury mechanism (rib fracture) is not equivalent for them. The lower performance limit (LPL) of 42mm was adopted based on the scaled adult values from UNECE Regulation No. 94. The higher performance limit (HPL) of 30mm was based on a later EEVC WG12 report reviewing the various methods considered such as the certainty method and logistic regression for AIS3+ injury risk [17].

Application of thoracic compression limits for the Q10 were delayed for 2026 assessment as biomechanical data upon which to base assessment criteria was limited. The EEVC Q10 report detailed Q10 injury assessment

reference values (IARV) that were based on injury risk curves developed using crash reconstruction and scaling [18]. However, different IARV were created that were either based on scaling down from Hybrid III injury risk curves (28-56mm) or scaling up from Q3 (23-37mm). A LPL of 56mm was adopted with no HPL, and with further experience being gained in the use of the Q10 a sliding scale assessment was considered for the future. This led to a project being undertaken by ATD manufacturers to improve the repeatability and reproducibility of the Q10 chest deflection response.

Four areas of the Q10 were highlighted as having a major influence on the chest compression response: the shoulder liner, clavicle, lumbar spine and abdominal foam. Improvements were made to better control the production of these components, and certification tests were included which led to a more reproducible response. This work was reported by Putzner et al. [19]. Euro NCAP requires the use of these upgraded components and will continue to monitor chest responses so that an improved assessment of chest injury risk can be adopted in future.

Side Impact Protection

The side impact assessment has undergone refinements to the test and assessment procedures for 2026 rather than major changes as seen in frontal impact assessments. The AE-MDB and oblique pole impact tests have both been included in the assessment since 2015 utilising the WorldSID ATD. The last major change to full-scale test procedures was an increase in the AE-MDB test speed from 50 to 60km/h in 2020. The far side occupant protection assessment was also introduced in the rating for assessments in 2020, the development of this procedure reported by Ellway et al. [20]. Until then, side impact protection had always focussed on impacts to the driver's side of the vehicle, and this was a first step towards expanding the scope of side impact assessments.

Far Side Protection

The far side occupant protection assessment was based on the performance of two sled tests, one being an AE-MDB pulse the other an oblique pole impact pulse, both with a WorldSID ATD driver. During the development of this procedure, it was thought that the WorldSID would be capable of offering a reliable measurement of injury risk to the thorax in this impact scenario. However, data gathered since then suggests that this is not the case, as the ribs are very sensitive to the location and direction of loading when the occupant is leaning over into the adjacent seating position, as is the case in far side impacts. Subsequently, the Virtual Testing Crashworthiness Working Group (VTC) developed a virtual based method for the evaluation of far side occupant protection robustness and an assessment was implemented in 2026. The development work formed the basis of a VTC protocol which was summarised and reported by Klug et al. [11]. This procedure combined the use of physical sled testing and virtual simulations in the far side occupant rating.

To further increase confidence in the simulation results, the procedure was changed in 2026 to randomly select the physical tests from the catalogue of submitted simulation results. To ensure fair conditions among different car manufacturers, the scoring is then based on the outcome of the simulations (not the physical tests). Furthermore, as it was identified over the years, that the main factor in the assessment are the head excursions, the scoring is limited to this metric and the other assessment criteria are used as capping limits only.

WorldSID ATD

In the late 1990s, the development of the WorldSID crash test ATD was initiated by the ISO/TC22/SC12/WG5 working group on ATDs. Over 45 organisations worldwide contributed with expertise and resources to create a globally accepted and improved biofidelic side impact ATD. The design was finalised in 2004, and WorldSID achieved a biofidelity rating of 7.6 on the ISO/TR 9790 scale (classified as 'good'), significantly outperforming earlier dummies like US-SID and EuroSID, which scored between 2.3 and 4.7 on (classified as poor and marginal respectively) [21]. WorldSID was formally incorporated into the UN ECE regulatory framework in 2015, under Regulation No. 135 for Pole Side Impact testing. That same year, it was adopted by Euro NCAP in its near-side side impact protocol, replacing ES-II.

As experience with the WorldSID has grown, poor repeatability has become evident in a very small number of cases, primarily due to its high sensitivity to arm position relative to rib 1. When the arm aligns with and subsequently loads rib 1, deflections increase significantly, whereas positioning the arm just above rib 1 may result in much lower deflections. Even minor changes in arm position can raise rib 1 deflection from approximately 20 mm to 40 mm, corresponding to an estimated thoracic injury risk increase from 0% to 50%. This variability compromises test repeatability and has influenced side airbag design strategies. In response, manufacturers have adopted measures to elevate the WorldSID's arm above rib 1 to reduce variability associated with direct loading on that specific rib.

Discussions regarding the rib 1 to arm interaction have taken place within the ISO-led WorldSID task group, during 2024. No consensus has been reached on the root cause. Multiple factors may contribute to the observed issue. These include the stiffness of the arm, the geometry of the ribs (which are wider than human thoracic ribs at that level), and the design of the shoulder and clavicle. Currently, no modifications are planned, partly due to the lack of supporting biofidelity data, but also because of a shared concern within the group that WorldSID's design is a highly interdependent system that could become destabilised if some parts are altered. It is acknowledged that any ATD thorax is not able to replicate the complex force-displacement characteristics of human ribs [22]. Studies have shown the variable responses in human ribs when subjected to localised and concentrated loading, which are characteristics that cannot be incorporated into ATD.

Due to the variable behaviour observed with rib 1 loading, Euro NCAP may, under certain conditions, permit an alternative assessment for rib 1 in the official test. This alternative assessment will apply only to the lower performance and capping limits for rib 1 rather than the sliding scale. The assessment of ribs 2 & 3 will remain unchanged and use the sliding scale.

The OEM must provide information in advance of testing informing Euro NCAP that during the development of the vehicle issues with arm to rib 1 loading have been observed, and this may also be the case in the official test. It must be demonstrated that the loading is purely from arm to rib 1 loading and not from any other sources such as the seat, door, or intruding structures. Furthermore, the alternative assessment will not be permitted if either the shoulder load modifier is applied or the side airbag deploys incorrectly. With the preconditions met, two key aspects must be addressed by supporting data from the vehicle manufacturer.

1. The vehicle manufacturer must provide a comparison of the WorldSID thorax loading both with and without rib 1 loading. This is to be done with the use of correlated virtual models.
2. The vehicle manufacturer must provide HBM data demonstrating that variations in arm position do not lead to a risk of increased thoracic loading.

Euro NCAP offers this alternative assessment approach to address the issues observed with WorldSID, and to allow restraint system development to focus on occupant safety rather than compensating for limitations or artifacts in the crash test ATD design.

Rollover

The rollover crash scenario was included in the Roadmap Vision 2030 and subsequently adopted in the Side Impact assessment for 2026. This scenario is less relevant in the European crash statistics compared to other global regions such as the United States of America. However, studies suggest that although rollover makes up only a small percentage (less than 10%) of all vehicle accidents with severe injuries, rollover contributes approximately 25% of all serious injuries to vehicle occupants [23]. The large majority of rollover crashes in Europe, around 77%, are single-vehicle events [24]. The increasing trend towards heavier, tall/SUV style vehicles (with high centre of gravity) is already prevalent in Europe, where they constitute approximately half of new registered vehicles. Therefore, it was decided to develop a simple assessment for encouraging rollover countermeasures as the principle architecture of the vehicle is already prepared for a roll over scenario. It is often the case that only a lack of rollover sensing prevents a vehicle from providing some protection in this crash scenario. With such sensing, the risks of partial ejection and injury can be mitigated by longer inflation times of curtain airbags.

The Side Impact assessment within the 2026 Crash Protection stage includes the rollover scenario as part of the head protection device (HPD) assessment. An additional static assessment of head side protection systems, combined with manufacturer data for sensing the load case and triggering the countermeasure, forms part of the inspection performed after the side impact crash tests. Analogous and equivalent to the coverage scoring, it is included as a penalty point in the overall assessment if the timing and 'stiff and stable' requirements are not met. The manufacturer has the opportunity to address concerns that may arise during the evaluation by providing 'long-duration' curtain airbag pressure data as described in the C-NCAP 2024 protocol or the existing ejection mitigation qualification (according to FMVSS226).

The introduction of the rollover modifier as a supplementary assessment of the head airbag coverage area does not require the development of a fundamental new curtain airbag (CAB) technology, since CAB qualification for long-term pressure retention according to the 2024 C-NCAP protocol or the FMVSS226 (2011) standard is possible using current countermeasures. However, for the European market and therefore Euro NCAP, it is expected that many unsealed so-called 'First Impact CABs' will be replaced by sealed CABs. Vehicle manufacturers already using this type of CAB to protect against a second impact only need to expand their sensor technology to include this rollover load case to ensure deployment in the event of a rollover. This should be the case whether it be a single or multiple vehicle impact.

Rear Impact

Advancements in rear impact protection, specifically whiplash, have been arrested by many factors, most notably a poor understanding of the injuries themselves and the mechanisms by which they occur. The evaluation of rear impacts began in 2008 with a static geometric assessment and dynamic sled testing. Seat design criteria were established to promote best practice and ensure stability of the seat structure during loading.

In 2020, the Euro NCAP whiplash working group reviewed and updated the assessment protocol, which saw changes to both the static and dynamic assessments. The static measurement for head restraint geometry was modified to adopt the ‘effective’ head restraint height and backset detailed in Global Technical Regulation No. 7. The dynamic sled tests were reduced to a medium (Δv 16km/h) and high (Δv 24km/h) severity pulse with a reduced number of assessment criteria. An additional work item for the group was to address the deficiencies in the geometric assessment for smaller occupants.

The geometric assessment evaluates the head restraint height and backset in mid/mid and lowest, or ‘worst case’, positions. The parameters were set to ensure that in the mid position, protection is offered to some of the tallest occupants, i.e. statures taller than 50th percentile. However, this assessment overlooked the shortest occupants. To expedite an improved assessment for shorter occupants, a requirement was included from 2026 to ensure that there is sufficient structure within the head restraint that supports the head of both tall and short occupants.

Further efforts to address equity in rear impact crash scenarios are ongoing and the target for implementation in Euro NCAP assessments is 2029; details of these efforts are provided later in this paper.

Vulnerable Road Users

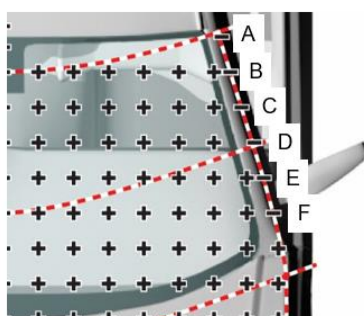
Many updates have been made to the passive VRU protection assessment since the first publication of Euro NCAP results in 1997. Both test and assessment procedures have changed considerably since then, contributing to improvements in protection offered to pedestrians and pedal cyclists as the most vulnerable of external road user groups. Examples include the grid approach which more accurately maps the performance at specific locations on the vehicle; modifications to the test with the upper legform impactor and the consideration of untested areas [25]; and updated impactors and the addition of virtual test methods [26] [27]. The modified test and assessment protocols aimed to harmonise with legal requirements (where possible), an objectification of test procedures and the improvement of biofidelity and injury assessment ability.

The most recent updates to the Euro NCAP VRU procedures saw the headform impactor assessment zone extended to cover car to cyclist impacts [28], and the adoption of the aPLI impactor and associated assessment criteria. However, there remain areas on the vehicle front that continue to present high risk of injury to VRUs as identified by Fredriksson et al. [29]. These are typically the A-pillar, roof and other supporting windscreen structures, and although they are included in the Euro NCAP grid, further incentives are required to encourage protection in those specific areas.

An updated grid assessment has been adopted to offer higher rewards to A-pillar areas. The assessment principle awards 1 point to all headform impact locations, but additional points are awarded to A-pillar locations that have some specific countermeasures to offer additional protection. A-pillar locations with countermeasures will benefit from further rewards depending upon the efficacy of protection offered at different impact speeds. The highest impact speed where a predefined performance is offered will be rewarded as detailed below in Table 5.

- 20km/h, HIC15 < 1000 1.00 bonus point per grid point
- 30km/h, HIC15 < 1700 2.00 bonus points per grid point
- 40km/h, HIC15 < 1700 3.00 bonus points per grid point

Table 5: A-pillar assessment



Example	20 km/h	30 km/h	40 km/h	Score
A	HIC < 1000	HIC > 1700		1.00
B		HIC < 1700	HIC > 1700	2.00
C			HIC < 1700	3.00
D			HIC > 1700	0.00
E			HIC > 1700	0.00
F			HIC > 1700	0.00
Total				6.00

Euro NCAP does not typically test A-pillars at 40km/h due to the risk of damage to the impactor and instrumentation, but a small series of headform to A-pillar impactor tests were performed at 20 and 30km/h to prove the concept of low speed testing was feasible. It should be noted that the tests were performed to official Euro NCAP test vehicles that had no measures for A-pillar protection. The results indicated that with design and engineering effort, protection can be built into these injurious impact locations. High velocity rebounds and glancing blows were not encountered in any of the tests, and with measures in place regarding free flight travel of the impactor and ballistic compensation, correct targeting could be achieved.

Deployable pedestrian protection systems offer one way of mitigating injuries from head impacts to A-pillars and similar structures, and Euro NCAP has evaluated 111 vehicles with such systems. These have taken the form of movable bonnets and airbags which offer protection to structures around windscreen periphery such as A-Pillars, cowl etc in addition to the bonnet top. All of these rely on contact with the VRU to trigger deployment of the system. But as technology has developed, the possibility exists for deployable systems to be triggered before contact with the VRU. This can be done with the aid of Advanced Driver Assistance Systems (ADAS) that detect the VRU before impact and consider the subsequent need for deployment.

Euro NCAP's assessments in 2011 saw the introduction into the Pedestrian Testing Protocol (v5.2) of a procedure for assessing vehicles equipped with deployable systems. This applied to contact systems and was based on the principle that the system would deploy in the event of an impact with the 'hardest to detect' (HTD) pedestrian. When considering procedures for non-contact based or pre-trigger systems, Euro NCAP requires a common level of stringency in the sensing robustness whether they are contact or pre-crash triggered systems.

The definition of the HTD VRU is therefore completely different for contact and ADAS trigger systems. The Pedestrian Detection Impactor 2 (PDI-2) was developed specifically for contact systems to be representative of different pedestrian statures, including a six year old child, and load the vehicle in humanlike manner. Conversely, the six year old child pedestrian target used in the assessment of active safety systems, such as pedestrian autonomous emergency braking, was not intended to be the hardest to detect VRU. It was developed to be 'representative' of a child pedestrian when viewed by camera and radar systems, as defined by ISO 19206-2. Furthermore, the Euro NCAP AEB pedestrian scenarios do not offer sufficient reassurance that an ADAS triggered bonnet would deploy demanding in real-world scenarios.

Sensing is the critical factor for ADAS triggers. To maintain a common level of stringency between contact and pre-crash systems, Euro NCAP aims to ensure that the pre-crash systems robustly detect 'all' pedestrians in even the most challenging scenarios. For example, a child running into the road from behind a parked vehicle. Euro NCAP will continue to develop the assessment procedures for ADAS-triggered deployable systems and updates are planned for implementation in 2029.

2029 CRASH PROTECTION

New Anthropometric Test Devices

Euro NCAP has begun considering the use of the THOR 5th and EvaRID ATD in 2029 to enhance the assessments for females occupants. There are many factors that must be considered with the adoption of a new test tool particularly tools as complex as the THOR ATD. These include, but are not limited to, biofidelity, durability, repeatability and reproducibility, finalised design specifications, certification and injury risk functions. For a consumer information programme, cost and subsequent benefits in rating and assessment are important considerations.

The National Highway Traffic Safety Administration (NHTSA) has published a package of updated information on the THOR 5th ATD which includes the drawing package, qualification manual and an evaluation of its repeatability and reproducibility [31]. As part of the evaluation of the THOR 5th female ATD, a series of MPDB, FWDB and sled tests have been performed by the FIWG, this will form the basis behind the decision of whether or not to adopt a new ATD.

From 2007 the Bio RID-II 50th percentile was the only ATD available for assessing the rear-impact performance of passenger car seats in a dynamic rear-impact sled test. So far, vehicle seats have shown a continuous improvement in test performance, but real-world data indicates a lack of protection for females [30]. The first step was the introduction of static measures to ensure the head restraint offers support to small females. This will be taken further in the 2029 assessment and the use of a female rear-impact dummy (EvaRID) will be discussed in the working group.

EvaRID is an ATD developed under the European ADSEAT project to represent a 50th percentile female in rear-impact crashes [32]. It was created by scaling and adapting the BioRID-II male ATD using female anthropometric data and validated against volunteer rear-impact tests. The initial development focused on a virtual finite element model and in 2025 [33], the first physical EvaRID prototypes were produced. Euro NCAP testing and evaluations are planned in 2026 and the experience of other organisations will form part of the evaluation. C-NCAP plans to introduce EvaRID for monitoring in 2027 on rear seats, but Euro NCAP will initially aim for implementation in front row seats in 2029.

Front impact protection

The Frontal Impact Working Group will review both the Offset (MPDB) and Full width (FWDB) test procedures with the purpose of continuing improvements in both self and partner protection in frontal crashes. The specification of the MPDB trolley and deformable barrier face will be reviewed in light of the vehicle fleet and road casualties, and also consider possibilities for harmonisation with existing procedures and barrier face specifications.

Vehicle fleet studies are being conducted by Euro NCAP working groups to provide guidance on the relevance of test procedures, specifically the impact partners in the MPDB and AE-MDB tests. Both tests use a trolley mass of 1400kg and barrier faces that were developed more than 15 years ago. Considering how test procedures should be updated to more accurately reflect the situation in the real world, it is important to identify exactly what characteristics should be replicated to ensure the procedures are relevant. For example, in frontal impacts scenarios the MPDB was adopted to promote good structural interaction between impact partners, structural homogeneity and controlled deceleration of both occupant compartments [34]. The AE-MDB face was developed to better represent the accident situation and front-end stiffness seen in the passenger car fleet compared to that of the legislative barrier face [35]. Therefore, factors such as the vehicle fleet mass of the present time, the potential for further mass increases in the future and what aspects should be promoted in vehicle designs (e.g. compatibility) must all be considered in updated assessment procedures.

Studies have detailed the increase in vehicle fleet mass over the last decade or more [36], and this is supported by Euro NCAP’s own data which indicates that the average unladen kerb weight (UKW) of vehicles tested from 2012-2018 - 1453kg - has increased to 1803kg in the period 2019-2025. Figure 1 details a histogram of UKW for each vehicle category assessed by Euro NCAP since 2009. It must be remembered that this data is from ‘new’ vehicles to market and does not account for sales, market penetration or weighting method in any way. Furthermore, vehicle category must also be considered as only a guide for vehicle rather than a specific definition for the type, size and mass of vehicle. Multiple factors contribute to this increase including electrification of powertrains, increased consumer demand for larger vehicles and the fitment of new features.

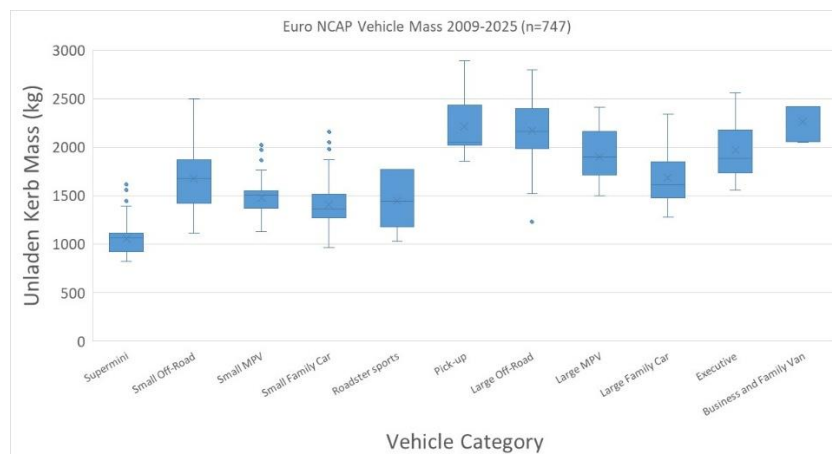


Figure 1: Unladen kerb by vehicle category of Euro NCAP test vehicles from 2009-2025

However, kerb weight is not the only factor that should be considered when reviewing the vehicle fleet. Vehicle age is also important given that the mass is changing with time. The average age of the passenger car fleet in EU and UK is approximately 12 and 10 years old respectively, [37] & [38]. Therefore, as vehicle mass increases in combination with the ageing fleet, it becomes very difficult to make a prediction of ‘average’ fleet mass in the context of future test procedures. However, the focus will be on ensuring that the test severity and subsequent injury assessments are relevant to the real-world crash situation. The goal is to balance the demands of

compatibility and self-protection. The heavier the barrier gets, the more self-protection is required. Maintaining the current barrier weight, or with a slight increase, partner protection can continue to be improved. It should be remembered that the actual vehicle fleet up to 2029 will include new vehicle classes such as M0 or small electric cars. Having taken all of these factors into account, the FIWG decided that trolley mass of 1550kg shall be used in 2029 as it is representative of the ‘average’ vehicle mass at this current time.

Further steps are being taken to address the diverse driving population by investigating the feasibility of adopting the THOR 5th percentile ATD and developing assessments that can evaluate those occupants at the highest risk on the road, such as the elderly. All criteria and injury thresholds, in particular the thorax and lower legs will be fully reviewed.

To enhance the evaluation of restraint system robustness, Human Body Models will be considered to cover different genders, statures, seating variations, etc. As mentioned previously, HBM qualification is essential and must be carefully considered, but it is acknowledged that these tools will offer an alternative assessment to enable enhanced injury prediction and consider sizes for which no ATD exists, such as the 50th percentile female which is planned for 2029. Based on the monitoring data collected, the qualification procedures as well as the HBM protocols will be further enhanced to enable the use of HBMs for injury prediction and at the same time also include additional HBM statures. The knee mapping assessment is one area that could be complemented and possibly replaced by virtual test methods in a similar manner to that of the far side occupant assessment.

Side Impact Protection

Future work being undertaken in the Side Impact Working Group (SIWG) will focus on improving the side impact assessment(s) to become more reflective of real-world conditions. Recent data has shown that 28% to 38% of serious injuries and fatalities are a result of side impact collisions, ERSO [39]. Nevertheless, very high scores have been observed in both Euro NCAP side barrier and oblique pole impacts, with points lost only in chest body region in most cases. Of greater concern is that, in a small number of cases, Euro NCAP still sees head to pole contact as a results of side curtain airbag bottoming out.

By studying real-world crash data, the SIWG will identify potential areas to increase test severity such as trolley mass, speed and barrier face aggressivity. The AE-MDB face has limited capacity for increased energy, especially with the continued increase in fleet mass, but it is thought that some speed increase may be possible. Alternative barrier faces will be considered such as those in use by the Insurance Institute for Highway Safety (IIHS) and China NCAP (C-NCAP) which may allow for some harmonisation of procedures with other global regions.

An enhanced robustness assessment will be built into the full-scale tests alongside virtual assessments to promote more reliable performance and to address a diverse occupant population. As well as enhanced assessment criteria such as DAMAGE, variation in test parameters will be incorporated to ensure that restraint systems are developed to protect occupants with differing anthropometries rather than a single body type. Items under consideration include random selection of impact side, variation in impact location and variation in seat adjustments.

Finally, some vehicle manufacturers have already developed innovative technologies that can drive improvements in real-world side impact protection. Such systems include pre-crash sensing that allows for triggering of restraints and lowering of ride height before an impact occurs. These technologies will be considered and incorporated into the side impact rating methodology.

DAMAGE

Euro NCAP has been using the offset MPDB test protocol since 2020. This test procedure included an updated frontal impact test configuration with the THOR 50th percentile ATD in the driver’s seat. The use of this ATD meant that additional injury measures to those offered by the Hybrid III could be investigated. The Euro NCAP Brain Injury Working Group investigated the application of a criterion that could evaluate the risk of sustaining a mild traumatic brain injury (mTBI, AIS2 moderate concussion) in addition to the longstanding use of HIC. The outcomes of the Euro NCAP working groups were reported at the 27th ESV conference, Yokohama 2023 [40].

Calculation of the Diffuse Axonal Multi-Axis General Evaluation (DAMAGE) criterion [41] was chosen by Euro NCAP as a first step in the evaluation of brain injury risk in full scale vehicle testing and implemented for all assessments in 2023 and beyond. The DAMAGE criterion forms part of the driver’s head assessment as a modifier applied after the assessment of HIC and 3ms exceedence. The modifier limits were selected to address the worst performing vehicles based on a qualitative assessment of head kinematics.

Building upon the work undertaken for frontal impacts, Euro NCAP has begun investigating the further application of DAMAGE in lateral impacts given its omnidirectional capabilities. Data collection from side barrier

and oblique pole impacts to the nearside occupant as well as far side occupants have been included in the most recent work of the Brain Injury group, see Figure 2 and Figure 3. The plots show a simple comparison of DAMAGE values obtained in recent official Euro NCAP tests, with the modifier limits highlighted as orange and red lines denoting values of 0.42 and 0.47 respectively. The quantitative limits established for the MPDB frontal impact have barely been exceeded over the last six years, but in side impacts values above 0.47 were recorded in two AE-MDB and 14 pole tests.

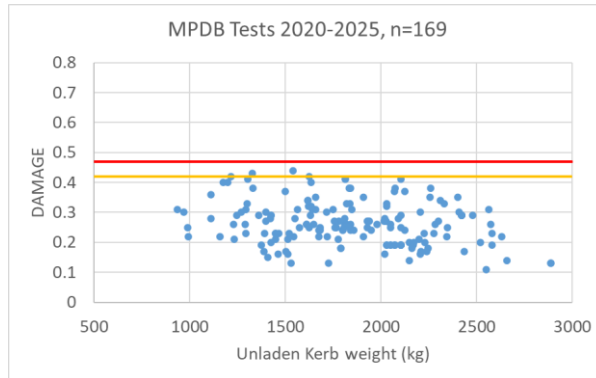


Figure 2: Frontal impacts

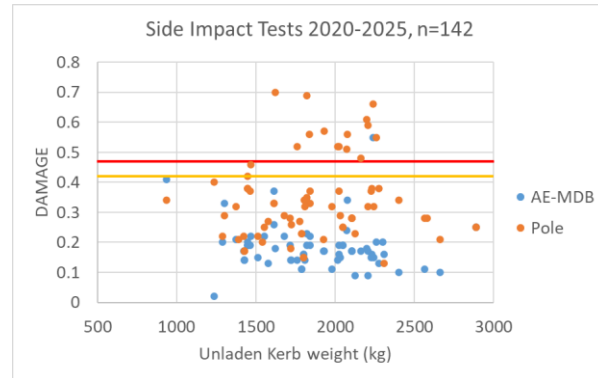


Figure 3: Near-side impacts

It is essential for the application of DAMAGE in lateral impacts to ensure that the head kinematics of the WorldSID are sufficiently humanlike to provide a reliable evaluation of brain injury risk. Work was undertaken by Roka et al. comparing the head kinematics and subsequent DAMAGE response between ATD model and HBM simulations in near-side impacts [42]. That study concluded that while WorldSID and HBM models demonstrated different kinematic responses in near-side impacts, with the WorldSID head primarily rotating around the T1 vertebra and HBMs exhibiting more lateral translation before rotation, the DAMAGE metric showed consistent response characteristics across all surrogate types. Their research revealed that the rebound phase could generate DAMAGE values equal to or exceeding initial impact values, highlighting the importance of evaluating the entire impact event. However, each HBM used in the study should be carefully evaluated from the validation standpoint. Further analysis demonstrated direction-dependent performance of DAMAGE, with stronger correlation to Maximum Principal Strain in frontal impacts ($R^2 = 0.84$) compared to near-side impacts ($R^2 = 0.53$), suggesting the need for direction-specific certification. Additionally, variations in rotational stiffness between surrogates, particularly around the Z-axis, significantly influenced DAMAGE calculations, with the WorldSID-50M exhibiting greater Z-axis stiffness than most HBMs. The aforementioned limitations notwithstanding, the study demonstrated that the ATD and HBM were comparable in terms of kinematics and rotational acceleration in other body regions. Further work is still to be conducted on this topic.

The research by Roka et al. [42] also identified critical aspects regarding occupant surrogate selection for brain injury assessment. Analysis of the curves using ARCGen methodology quantified the consistency of DAMAGE responses across different surrogate models, revealing a mean standard deviation of only 6.5% relative to the characteristic average peak value of 0.425. This relatively low variation indicates that despite fundamental differences in head-neck kinematics between the WorldSID and HBMs, the DAMAGE metric demonstrated consistent response patterns across surrogate types. However, the observed discrepancies in head-neck kinematics between the WorldSID and HBMs raised important questions about the surrogate-specific biomechanical characteristics when interpreting brain injury metrics in lateral impacts. These findings align with the Euro NCAP data showing significantly higher DAMAGE values in side impacts compared to frontal impacts, and highlight why Z-axis rotational response is particularly critical for accurate brain injury risk assessment.

With the promising results from the virtual studies, attention has turned to the WorldSID and particularly the neck response. In many cases, the principal component of the peak DAMAGE value was due to the angular acceleration about the vertical (Z) axis, or neck torsion.

Although, the WorldSID achieved a good biofidelity rating of 7.6 on the ISO/TR 9790 scale [21], it is noted that at component level ISO 15830 indicates the neck twist (Mz) biofidelity as poor [43]. Other studies performed by Rhule et al. indicate an internal neck biofidelity of 0.8 [44], which has response corridors based on different tests to those used in ISO. The full-body lateral drop test was removed as it is poorly specified, difficult to execute correctly, and has poor reproducibility. Another way in which the work of Rhule et al. differs from ISO is in having a more accurate evaluation of cadaver responses giving an overall more accurate method for establishing internal biofidelity.

Aside from the biofidelity of the WorldSID neck, certification is also an area being investigated. The latest version of ISO 15830, part 2, 2022 introduces a neck torsion test with corresponding corridors. The torsion corridors were developed based on the response of necks from dummies in the field and not on biomechanical performance requirements. For official Euro NCAP testing from 2026 onwards, WorldSID dummies must be in accordance with ISO 15830 2022, and both the control of the neck and subsequent response in testing is expected to improve. However, up to the end of 2025, dummies were only required to meet previous versions of ISO 15830 which did not include this specific test. Therefore, all data shown in Figure 3 is from dummies certified before the application of ISO 15830 2022.

Child Occupant Protection

There will be no major changes to the child protection elements in the 2029 rating such as new dummies or test configurations. The focus of the Front and Side Impact Working Groups will be to review the existing ATD criteria and dynamic assessments. For example, with the improvements to the thorax repeatability in the Q10 ATD, consideration will be given to the adoption of a sliding scale assessment. Further biomechanical considerations will be given to the use of the anterior superior iliac spine (ASIS) load cell in the evaluation of belt geometry and submarining.

In side impacts, head protection will be reviewed for the Q10 as many Euro NCAP tests have seen head curtain airbags ‘bottom out’ onto the underlying vehicle structures. These airbags should provide protection to both adult and children seated on booster cushions, and if such devices bottom out with the Q10, their efficacy for adult occupants is also questionable. Euro NCAP has also seen poor dynamic performance in the side impact test with a lack of restraint being offered to the Q6 ATD as a far side occupant. This results either in high levels of lateral head excursion or direct contact between the child dummies, both of which will be penalised.

VRU impact protection

Following the release of the 2026 VRU test and assessment protocol, the Euro NCAP VRU Working Group is developing further updates and improvements to reflect the threats posed to VRU in the real world. While the protocols will maintain Euro NCAP’s philosophy of independent active and passive safety assessments, including the separation of impact speeds for passive tests from any ADAS functions, the VRU scoring and weighting between the different body regions is under review. Updated crash data from the German In-Depth Accident Study (GIDAS) of AIS2+ injuries in car-pedestrian collisions indicate higher relevance of head (including brain) and thoracic injuries compared to those injuries to the lower extremities that are currently addressed by the aPLI.

The advanced aPLI, under development with support of ISO, intends to specifically address pelvic injuries by replacing the upper body mass with an instrumented pelvic ring. Furthermore, several studies addressed the possible gap in VRU injury pattern by including a physical test with a thorax impactor into the existing set of component test and assessment procedures [45][46][47][48].

While the 2026 rating will award points on the A-Pillars giving HIC below 1700, the scoring bonus is under review before a possible extension to other potentially highly injurious locations such as the remaining parts of the windscreen frame, roof and bonnet supports etc.

The feasibility of an extension in the use of headform data predicted by the manufacturer to the remaining areas (upper legform, lower legform) will be investigated. In this context, the comparatively small colour boundaries remain challenging.

If and where possible, the tolerance for predicted head data to be accepted without any up- or downgrading of the colour should be aligned with the one recently introduced for the full-scale tests; however, the increased test scatter during headform tests with higher loading will be carefully considered.

The protocol for testing deployable pedestrian protection systems (DPPS) that are triggered by ADAS systems needs to be further developed, maintaining equivalence of triggering with contact-based systems, using hardest to detect pedestrian surrogates. Furthermore, the actual requirements for bonnet deflection as recently investigated in full-scale vehicle to ATD tests may need further revision [49].

Up to this point in time, simulations with qualified human body models provide head impact times (HITs) the critical parameter in deciding whether headform tests to deployable systems may be performed statically (on fully deployed or undeployed systems) or dynamically (on deploying systems) [27]. For the future, finite element simulations with HBMs show a high potential for closing gaps where impactors show limitations with respect to their biofidelity or are still in their development process, and to cover a broader variety of impact speeds, locations, angles etc. Furthermore, HBM may better address the vulnerability of pedestrians and bicyclists particularly be associated to long-term consequences of injuries which are in focus of the IMPROVA project [50], funded by the

European Commission. HBMs can be also used to reflect sex-specific differences [51], the ageing society or differences due to the body height or, in the future, to analyse crashes with other micromobility users such as e-scooter riders.

CONCLUSIONS

Euro NCAP implemented updated test and assessment procedures for all vehicle publications from the 1st January 2026 onwards. A revised rating scheme has been developed that, as well as addressing the four stages of occupant safety, accounts for the variability inherent in both full-scale and sub-system crash testing. Under the Safe Driving stage, a large step forward has been made in evaluation of in-cabin monitoring and Crash Avoidance has for the first time addressed system robustness.

Within Crash Protection, greater use has been made of ATDs with differing anthropometries and revised injury criteria provides a more challenging assessment of vehicle restraint system performance. This, in combination with a wider scope of crash severities and greater use of virtual testing techniques, will ensure that vehicles must be designed with a holistic approach to safety in order to obtain five-star Euro NCAP ratings. Should the worst happen, Post-Crash assessments within the final stage will offer first responders the best information possible at the scene of an accident so they can effectively and safely apply their crucial skills.

Real-world crash data has highlighted the need to ensure that certain areas of vehicle safety require particular focus and improvement. While there are gaps in understanding this data, these areas will continue to be investigated for incorporation into future updates in the rating scheme in 2029. Euro NCAP aims to ensure that its ratings extend well beyond minimum safety standards and are applicable to all human characteristics. This is especially the case for those occupants which appear to be overrepresented in vehicle crashes (e.g. elderly) and forms an integral part of Euro NCAP's Vision 2030 to drive innovation forward and ensure a safer mobility future for all road users.

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Frontal Impact Working Group

Side Impact Working Group

Brain Injury Sub-Group

Vulnerable Road User Working Group