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Euro NCAP Safety Tests: Trials Road Cars go through before they Receive a Star Rating

[1] Gheorghe Neamțu, [2] Marinela Ință

[1] Ph. D. Engineer, Associate Professor, "Lucian Blaga" University of Sibiu, 10 Victoriei Street, Sibiu, Romania

[2] University Lecturer, Ph. D. Engineer, Professor, „Lucian Blaga" University of Sibiu, 10 Victoriei Street, Sibiu, Romania

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Corresponding Author: **Gheorghe Neamțu**

Abstract

Road safety is an issue of major importance in European Union policies, with the main objectives of reducing/eliminating road accidents, reducing/eliminating road casualties and fatalities, and increasing the level of safety and comfort for all road users. The scientific paper presents a concrete research carried out by the authors in order to implement some technical concepts, so that those interested in this field can become acquainted with a certain way of presenting the problems of the safety tests carried out by the European organization for road safety assessment Euro NCAP, established in 1996, based in Louvain, Belgium, the first results of the tests carried out on road vehicles were published in February 1997. In this way, readers can learn about how European organizations interpret the number of stars in road vehicle safety tests, the scales of results for awarding safety stars, the evidence of Euro Ncap tests and levels of protection for adult and child road users, the protection of vulnerable road users (motorcyclists, cyclists, pedestrians) and the conditions for testing the effectiveness of safety systems fitted by manufacturers on road vehicles. It is then presented, the Euro NCAP assisted driving of road vehicles, quadricycle ratings of road vehicles, Euro NCAP tests for trucks and a case study on Euro NCAP tests for the Romanian off-road car, Dacia Duster 3rd generation. The conclusions of the scientific research are presented at the end of the paper.

Keywords: Road Vehicle, Euro NCAP Tests, Scales, Results, Stars Awarded, Dacia Duster Car

1. Introduction

On Europe's roads in 2023, an estimated 20,400 people lost their lives in car crashes. The number of fatalities in this case is 1% compared to 2022 [1]. In Romania, 86 out of one million people die in road accidents every year. It's a figure that puts our country at the top of road deaths in the European Union. The number of serious accidents is decreasing, but not the suffering caused by such an event. Speed remains one of the main causes of tragedies, both in Romania and in Europe [2]. The statistics are grim: Thousands of serious road accidents occurred in 2023, resulting in 1,545 deaths and 3,535 injuries [3]. The safety systems installed on means of road transport have been designed to protect the driver, passengers in the vehicle, pedestrians, cyclists, motorcyclists, goods being transported, other vehicles involved in traffic, etc. Today, road vehicle manufacturers, through their research departments and centers, are making special efforts to research and develop existing systems and to design new systems to protect people in the event of a road accident. The efficiency and effectiveness of these systems is proven by the numerous tests to which means of transport are subjected and which indicate the degree of safety they can offer. The degree of safety can also be increased by the toughness and impact resistance of the passenger compartment, cab or body of the vehicle, a basic characteristic taken into account in car construction. It is an attribute of the quality of means of road transportation. The protection of drivers or passengers of a vehicle from impact with elements on or near the road, or with other vehicles on the road, has become a priority for authorities worldwide This is due to the high number of road accidents, fatalities and injuries worldwide. In this sense, an important role in increasing the safety of transport vehicles at European level is played by the impact tests of road vehicles by the Euro NCAP organization. Euro NCAP (The European New Car Assessment Programme) is a privately owned organization. It guides itself and has its own standards that are in line with European road vehicle safety rules. The organization was established in the United Kingdom by the Department for Transport

and operates as a Transport Research Laboratory. Its founding members include transport, road safety, insurance and other consumer organizations from several countries. The European Community is part of the organization as an observer, which provides additional support. Euro NCAP has nothing in common with car manufacturers and is not controlled by political authorities. Any country in Europe can be a member of this organization and can support it financially. The safety of cars tested by this organization is assessed by awarding a number of 0-5 stars. The number of stars awarded depends on whether the car is safe or not.

2. Literature review

By the 1960s, one of the downsides of mass motorization could no longer be ignored, as the number of road fatalities was rising exponentially. In 1968, at NATO's initiative, the American Department of Transportation decided to start a program to develop experimental vehicles to demonstrate and develop safety technologies. At the same time, the US government issued an invitation to European countries to take part in the program. Thus, in October 1970, the European Experimental Vehicles Committee (EEVC), a body designed to assess road safety, was set up. Over the years, a series of safety tests were devised and by the early 1990s the committee had already developed a series of procedures to measure the protection offered by a car to both passengers and pedestrians. By 1994 there had been several proposals from the EEVC to integrate safety measures into European legislation, but as expected, the car industry was not ready to accept them.

The decisive move came from the UK, which, through the Department for Transport, considered in June 1994 the introduction of a new car assessment program. This program was to be based on procedures devised by the EEVC and could later be extended to the rest of Europe. Two years later, the Swedish Road Administration, FIA (Fédération Internationale de l'Automobile) and International Consumer Research & Testing were the first organizations to join the safety testing programme. The result was the creation of Euro NCAP, an independent organization based in Belgium that would put safety tests for new cars into practice [4]. Euro NCAP has created the five-star safety rating system to make it easier for road vehicle users, their families and road transport organizations to compare vehicles and to help them identify the safest choice for their needs. The safety rating is based on a series of vehicle tests designed and carried out by Euro NCAP. These tests represent, in a simplified way, important real-life accident scenarios that could result in injury or death to vehicle occupants or other road users. While a safety rating can never fully capture the complexities of the real world, improvements in vehicles and technology in recent years through the application of high safety standards have been shown to bring real benefits to European consumers and society as a whole.

February 1997 saw the first Euro NCAP results, but the safety performance of cars has changed a lot over the years. The biggest such change came in 2009. Until then, Euro NCAP gave an overall star rating for three distinct categories: Adult passenger protection, child protection and pedestrian protection. The first two could receive a maximum of five stars, while the pedestrian category was rated from zero to four stars.

In 2009, the organization decided that each car tested would receive a single rating that encompassed the individual results for four test categories: Adult Passenger Protection, Child Passenger Protection, Bicyclist, Motorcyclist, and Pedestrian (referred to as vulnerable road users) Protection, and Safety Systems Effectiveness. And each of these four categories comes with a certain weight in the final result.

For the 2020-2023 timeframe, Euro NCAP has set adult passenger protection to account for 40% of the final result, with the remaining categories accounting for 20% each. Each category tested is scored individually and the final result is actually a percentage. The overall classification given by Euro NCAP on the basis of the safety tests is valid for 6 years from the time of the test, which is why a direct comparison of the results between two cars should also be subject to the "expiry" of the test.

In recent years, Euro NCAP has been preparing tougher and tougher tests to check the effectiveness of active safety systems. In this context, since 2016, certain models can receive two safety ratings. This is because tests are carried out on two different versions of the same car. The first includes only the standard safety package (which does not always include the full suite of systems in the manufacturer's portfolio), while the second is always equipped with an extended safety package. Thus, in some cases, the same car can be found in the Euro NCAP database with two ratings: One for the base version, the second for the version equipped with the *Safety Pack*.

The number of stars reflects how well the car performs in Euro NCAP tests, but it is also influenced by what safety equipment the vehicle manufacturer is offering in each market. So a high number of stars shows not only that the test result was good, but also that safety equipment on the tested model is readily available to all consumers in Europe. The star rating goes beyond the legal requirements and not all new vehicles need to undergo Euro NCAP tests. A car that just meets the minimum legal demands would not be eligible for any stars. This also means that a car which is rated poorly is not necessarily unsafe, but it is not as safe as its competitors that were rated better [5].

3. Interpreting the number of stars in Euro NCAP tests

The more stars, the better. The number of stars reflects how well the car performs in Euro NCAP tests, but it is also influenced by what safety equipment the vehicle manufacturer is offering in each market. So a high number of stars shows not only that the test result was good, but also that safety equipment on the tested model is readily available to all consumers in Europe. The star rating goes beyond the legal requirements and not all new vehicles need to undergo Euro NCAP tests. A car that just meets the minimum legal demands would not be eligible for any stars. This also means that a car which is rated poorly is not necessarily unsafe, but it is not as safe as its competitors that were rated better.

The five star safety rating system continuously evolves as older technology matures and new innovations become available. This means that tests are updated regularly, new tests are added to the system and star levels adjusted. For this reason the year of test is vital for a correct interpretation of the car result.

The latest star rating is always the most relevant and comparing results over different years is only valid if the updates to the rating scheme were small. Recently, the inclusion of emerging crash avoidance and driver assist technology has significantly altered the meaning of

the stars.

Because of this evolution of the rating scheme, cars' ratings expire when their date stamp (i.e. the year the car was rated, indicated on the rating) is more than six years old. An expired rating does not necessarily mean that the car has changed in any way; simply that the rating scheme has moved on so much since the car was rated that its assessment is largely irrelevant in comparison with cars tested more recently.

During the six years or so until the rating expires, Euro NCAP performs reviews to ensure that it remains valid for cars currently on sale. Manufacturers are asked each year to confirm that the car has the same safety equipment it had when it was assessed, and that no other changes have been made which might affect the validity of the rating. Additionally, when a car is updated ('facelifted'), which typically happens about mid-way through its life cycle, manufacturers must submit details of the changes made and the influence these might have on safety performance. In-house data is often provided to demonstrate that the changes have only a minor influence on the relevant aspect of safety performance. The "Annual Reviews & Facelifts" table indicates whether or not the original star rating remains valid, although performance in one of the areas of assessment may have changed slightly [5].

From 2016, some cars have two star ratings. One rating is based on a car fitted only with safety equipment which is standard on every variant in the model range throughout EU28. This rating reflects the minimum level of safety you can normally expect from any car sold anywhere in the European Union. All cars assessed by Euro NCAP have this basic safety rating.

The second rating is based on a car with an additional "safety pack", that may be offered as an add-on option to consumers. The additional safety equipment included in a safety pack will boost the car's safety rating and, therefore, the second star rating demonstrates the safety level that the car can achieve if this additional equipment is included. Not every car has this second star rating, but when available, it helps consumers to easily understand the benefit of additional equipment expressed in extra stars. The additional safety equipment that is allowed as an option in the pack changes over time. When a technology is well-established, it can no longer be an option and must be standard equipment if it is to be included in the rating. New technologies are added to the list that can form part of the option pack. Finally, Euro NCAP only gives an optional rating if the pack is offered on all variants and in all European markets [5].

The following provides some general guidance as to what safety performance the stars refer to in today's system [5]:

★★★★★ **5 star safety:** Overall excellent performance in crash protection and well equipped with state-of-the-art crash avoidance technology.

★★★★☆ **4 star safety:** Overall good performance in crash protection and prevention, but does not reach the highest standards in all key assessment areas.

★★★☆☆ **3 star safety:** A vehicle that provides an average level of safety performance, offering a medium standard in safety.

★★☆☆☆ **2 star safety:** Nominal crash protection but below-average performance in one or more of the key assessment areas.

★☆☆☆☆ **1 star safety:** Marginal crash protection and minimal crash avoidance technology beyond the legal requirements.

☆☆☆☆☆ **0 star safety:** Meeting type-approval standards so can legally be sold but lacking critical modern safety technology.

An evaluation study [6, pp. 288-293] showed that the risk of serious or fatal injury is reduced by about 12% for each Euro NCAP star. No difference was found for lighter injuries. In a cost-benefit analysis [7], It has been estimated that each Euro NCAP star increases the cost of new cars by around. 600 euro. The associated benefit is a reduction in the severity of accidents. The analysis showed a benefit-cost ratio of 1.31.

4. Euro NCAP safety star results tables

In order to achieve a certain overall number of stars, all four main categories tested must score a certain percentage of the total number of points. As mentioned above, Euro NCAP tests follow four main categories of tests of road vehicles on: The protection of adult passengers; the protection of child passengers; the protection of cyclists, motorcyclists and pedestrians (vulnerable road users); and the effectiveness of safety systems fitted to road vehicles. Table 1 shows the score, in percentages out of a maximum of 100 points, that a road vehicle must obtain in order to obtain one to five Euro NCAP stars.

Table 1: The score, in percentages out of a maximum of 100 points, that a road vehicle must obtain in order to obtain 1- 5 Euro NCAP stars [4]

Required conditions	Passenger protection adults	Child passenger protection	Protection of vulnerable road users	Efficiency of vehicle safety systems
	Graphical symbol	Graphical symbol	Graphical symbol	Graphical symbol
For 5 stars, at least	80%	80%	60%	70%
For 4 stars, at least	70%	70%	50%	60%
For 3 stars, at least	60%	60%	40%	50%
For 2 stars, at least	50%	50%	30%	40%
For 1 star, at least	40%	40%	20%	30%

Note: Scores are awarded for achieving a certain number of stars and pertain to all Euro NCAP tests from 2020-2022

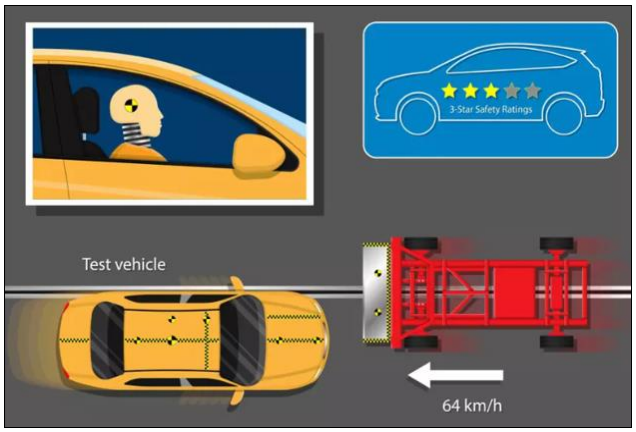

Fig 1: 64 km/h frontal impact test with a deformable barrier [8]

We would like to mention that for the period [2023-2024], Euro NCAP has imposed the following change: All percentages in the column *"Protection of vulnerable road users"* will increase by 10% for each threshold.
It is stipulated that if a vehicle has a poor rating in one of the four overall chapters, then the final number of stars will be restricted to emphasize that the model does not, overall, offer good protection. In other words, if a major category gets a score that qualifies for only two stars, the overall rating cannot exceed those two stars (e.g. 2017 Ford Mustang, which scored two safety stars, and recently with the Dacia Sandero/Logan, which scored two safety stars), even if models scored four-star ratings for certain categories.

5. Tests that road vehicles undergo in Euro NCAP tests

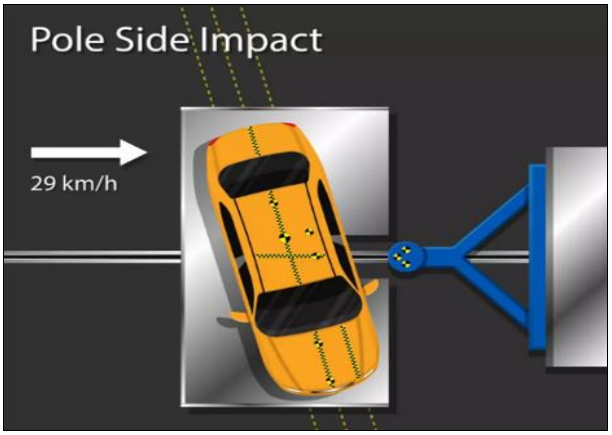

Fig 2: Side impact test with a pole at 29 km/h [8]

Euro NCAP analyzes the performance of on-road vehicles according to a complex grid. In general, cars being tested must pass the following tests [8]:

- protection of adult passengers, with 40% of the overall score;
- child passenger protection, with 20% of the overall score;
- protection of pedestrians, cyclists and motorcyclists, with 20% of the overall score;
- the protection provided by active safety systems, with 20% of the overall score.

The European New Car Assessment Program conducts crash tests on the most popular types and makes sold in Europe to assess the protection they offer to passengers and pedestrians. The tests include a frontal impact test at 64 km/h with a deformable barrier (Fig 1), a side impact test at 50 km/h, a side impact test with a pillar at 29 km/h (Fig 2) and head and foot tests with (partial) pedestrian dummies at 40 km/h. Safety performance is assessed for both adults and children. Unbuckling attention is also taken into account in the assessment and a general recommendation is made for vehicles with Electronic Stability Control (ESC). Recently, a polygon test has been introduced, which tests autonomous braking systems in scenarios involving pedestrians, cyclists and vehicles moving in the same direction. The final result communicated by Euro NCAP is valid only for the basic versions of the vehicles, with no optional features that could influence performance at the moment, and is not available on all cars sold.

5.1 Adult passenger protection

When Euro NCAP tests are carried out to determine the level of protection of adult passengers, two 75-kilogram dummies simulating the dimensions of an adult human are used. Depending on the type of test being carried out, they are positioned either in the front or side rear seats. Since 2020, the offset frontal impact test has been replaced by the progressive offset frontal impact test. This is performed with an aluminum deformable barrier at a speed of 50 km/h.
The frontal impact with a concrete wall (100% of the width of the car) occurs at a speed of 50 km/h of the tested vehicle. Table 2 shows the development of this test over the period 2019-2024, the names of the tests and the maximum score to be achieved by a motor vehicle for the protection of adult passengers.

Table 2: Evolution of the adult passenger protection test in the period 2019-2020, test name and maximum score to be obtained by a vehicle [4]

Test performed / Year	2019	2020	2021	2022	2023	2024
Offset frontal impact	8	-	-	-	-	-
Progressive offset frontal impact	-	8	8	8	8	8
Frontal impact	8	8	8	8	8	8
Lateral impact	8	6	6	6	6	6
Side impact with a pylon	8	6	6	6	6	6
Side impact on the opposite side	-	4	4	4	4	4
Cervical protection in rear impact	2	4	4	4	4	4
Automatic braking at city speeds	4	-	-	-	-	-
Post-accident	-	2	2	2	4	4
Total	**38**	**38**	**38**	**38**	**40**	**40**

Note: Scores awarded for each of the tests in the adult passenger protection chapter

The side impact is carried out with a deformable aluminum movable barrier at a speed of 60 km/h. This test is carried out in two versions: With the driver only, then with the driver and passenger on the right-hand side (this also checks the risk of interaction between the two during an accident).
The side impact with a pillar occurs at a speed of 32 km/h, and the test is carried out with driver only.
To determine cervical protection, Euro NCAP tests at both 16 km/h and 24 km/h. The test is carried out for both front and rear seats.
The last test dedicated to the Adult Passenger Protection chapter was entitled *Rescue & Extrication* (Post-Accident). It awards points for the automatic emergency call system and the automatic braking system after an impact.

5.2 Child passenger protection

Euro NCAP uses two dummies to carry out the crash tests. One is the size of a six year old child and is placed in a special seat facing forward, and the second is the size of a ten years old child, placed on a booster seat and also facing forward. Both dummies are placed in the back seats of the car. Euro NCAP carries out two crash tests to determine the safety of child occupants. The first is a frontal test and is performed with an aluminum deformable barrier at a speed of 50 km/h. In this case, the six years old dummy is positioned behind the driver. The second is a side test also with a deformable battery at 60 km/h. This time the positions of the two dummies are reversed. Table 3 shows the development of this test over the period 2019-2024, the names of the tests and the maximum score to be obtained by a vehicle for the protection of child occupants.

Table 3: Evolution of the child passenger protection test in the period 2019-2020, test name and maximum score to be obtained by a vehicle [4]

Test performed / Year	2019	2020	2021	2022	2023	2024
Impact test	24	24	24	24	24	24
Safety features	13	13	13	13	13	13
Anchorage points	12	12	12	12	12	12
Total	**49**	**49**	**49**	**49**	**49**	**49**

Note: Scores awarded for each of the tests in the child passenger protection chapter

The safety features chapter measures how easy it is for customers to find information about car seat anchorage points and how easy it is to deactivate the front passenger-side side airbag. The chapter on anchorage points refers to how easy it is to fit car seats for toddlers, as well as how compatible the car is with the different anchorage methods available.

5.3 Protecting vulnerable road users

This Euro NCAP test measures the performance of safety systems developed in recent years by European car manufacturers on impact with road user dummies (pedestrians, cyclists, motorcyclists). To measure the effects on the head, Euro NCAP conducts crash tests simulating both children and adults. Impact tests to determine these effects are carried out at a speed of 40 km/h. The same speed is used to measure the effects on the legs (thighs and shins). For the tests dedicated to active safety systems (avoidance and automatic braking), Euro NCAP carries out tests both day and night, in several scenarios and at different speeds. From 2020, the organization has also introduced tests for reversing manoeuvres and intelligent systems that monitor intersections. Scenarios with pedestrians and cyclists include both pedestrians and cyclists coming perpendicular to the direction of the car or moving in the same direction as the car. The system's capabilities are also being tested to see how the system reacts when a pedestrian/cyclist crosses in front of the car coming from between other vehicles parked on the side of the road. From 2023, such tests will also be introduced for situations where pedestrians or cyclists are replaced by people on motorized vehicles (scooters, motorcycles).
Table 4 shows the development of this test over the period 2019-2024, the test names and the maximum score that a vehicle must achieve to protect vulnerable road users.

Table 4: Evolution of the vulnerable road user protection test in 2019-2020, test name and maximum score to be achieved by a vehicle [4]

Test performed / Year	2019	2020	2021	2022	2023	2024
Impact to the head	24	24	24	24	18	18
Impact to the legs	12	12	12	12	18	18
Automatic emergency braking/avoidance for pedestrians	6	9	9	9	9	9
Automatic emergency braking/avoidance for cyclists	6	9	9	9	9	9
Automatic emergency braking/avoidance for motorcycle	-	-	-	-	9	9
Total	**48**	**54**	**54**	**54**	**63**	**63**

Note: The scores awarded for each of the tests in the chapter on the protection of vulnerable road users

5.4 Efficiency of vehicle safety systems

In recent years, manufacturers have increasingly invested in the development of active driver assistance and safety systems. Several versions of systems capable of automatic braking in emergency situations have appeared, some of them working at night and with the possibility of detecting pedestrians or cyclists. Systems capable of avoiding collisions when changing direction or technologies capable of controlling steering, acceleration and braking in multiple scenarios (semi-autonomous driving systems) have also been introduced. Under these circumstances, Euro NCAP needed to update the tests and introduce additional subtests. For the tests measuring the effectiveness of the safety systems, Euro NCAP looks at versions with safety packages offered as standard. However, it is possible that certain models may also be tested with an extended package of such systems in order to demonstrate their importance to the safety offered. Table 5 shows the development of this test over the period 2019-2024, the names of the tests and the maximum score that a vehicle must obtain for the effectiveness of the safety systems

Table 5: Evolution of the test on the effectiveness of road vehicle safety systems in the period 2019-2020, test name and maximum score to be obtained [4]

Test performed / Year	2019	2020	2021	2022	2023	2024
Alert seat belt reminder/Occupant monitoring	3	3	3	3	3	3
Speed assistance system	3	3	3	3	3	3
Car-to-car automatic emergency braking	3	6	6	6	9	9
Lane Departure Warning System	4	4	4	4	3	3
Total	**13**	**16**	**16**	**16**	**18**	**18**

Note: The scores awarded for each of the tests in the chapter on the effectiveness of road vehicle safety systems

Check whether or not the seat belt reminder and occupant monitoring system is active for the rear passengers. Additional points are also awarded for the driver monitoring system.

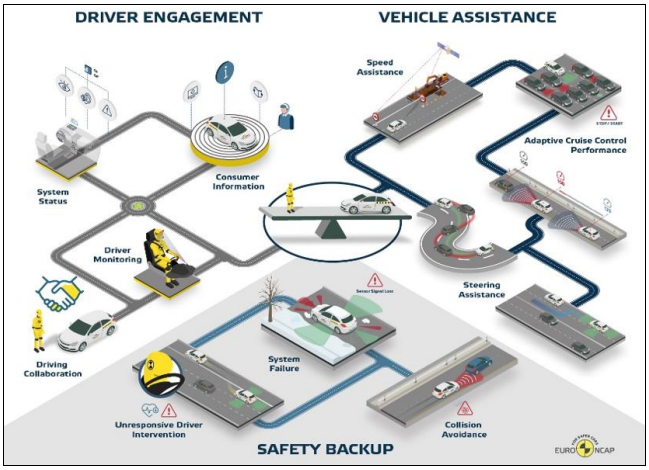

Fig 3: Driver Engagement and Vehicle Assistance [5]

The chapter on speed assistance systems looks at the presence and operation of systems such as electronic speed limiter, cruise control and traffic sign recognition. Since last year, Euro NCAP experts also note how these systems work together (e.g. setting the speed limit of the cruise control system based on information received from the traffic sign recognition system). To check the automatic emergency braking system when other vehicles are detected, Euro NCAP has broken down the program into eight individual tests. Experts test how the system works in different scenarios (approaching a stationary vehicle, a slow-moving vehicle or a braking vehicle) and a test for the system's effectiveness at intersections when cornering.

The lane-hold system is scored according to how it reacts to leaving the lane. Points are awarded if the system brakes or steers when the car accidentally leaves the lane.

6. Assisted driving of road vehicles by Euro NCAP

Since 2018, Euro NCAP has evaluated various Highway Assist systems offered by car manufacturers. Highway Assist helps the driver to maintain a steady speed, to keep a safe distance from the car in front and to keep the vehicle in the centre of the lane by combining (intelligent) Adaptive Cruise Control (ACC) with Lane Centering (LC). However, the driver always needs to be responsible and engaged behind the wheel, and the assisted system is there to do just that – assist. Euro NCAP tests the capability of each system to support the driver under normal traffic driving conditions and investigates how the system ensures that the driver remains engaged in the driving task. From 2020 onwards, Euro NCAP has issued separate Highway Assist gradings, based on dedicated test and assessment protocols [9].

The grading is divided into two main areas [5]:

- assistance Competence, based on the balance between Driver Engagement and Vehicle Assistance (Fig 3);
- safety backup.

The significance of gradations within this type of driving is shown in the Table 6.

Table 6: Significance of gradations within this type of driving [9]

Grading mean	Significance
	An Entry vehicle assistance system typically provides assistance in the less challenging scenarios and comprises only a basic ACC and Lane Centering system, with no additional features. Or, the system's performance in Assistance Competence is highly unbalanced between Driver Engagement and Vehicle Assistance. The safety back-up is limited.
	ACC and Lane Centering generally perform well in the less challenging scenarios, but the system has a better performing safety back-up compared to Entry-graded vehicles. Unbalanced vehicles with a good safety back-up also end up in this category.
	Both ACC and Lane Centering perform well in most situations and the system keeps the driver engaged. Good systems also contain some extra features to provide the driver more assistance and provide a good safety back-up.
	Vehicles graded Very Good are state-of-the-art ACC and Lane Centering systems with additional functions to support the driver and keep him engaged. These vehicles also provide a high-level safety back-up in challenging scenarios, utilizing the extended sensor set these vehicles are equipped with.

The balancing of Driver Engagement and Vehicle Assistance captures the principle that good performance in one area is not helpful unless it is accompanied by good performance in the other. In other words: High levels of assistance must be matched with good driver oversight to avoid overreliance of the driver and increased crash risk. The Safety Backup evaluation consists of crash avoidance testing and rates the vehicle's ability to mitigate a crash in case the assistance system is unable to prevent a collision. The total score is the sum of Assistance Competence and

Safety Backup and is divided into the following gradings: ENTRY-MODERATE-GOOD-VERY GOOD.

7. Quadricycle ratings of road vehicles by Euro NCAP

Euro NCAP developed special protocols for testing heavy quadricycles. These vehicles are not subject to the same legislation as passenger cars, and do not have to be crash tested before they can be sold for road use. Safety equipment such as a driver or passenger airbag is also sparsely fitted to these vehicles and it is expected that they would all perform very poorly when tested using Euro NCAP's regular procedures for passenger cars. Nevertheless, heavy quadricycles are allowed on public roads where they are at risk of collision with other vehicles or obstacles. Therefore, tests are used which challenge the vehicle structure and occupant restraint systems but which offer some resolution in results to allow for meaningful comparison between vehicles in this category. Euro NCAP currently bases the star ratings of quadricycles only on the protection they offer to adult occupants in the front seats. In the future, other components may be added to the assessment, such as child and pedestrian protection and driver assistance features. Two full-scale crash tests are done: A full-width frontal impact at 50km/h against a deformable element; and a side impact test, also at 50km/h, in which a deformable barrier is driven into the side of the vehicle [5].

The maximum score in each test is the same (16 points). The scores are added and the percentage of the maximum is calculated. Based on this percentage, the star rating is determined. While these are severe tests for quadricycles, they are far less stringent than those for passenger cars. Quadricycle star ratings should be used only for comparison within this category of vehicles. Comparison with other star ratings is not valid.

8. Euro NCAP tests for trucks

According to the author's research, in Europe, trucks account for 3% of all vehicles on European roads and 15% of all road accidents. More than 60% of people killed in collisions between cars and trucks are passengers in cars and less often in trucks. This is shocking, but to date there is no incentive for manufacturers and suppliers of goods transport vehicles to install advanced safety or driver assistance technologies on trucks. Traditionally, Euro NCAP exclusively tests only the safety of passenger cars. For this reason, Euro NCAP has announced that it has started testing the first trucks for the new heavy vehicle safety standard in its laboratories in Europe.

The first trucks to be tested by Euro NCAP are long haul models from Europe's largest manufacturers: DAF XF, Iveco S-WAY, MAN TGX, Mercedes-Benz Actros, Renault Trucks T, Scania R and Volvo FH [10]. This action has been underway since early 2024, and the testing program will highlight good safety performance, targeting the highest industry practices, not just minimum standards. Under the name *Euro NCAP Truck Safe City and Highway*, it is the first truck safety assessment program. It is designed to test the unequal number of fatalities resulting from road accidents caused by goods vehicles on European roads. The tests consist of research on the braking system and steering mechanism, automatic braking and steering control. Other driver assistance systems will also be tested and improved.

"Euro NCAP's Truck Safe rating scheme will allow everyone in the freight industry to identify and assess the safety level of trucks. Euro NCAP wants to encourage manufacturers and suppliers to innovate", said Dr. Michiel van Ratingen, Secretary General of Euro NCAP [10].

The new tests will assess real-world collisions by addressing real collisions and will encourage manufacturers to install collision avoidance and driver visibility enhancement technologies. The tests are being carried out at six Euro NCAP facilities in Spain, Sweden, Germany, Italy, Spain, Sweden, Italy, the UK and France. The results of the first truck safety tests will be announced on November 20, 2024 at an exclusive media and industry event in cooperation with Horiba Mira [11], a UK based automotive engineering and development consultancy organization. Based on data presented by Euro NCAP in its latest report *"Safer Trucks: On the road to Vision Zero"*, the new *Truck Safe* rating system will enable all stakeholders in the transport industry to identify and assess the safety level of the equipment in their fleets. Cities and public authorities will be able to identify the best trucks for their roads and stimulate their adoption, and road transport organizations will be able to easily identify the specifications of the means of transport that they must strictly comply with in their mandated road programs.

However, the following point should be borne in mind: Many trucks, for example, are used from one warehouse to another, never reaching urban areas, others distribute goods exclusively in urban areas, and rigid four-axle dump trucks are used only on construction sites, on unpaved roads, in highway construction, on roads or in urban construction. Such a safety solution for these means of road transportation is pointless and involves unnecessary expense without any benefit. This is why they should be kept by their owners away from modern roads on which safe vehicles travel. This is why Euro NCAP has designed the dual rating system for urban and highway environments. All heavy vehicles will be assessed against these two criteria. If a fleet buys a heavy goods vehicle, it will be tested by Euro NCAP according to the area in which it is used. Only general purpose trucks will require Euro NCAP performance tests for both classifications.

The Euro NCAP *Truck Safe* programme will not only increase driver safety, but will also create financial and strategic opportunities for organizations that invest in safer trucks on the road, making them more attractive to insurers. In this way, the safest truck will also be the most profitable. This is why Euro NCAP will encourage truck manufacturers to innovate as testing methods evolve.

To present the risks of a truck accident, the Swedish Transport Administration, together with Autoliv, conducted a crash test between a truck and a modern car with the highest Euro NCAP safety class. The tests were carried out with both means of road transport at a speed of 50 km/h, corresponding to a cruising speed of 80 km/h, with both vehicles having automatic braking at 30 km/h. It should be noted here that the violence of the collision in the event of such a head-on collision, with both vehicles traveling at a speed of 80 km/h, can be compared with the situation where a road vehicle drives head-on into a wall at a speed of 150-160 km/h.

Fig 4: Dacia Duster car 3rd generation in frontal impact with an obstacle simulating a car weighing 1,400 kilograms [13]

To mitigate the destructive effects of cars in road collisions, in 2023 Chalmers built a prototype for a new 'softer' truck front end, intended to be less aggressive (incisive) in relation to the other side of another vehicle it crashes into. In the fall of the same year tests were carried out with the vehicle with the improved front end, the results were positive and the deformation and damage to the other, much smaller vehicle (car or van) was reduced compared to the truck. The tests were carried out on AstaZero's test tracks (from my research it appears that Scania and Volvo truck manufacturers have been able to test their trucks from a road safety point of view on this track since August 2023). AstaZero is the most advanced test track in the world, owned by the SP Technical Research Institute and Chalmers University of Technology and named after the parliamentary vision of zero deaths and serious injuries on Swedish roads, with a total deployed area of two million square meters (2,000 km^2), reminiscent of a movie studio, and located in a forest near the Swedish town of Boras. The circuit has been developed in partnership with the two major truck manufacturing groups, simulating 1:1 scale cities, multi-lane highways, national, regional and off-road roads, at a total investment cost of over half a billion euros. The test track also features almost six kilometers of rural road, with intersections, street lights, bus stops, as well as an urban environment where vehicles can be tested in authentic scenarios involving other vehicles in traffic, cyclists, motorcyclists or pedestrians. All these test track buildings are certified at European level.

9. Euro NCAP test Dacia Duster 3rd generation. Case study

A. Adult occupant protection. In this category of test, the score obtained by the tested model is the result of the scores obtained in 5 impact simulations, as follows:

- **Head-on impact, half of the frontal area, with an obstacle simulating a car weighing 1,400 kilograms** (Figure 4). Both the tested model and the reference obstacle have a speed of 50 km/h. In the front seats are dummies simulating adults of 75 kg mass and average height, and in the rear seats are dummies simulating children of different ages secured with devices specific for their age and height. The test was introduced in 2020.

Fig 5: Dacia Duster car 3rd generation in frontal impact with an obstacle a non-deformable barrier - concrete wall [13]

- **Head-on impact with a non-deformable barrier - concrete wall** (Fig 5) - on 100% of the frontal area. A dummy simulating the presence of a female miniature person is placed behind the steering wheel and in the right rear seat. The impact is at 50 km/h, the test was introduced in 2015;
- **Lateral impact** (Fig 6). The model tested does not move, but is hit from the side by a moving obstacle simulating an automobile. The impact is made at 60 km/h. A dummy simulating an adult is placed in the driver's seat and a dummy simulating a child is placed in the left rear seat. Test introduced in 1997 and revised in 2020;

Fig 6: Dacia Duster car 3rd generation to side impact [13]

- **Side impact with a pillar:** A loss of control and side impact with a pole at a speed of 32 km/h is simulated. The pole has a diameter of 254 mm. The car hits the pillar with its left side at an angle of 15 degrees to perpendicular. In cars equipped with a central airbag (the airbag that prevents the front occupants hitting each other), two dummies simulating adult males are placed in the front seats. Models without this equipment have only one dummy in the driver's seat. Test introduced in 2001 and revised in 2020;
- **Additional side impact simulations:** Almost all side-impact protection data are aggregated from the simulations in paragraphs 3 and 4. There are, however, cases where additional tests are carried out with the model fixed to a trolley/chair to simulate the accelerations exerted on a human body in a side impact.

In these cases the displacement of the dummy through the passenger compartment and what it may hit in its displacement is also measured. Test introduced in 2020 and revised in 2023;

- **Rear impact:** A rear impact is simulated at speeds between 16 and 24 km/h. Introduced in 2009 and revised in 2020.

Here are the Euro NCAP justifications:

- **50% frontal impact with deformable barrier.** Reduced protection for the driver in the thorax, compressions were recorded in this area of the dummy. Medium risk of injury to the right calf. The right passenger is well protected and at low risk of injury;
- **100% frontal impact with non-deformable barrier.** Both the driver and the right rear passenger have a medium risk of chest injury. Note one detail, while in the case of the driver there may be a suspicion that this chest compression may also be the result of contact with the steering wheel (say), in the case of the right rear passenger - his chest does not hit anything, the compression occurs as a result of the seat belt restraint. So this average risk of injury is only natural, anyone who has been in an accident (even a minor one) and has been saved by a seatbelt knows that they will have their seatbelt tattooed for a week. In frontal impact tests, the new Duster scored 11.4 points out of 16.
- **Side impact** – Dacia Duster car gets top score, no risk of injury to driver.

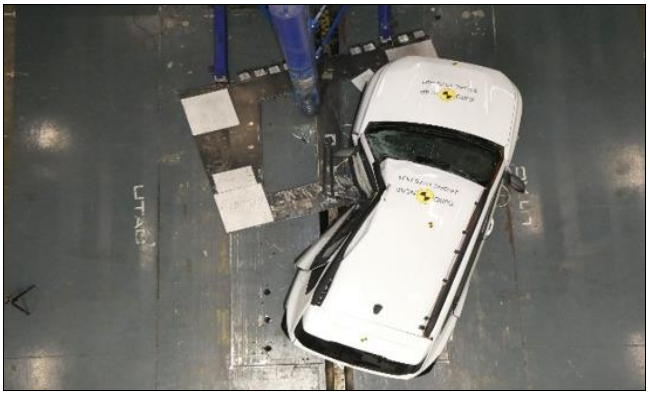

Fig 7: Dacia Duster car 3rd generation to side impact with a pylon [13]

- **Side impact with a pillar** - full points. Although the deformation of the car's body suffered serious damage the images shown have a high percentage of drama. There is significant deformation, the car protects the driver very well and there is no risk of injury.
- **In additional side-impact** simulations, there was a risk of serious injury. In the event of a side impact, the driver is not sufficiently restrained in the seat and this body displacement leads to serious injuries. The car was also downgraded for the lack of a center airbag to prevent contact between the front occupants in a side impact. In side-impact tests, the Duster received 12 points out of a maximum of 16.
- In the event of **a rear** impact, the seats protect front passengers very well. The Duster scores 3.6 points out of a maximum of 4.

Fig 8: Test sheet for the adult occupant protection chapter [13]

Also in this chapter, Euro NCAP awards additional points for four other elements: The existence of a manufacturer-issued rescue card (useful for rescue services), Advanced eCall, Multi Collision Brake and the possibility of exiting a submerged wreck. Here, the Duster scored 1.2 points out of a maximum of 4. In total, the Duster scores 28.1 points in the adult passenger protection category, 70% of its maximum potential score. The test sheet for the adult occupant protection chapter developed by EuroNCAP experts for the Dacia Duster 3rd generation is shown in Fig 8.

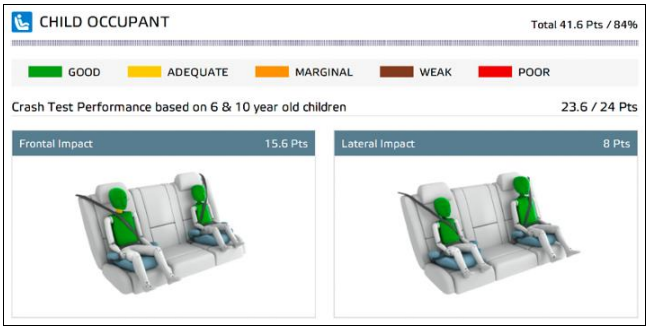

Fig 9: Test sheet for the child passenger protection chapter [13]

B. Child passenger protection: The protection offered to children is assessed in two impact tests. The first is 100% frontal fixed barrier impact. The rear seats are fitted with ISOFIX [12] mannequins simulating the presence of six and ten year old children. The same scenario for the side impact where the car is hit perpendicularly by a trolley with a deformable front at 60 km/h (simulating an accident where a car hits you from the side). In both cases, the protection offered to children is almost maximum. The Duster received 23.6 points out of 24. The small penalty comes from the stress that occurs to the 10 year old dummy/child's neck in frontal impact. But the forces are in the area that can lead to mild injuries. Still, the Duster lost important points for safety systems, as out of a total of 13 points it scored only 6. The EuroNcap specialists' reasoning is as follows: The front right seat is not equipped with ISOFIX, i-size, Integrated CRS, Top Tether and child seat detection. The same goes for the middle rear seat. The rear outboard seats have been downgraded for lacking the Integrated Child Restraint System (CRS) and the Child Seat Occupant Sensing System (CSOSS When it comes to instructions on how to install a child seat, the Duster scored full marks, 12 points out of 12. The information is clear and easy to follow. Finally, in the Child Passenger Protection category, the car scored 41.6 points, 84% of the maximum score. The test sheet for the child occupant protection chapter developed by the EuroNCAP experts for the Dacia Duster 3rd generation is shown in Fig 9.

C. Protection of vulnerable road users. From the factory, the Dacia Duster is not equipped with a system to warn occupants that someone is approaching the car, and opening the doors can be synonymous with blocking the path of a cyclist. There's a point lost here. Autonomous Emergency Braking (AEB) when approaching a stationary motorcyclist scored full marks. The system also scored top marks for the way it reacts to a motorcyclist approaching a motorcyclist running in front of the car at low speed. If the driver of the Duster wants to change direction and there's a motorcycle ahead, the car will brake automatically and the response is considered correct. Here the model received 5 points out of a maximum of 6. However, the car could not warn or react if the driver changes lane and is either in the scenario where a motorcycle is coming from the front or when changing lane, it is in the path of a motorcyclist already overtaking. Aspects of the Euro NCAP specialists' tests with the third generation Dacia Duster car are shown in Fig 10.

Fig 10: Aspects from EuroNCAP testing of the Dacia Duster car 3rd generation for the protection of vulnerable road users [13]

The car received top marks for Autonomous Emergency Braking (AEB) in three situations in which it can intersect with cyclists: when a cyclist is crossing from behind a parked car, when the cyclist is crossing the road, and when approaching from behind a cyclist. The system reaction was rated as average when the driver turns into the path of an oncoming bicyclist. Out of a maximum of 8 points, the Duster received 6.2 points. AEB for pedestrians received 5 points out of a maximum of 9. It behaved very well with an adult crossing the street day or night. It reacted very well to a child crossing the street during the day from behind a parked car, at night the system's reaction was considered good, in the safe zone. The system also reacted very well to a pedestrian approaching from behind, day or night. The system did not react to rear-end maneuvers when an adult or child pedestrian was in the path. The car's response was also poor in the scenario where the driver enters a street where a pedestrian is already crossing.

In the case of impact with a pedestrian or cyclist, the Duster received 21.9 points out of a maximum of 36. The Duster received 10.8 points for how well it manages to protect the head of pedestrians or cyclists in the event of impact. It gets no points for how well it manages to protect the victim's pelvis, 4.5 points for protecting the femur and 6.6 points for kindness to the knee and tibia.

In the end, we are talking about 38.2 points in this category, 60% of the maximum score.

Fig 11: First generation Dacia Duster car in the EuroNCAP frontal test (2011) [13]

D. Efficiency of car safety systems: This category is the key to the three EuroNCAP stars the car received. The Duster was downgraded for not having a rear passenger occupant sensing system. Even though it does have a rear seat belt reminder, the lack of the aforementioned system meant that it didn't score any points. The car is equipped with a system that indirectly monitors driver fatigue. The lane-keeping system does its job properly and can also intervene in more dangerous situations. The car uses both digital map and camera information to inform the driver of speed limits and gives the driver the option to choose to have the system automatically adjust the speed. However, despite some positive findings, the car received 10.3 points, 57% of the maximum score.

10. Previous generation Dacia Duster Euro NCAP test results

Here we present a comparative study of the results obtained by the first and second generations of the Dacia Duster car, compared to the third generation. The situation is as follows [13]:

- ***Dacia Duster car 2011 - first generation.*** In 2011 Dacia was still a low cost brand. The fact that the brand's products were not up to the same standards, even with what we then called volume models, was an officially assumed fact, and we - the patriots - accepted a lot of it, because the joy of seeing a Romanian brand in the process of rebirth meant a lot. Of course, the moment the Dacia Duster passed through the Euro NCAP testing range was a moment of great media agitation.

Fig 12: Second generation Dacia Duster car in the Euro NCAP frontal test (2017) [13]

- **Tested model:** Dacia Duster car, 1.5 dCi Laureate;
- **Results obtained:** Adult passenger protection - 26.7 points/ 74% of maximum score; child passenger protection - 38 points/ 78% of maximum score; protection of vulnerable road users - 10 points / 28% of maximum score; safety Assist - 2 points / 29% of maximum score..
- ***Dacia Duster car 2017- 2nd generation:*** The Dacia manufacturer from Mioveni, Argeș County, is moving with this model out of the low cost area. Thus the buds of a visual identity are beginning to appear on the car market in terms of design. The models are positioned in an accessible area, models that offer a cocktail of space and robustness. The second generation Dacia Duster is built on the same platform (same chassis) as the first generation.
- **Tested model:** Dacia Duster car, 1.5 dCi;
- **Results obtained:** Adult passenger protection - 27.1 points / 71% of maximum score; child passenger protection - 32.4 points / 66% of maximum score; protection of vulnerable road users - 23.6 points / 56% of maximum score; safety Assist - 4.5 points / 37% of maximum score.

11. Conclusions and unknown aspects of the Euro NACAP tests

The new tests under which road vehicles will receive 5 stars are different from previous years, so people should not compare today's with those of the past. It looks like the 5-star crash rating will be harder to get from summer 2020.

The score is determined by a series of tests on vehicles designed and carried out by Euro NCAP and are based on real life crash scenarios that could result in injury or death to passengers or other road users.

The number of stars reflects how well the vehicle performs in the Euro NCAP tests, but it is also influenced by the safety equipment that the vehicle manufacturer offers in each market. So, a high number of stars indicates not only that the tests were successful, but also that the safety equipment on the tested model is available to all consumers in Europe.

If we look at the new Duster as a piece of metal, the crash protection offered is good (for adult passengers) and very good (for child passengers).

When it comes to scoring the active assistance systems, things are somewhere in the middle. First of all, let's not forget that these systems are there to be able to help, not to rely on them 100%. Regardless of make and model, all manufacturers have mentions that these systems can fail for all sorts of reasons, from radio wave interference to a reflected light beam. We are not yet in the Autonomous Driving Level 5 scenario, nor have we heard of any lawsuit won by a driver who crashed into a pedestrian and was pardoned because the automatic braking system malfunctioned.

On another note, such a system can intervene and save a life when there are moments of driver inattention.

The recommendations say not to use a second-hand ISOFIX car seat or a second-hand car seat because you have no way of knowing whether they are still safe or not. Crash tests are organized by several organizations around the world, and the tests themselves are of several types. There are seven organizations that operate crash tests in the world: NHTSA, IIHS, NCAP, Euro NCAP, ANCAP, ADAC, JNCAP and C-NCAP. The first three cover the US market, Euro NCAP and ADAC test vehicles sold in Europe, and ANCAP, JNCAP and C-NCAP test vehicles sold in specific markets, namely Australia and Asia, Japan and China. There are also organizations around the world that carry out this type of testing independently, either for the domestic market or for other studies (such as the body that tests road signs and car crash attachments).

There are several types of tests, all of them rigorous and of high scientific value. Since such a test is very expensive, more expensive than the value of the vehicle itself, engineers need to extract the maximum amount of information from each impact. This involves a series of computers that record data at high speeds, at least one three-axis accelerometer and at least one crash test dummy. Crash tests often use several crash dummies. These tests are performed between a vehicle and a concrete wall at a specified speed. Impact is a common type of crash and checks the design of the car in question. The manufacturers' main aim is to protect the occupants and the element to avoid is intrusion into the passenger compartment. If this happens, the vehicle has safety problems and poses a risk to consumers. This test also checks a vehicle's ability to sustain serious damage. The impact is similar to a frontal impact, except that only 40% of the frontal area of the vehicle is involved. The test is carried out by hitting the vehicle against a rectangular object mounted in front of a wall, designed to simulate another vehicle. Some organizations also test staggered impacts between two vehicles. This kind of impact is more common in real life than 100% frontal impact and a good result is obtained if a smaller portion of the vehicle manages to absorb the full force of the impact.

Side impact tests can be divided into two categories - impact with another vehicle and impact with the pillar. Let's talk about the first category, common at intersections and even in parking lots. This impact is tested by a vehicle driving into the target vehicle at a fixed speed and at a pre-specified angle. The test checks the level of protection provided by the A and B pillars, together with the rigid elements mounted in the doors. Many vehicles have problems with this type of impact, especially those with very low mass and thin doors lacking solid reinforcements. This test uses a 950-kilogram trolley with a deformable aluminum front end that travels at 50 km/h towards the driver's seat or passenger's hip. The pole impact test is carried out by transporting the vehicle on a special stand with wheels to simulate impact with a pillar. This situation takes into account the consequences of a skid resulting in the attempted vehicle being thrown into a pillar. Unlike the other type of side impact, this one is harder because the vehicle tested absorbs a higher percentage of the forces generated by the impact, and is particularly risky for the occupants if it would have occurred with a vehicle in which passengers are occupants. This test is also carried out using a special “trolley”, where the tested vehicle is carried on it at a specific angle and projected onto the asphalt for rollover. The test is aimed at the resistance of the side and roof pillars to rollover on the road. Some vehicles have been found to flatten the roof to a dangerous level, a rollover being lethal for passengers. The problem was most prevalent in the United States in the late 1980s, when a series of SUVs came on the market that could easily roll over because of underperforming tires. This kind of impact is simulated to find out how dangerous a car is if it hits a pedestrian at 40 km/h. A section of the bumper, the

underside of the windshield and sections of the bonnet are hit with objects simulating a child's head, an adult's head, an adult's leg and thighs to see how well the vehicle can absorb the forces generated on impact. Older vehicles are particularly dangerous for passengers because they tend to use more metal in the construction of body parts (including bumpers) and the bonnet has no controlled deformation zones.

12. References

1. Infotrucker.ro. infotrucker.ro, 11 March, 2024. [Interactiv]. Available: https://www.infotrucker.ro/scadere-usoara-a-deceselor-din-accidente-rutiere-in-ue-in-2023/. [Accessed September 20, 2024].
2. Cornea O. Romania continues to lead the European Union in the number of road fatalities per 1 million inhabitants. Four shocking testimonies and a problem the government can't solve: Speeding on the roads. 1,500 people died in accidents last year, 25 August, 2024. [Interactiv]. Available: https://romania.europalibera.org/a/viteza-mortalitate-rutiera-drumuri-sosele-romania-victime-familii-autoritati/33088174.html. [Accessed September 20, 2024].
3. HotNews.ro. Grim statistic: Thousands of serious road accidents occurred in Romania in 2023, resulting in 1 545 deaths and 3 535 injured, 28 January, 2024. [Interactiv]. Available: https://hotnews.ro/statistica-sumbra-mii-de-accidente-rutiere-grave-s-au-produs-n-romnia-si-n-2023-soldate-cu-1-545-de-morti-si-3-535-de-raniti-20375. [Accessed September 20, 2024].
4. Șocariciu C. AutoCritica.ro, 29 June, 2021. [Interactiv]. [Accesat 20 September 2024].
5. Euroncap.com. How to read the stars, 20 September, 2024. [Online]. Available: https://www.euroncap.com/en/about-euro-ncap/how-to-read-the-stars/. [Accessed September 20, 2024].
6. Lie A, Tingvall C. How Euro NCAP results correlate with real injury risks - a comparative study of car-to-car crashes.," Prevent road traffic injuries, 2001, 288-293.
7. Erke A, Elvik R. Effektkatalog for trafikksikkerhet (Road safety measures: A catalog of impact estimates). Institute of Transport Economics, Oslo, 2006.
8. Grosoiu G. autovit.ro, 27 February, 2020. [Interactiv]. Available: https://www.autovit.ro/blog/ce-sunt-testele-euro-ncap-cum-se-realizeaza-si-ce-masini-au-primit-5-stele/. [Accessed September 20, 2024].
9. EuroNCAP.com. General, 20 September, 2024. [Online]. Available: https://www.euroncap.com/en/for-engineers/protocols/general/. [Accessed September 20, 2024].
10. Păduraru I. ziuacargo.ro. Euro NCAP has started first tests for trucks, 16 September, 2024. [Interactiv]. Available: https://www.ziuacargo.ro/cargo/camioane-si-servicii/euro-ncap-a-inceput-primele-teste-cu-camioane-229018.html/. [Accessed September 22, 2024].
11. HoribaMira. Horiba Mira. com, September 22, 2024. [Online]. Available: https://www.horiba-mira.com/. [Accessed September 22, 2024].
12. Toma S. autocritica.ro, 05 June, 2024. [Interactiv]. Available: https://www.autocritica.ro/feature/isofix-si-scaunele-auto-pentru-copii-tot-ce-am-ajuns-sa-stiu-despre-ele/. [Accessed September 20, 2024].
13. Ciobanu C. AutoCritica.ro, 11 July, 2024. [Interactiv]. Available: https://www.autocritica.ro/feature/dacia-duster-trei-stele-euro-ncap-decriptarea-testelor-de-siguranta/. [Accessed September 20, 2024].