LATIN NCAP LATIN NCAP

LATIN AMERICAN & CARIBBEAN
NEW CAR ASSESSMENT PROGRAMME
(Latin NCAP)

ASSESSMENT PROTOCOL – PEDESTRIAN PROTECTION
2020 - 2024

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1 INTRODUCTION

The Latin NCAP programme is designed to provide a fair, meaningful and objective assessment of the safety performance of cars and provide a mechanism to inform consumers.

Latin NCAP is introducing relevant changes to this new protocol such as the introduction of the overall rating scheme and together with it the pedestrian, whiplash, and safety assist systems assessment such as AEB. Individual documents are released for the four main areas of assessment:

- Assessment Protocol – Adult Occupant Protection;
- Assessment Protocol – Child Occupant Protection;
- Assessment Protocol – Pedestrian Occupant Protection;
- Assessment Protocol – Safety Assist;

In addition to these four assessment protocols, a separate document is provided describing the method and criteria by which the overall safety rating is calculated on the basis of the car performance in each of the above areas of assessment.

The following protocol deals with the assessments made in the area of Pedestrian Protection, in particular for the adult and child head, the upper leg form, lower leg form impacts and autonomous emergency braking for vulnerable road user (AEB VRU).

Latin NCAP considers the fulfillment of UN127 requirements as a threshold points reference for cars rated with three stars towards the end of the protocol duration. However Latin NCAP will perform a more comprehensive head and leg assessments than the one required by UN127 as detailed in this protocol. The objective of the pedestrian protection assessment under this protocol is to inform consumers about the full pedestrian protection offered by the vehicle and also compliance or noncompliance with UN127 requirements, not as a star rating, but as an additional consumer information. Finally, AEB - VRU will be assessed and rated.

DISCLAIMER: Latin NCAP has taken all reasonable care to ensure that the information published in this protocol is accurate and reflects the technical decisions taken by the organisation. In the unlikely event that this protocol contains a typographical error or any other inaccuracy, Latin NCAP reserves the right to make corrections and determine the assessment and subsequent result of the affected requirement(s).

2 METHOD OF ASSESSMENT

The assessment of pedestrian protection is made with the use of headform, upper legform, lower legform impacts and AEB test data. In the legform areas, the bumper and front of the bonnet of the car will be marked with a grid and are assessed using the two legform impactors. Latin NCAP will test "worst case" grid points and manufacturers may nominate additional tests to be performed and the results will be included in the assessment.

In the headform impact area, a grid will be marked on the outer surface of the vehicle. The vehicle manufacturer is required to provide the Latin NCAP Secretariat with data detailing the protection offered by the vehicle at all grid locations. The data shall be provided to the Latin NCAP Secretariat before any test preparation begins. The predicted level of protection offered by the vehicle is verified by Latin NCAP by means of testing of a sample of randomly selected grid-points and the overall prediction is corrected accordingly.

For AEB testing, the vehicle manufacturer is also required to provide the Latin NCAP with data detailing the validation test scenario and the expected performance of the AEB VRU system for the indicated validation test scenarios. The expected performance will be used as a reference to identify discrepancies between the expected results and the test results.

2.1 Points Calculation

For the legform impact areas, a sliding scale system of points scoring has been used to calculate points for each measured criterion. This involves two limits for each parameter, a more demanding limit (higher performance), below which a maximum score is obtained and a less demanding limit (lower performance), beyond which no points are scored. Where a value falls between the two limits, the score is calculated by linear interpolation. No capping is applied to any of the measurements. The maximum score for each grid point is one point for bumper and bonnet leading ledge tests. The total score will then be scaled to a maximum of six points for each impactor.

For the headform impact area, the protection predicted by the vehicle manufacturer will be compared to the outcome of the randomly selected test locations. The results at those test locations will be used to generate a correction factor, which will then be applied to the predicted score. Only data that results in a correction factor of between 0.750 and 1.250 is accepted. Where this is not the case, the cause will be investigated and the Secretariat will subsequently take a decision as to how to proceed. Where the data is accepted, the headform score will be based on the predicted data score with the correction applied.

For AEB, a sliding scale based on the speed reduction is applied for test speeds up to 40 km/h. Higher test speeds are assessed as pass/fail only.

3 PEDESTRIAN IMPACT ASSESSMENT

3.1 Criteria and Limit Values

The assessment criteria used for the pedestrian impact tests, with the upper and lower performance limits for each parameter, are summarised below. Where multiple criteria exist for an individual test, the lowest scoring parameter is used to determine the performance of that test, unless indicated otherwise.

3.1.1 Headform

The manufacturer must provide predicted data for all grid points. This data shall be expressed as a colour according to the corresponding colour boundaries for the predicted HIC_{15} performance below. Alternatively, HIC_{15} values may be provided.

Green	HIC_{15}	< 650
Yellow	$650 \leq HIC_{15}$	< 1000
Orange	$1000 \leq HIC_{15}$	< 1350
Brown	$1350 \leq HIC_{15}$	< 1700
Red	$1700 \leq HIC_{15}$	

The manufacturer is allowed to colour a limited number of grid points blue where the performance is unpredictable. These grid points will always be tested. The procedure is detailed in the Pedestrian Protection Test protocol.

Vehicle manufacturers must inform Latin NCAP the compliance (or not) of UN127 and Latin NCAP may test critical points to verify compliance. UN127 verification tests will be performed according to UN127 testing procedures.

Reference Note: UN127 criteria indicates that for Adult and Child, 2/3 of the areas should have HIC below 1000, and the rest areas should not exceed HIC 1700. For Child also is required that the HIC<1000 in at least 50% of the child head assessment area.

3.1.2 Upper Legform

Higher performance limit

Bending Moment	285Nm
Sum of forces	5.0kN

Lower performance limit

Bending Moment	350Nm
Sum of forces	6.0kN

3.1.3 Legform

Higher performance limit

Tibia Bending Moment	282Nm
MCL Elongation	19mm
ACL/PCL Elongation	10mm

Lower performance limit

Tibia Bending Moment	340Nm
MCL Elongation	22mm
ACL/PCL Elongation	10mm

3.2 Modifiers

There are no modifiers applied.

3.3 Scoring & Visualisation

3.3.1 Scoring

A maximum of 24 points is available for the headform test zone. The total score for all grid points is calculated as a percentage of the maximum achievable score, which is then multiplied by 24 points. The bonnet leading edge and bumper test zone will be awarded a maximum of 6 points each. A total of 36 points are available in the pedestrian protection (passive) assessment.

3.3.1.1 Headform

Each of the grid points can be awarded up to one point, resulting in a maximum total amount of points equal to the number of grid points. For each predicted colour the following points are awarded to the grid point:

$HIC_{15} < 650$	*1.00 point*
$650 \leq HIC_{15} < 1000$	*0.75 points*
$1000 \leq HIC_{15} < 1350$	*0.50 points*
$1350 \leq HIC_{15} < 1700$	*0.25 points*
$1700 \leq HIC_{15}$	*0.00 points*

3.3.2 Headform Correction factor

The data provided by the manufacturer is scaled using a correction factor, which is calculated based on a number of verification tests performed. The verification points are randomly selected grid points, distributed in line with the predicted colour distribution.

The actual tested total score of the verification test points is divided by the predicted total score of these verification test points. This is called the correction factor, which can be lower or higher than 1.

$$Correction\ Factor = \frac{Actual\ tested\ score}{Predicted\ score}$$

The correction factor is multiplied to all the grid points (excluding defaulted and blue points). The final score for the vehicle can never exceed 100% regardless of the correction factor.

3.3.2.1 HIC tolerance

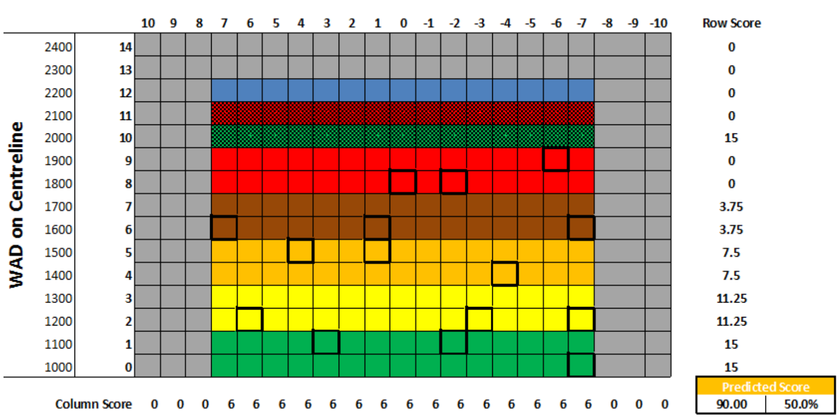
As test results can be variable between labs and in-house tests and/or simulations a 10% tolerance to the HIC value of the verification test is applied. The tolerance is applied in both directions, meaning that when a tested point scores better than predicted, but within tolerance, the predicted result is applied. The tolerance only applies to verify whether the predicted colour of the tested verification point is correct. When, including tolerance, the colour is not in line with the prediction, the true colour of the test point will be determined by comparing the actual measured HIC value with the colour band in section 3.3.1.1 without applying a tolerance to the HIC value.

Prediction	***HIC_{15} range***	***Accepted HIC_{15} range***
Green	$HIC_{15} < 650$	$HIC_{15} < 722.22$
Yellow	$650 \leq HIC_{15} < 1000$	$590.91 \leq HIC_{15} < 1111.11$
Orange	$1000 \leq HIC_{15} < 1350$	$909.09 \leq HIC_{15} < 1500.00$
Brown	$1350 \leq HIC_{15} < 1700$	$1227.27 \leq HIC_{15} < 1888.89$
Red	$1700 \leq HIC_{15}$	$1545.45 \leq HIC_{15}$

3.3.2.2 Example:

Headform testing:

Manufacturer X has provided the following prediction to Latin NCAP with a total score of 90 points (excluding blue) out of the possible 195:



The prediction consists of the following:

15 Default Green	*x 1.00 =*	*15.00*
30 Green	*x 1.00 =*	*30.00*
30 Yellow	*x 0.75 =*	*22.50*
30 Orange	*x 0.50 =*	*15.00*
30 Brown	*x 0.25 =*	*7.50*
30 Red	*x 0.00 =*	*0.00*
15 Default Red	*x 0.00 =*	*0.00*
15 Blue		
195 grid points		***90.00 points***

15 verification points were chosen for testing:

	Verification											Score
1-10	GRID-point	R2|C-7	R2|C-3	R1|C-2	R4|C-4	R5|C1	R5|C4	R8|C-2	R6|C-7	R2|C6	R1|C3	
	Prediction											**6**
	Test result (HIC)	750	600	500	1200	1492	850	2000	1400	1112	660	
	Test result (pts)	0.75	0.75	1	0.5	0.5	0.75	0	0.25	0.5	1	**6**
11-20	GRID-point	R8|C0	R6|C7	R0|C-7	R9|C-6	R6|C1						
	Prediction											**1.50**
	Test result (HIC)	2000	1822	700	1544	1450						
	Test result (pts)	0	0.25	1	0.25	0.25						**1.75**
											Correction factor	**1.033**

$$Correction\ Factor = \frac{Actual\ tested\ score}{Predicted\ score} = \frac{6.00 + 1.75}{6.00 + 1.50} = 1.033$$

8 Blue zones were tested containing 15 blue points:

	Blue points									Score
Blue	Blue Zone	1	2	3	4	5	6	7	8	
	GRID-point	12,7 | 12,6	12,5 | 12,4	12,3 | 12,2	12,1 | 12,0	12,-1 | 12,-2	12,-3 | 12,-4	12,-5 | 12,-6	12,-7	
	Test result (HIC)	1000	650	1700	1500	1700	1699	1350	1349	
	Test result (pts)	0.5	0.75	0	0.25	0	0.25	0.25	0.5	**4.5**

The final score will be:

150 Predicted	*75.00 x 1.033 = 77.475*
15 Default Green	*15.000*
15 Default Red	*0.000*
15 Blue	*4.500*
195 grid points	***96.975 points***

The score in terms of percentage of the maximum achievable score is 96.975/195 = 49.730%
The final headform score is 49.730% x 24 = **11.935 points**

3.3.2.3 Upper Legform

Each of the grid points can be awarded up to one point resulting in a maximum total of points equal to the number of grid points. A linear sliding scale is applied between the relevant limits of each parameter. The upper legform performance for each grid point is based upon the worst performing parameter.

The total score for the upper legform area will be calculated out of six by scaling the sum of grid points score by the relevant number of grid points.

Example:
For a vehicle that has 9 grid points and tests are performed to points U0, U-2 & U-4 with the following results:

Test result U0	**Score**	**Total**
Femur upper bending moment = 281.40Nm	1.000	
Femur middle bending moment = 342.60Nm	0.114 =>	**0.114**
Femur lower bending moment = 324.10Nm	0.398	
Femur sum of forces = 5.26kN	0.740	

Test result U-2	**Score**	**Total**
Femur upper bending moment = 395.81Nm	0.000	**0.000**
Femur middle bending moment = 467.69Nm	0.000	
Femur lower bending moment = 435.69Nm	0.000	
Femur sum of forces = 6.80kN	0.000	

Test result U-4	**Score**	**Total**
Femur upper bending moment = 152.00Nm	1.000	**1.000**
Femur middle bending moment = 208.00Nm	1.000	
Femur lower bending moment = 245.00Nm	1.000	
Femur sum of forces = 4.89kN	1.000	

Grid points that have not been tested will be awarded the worst result from one of the adjacent points. Given that U-1 and U-3 have not been tested, both will be awarded the result from the adjacent point U-2. Symmetry will also be applied to all grid points on the opposite side of the vehicle (U+1 to U+4).

U+4	U+3	U+2	U+1	U0	U-1	U-2	U-3	U-4
1.000	0.0	0.0	0.0	0.114	0.0	0.0	0.0	1.000

The score for each individual grid point is then summed, this produces a score in terms of the maximum achievable percentage of 2.114/9 = 23.488%
The final upper legform score is 23.488% x 6 = **1.409 points**

3.3.2.4 Legform

Each of the grid points can be awarded up to one point resulting in a maximum total of points equal to the number of grid points. A linear sliding scale is applied between the relevant limits of each parameter. The one point per grid point is divided into two independent assessment areas of equal weight:

1. Tibia injury assessment based on the worst performing of tibia moments T1, T2, T3, T4 (0.500 point).

2. Knee injury assessment based upon MCL elongation, as long as ACL/PCL elongation is smaller than the threshold (0.500 point).

The total score for the legform area will be calculated out of six by scaling down the sum of grid points scores by the relevant number of grid points.

Example:
For a vehicle that has 11 grid points and tests are performed to points L1, L+3 & L+5 with the following results:

Test result L+1	**Score**	**Total**	
Tibia bending moment = 280.00Nm	0.500	0.500	
ACL or PCL elongation = 10.00mm	Fail	} 0.000	**0.500**
MCL elongation = 15.00mm	0.500		

Test result L+3	**Score**	**Total**	
Tibia bending moment = 320.00Nm	0.172	0.172	
ACL or PCL elongation = 9.50mm	Pass	} 0.250	**0.422**
MCL elongation = 20.50mm	0.250		

Test result L+5	**Score**	**Total**	
Tibia bending moment = 340.00Nm	0.000	0.000	
ACL or PCL elongation = 10.00mm	Fail	} 0.000	**0.000**
MCL elongation = 19.00mm	0.000		

Grid points that have not been tested will be awarded the worst result from one of the adjacent points. Given that L0, L+2 & L+4 have not been tested, L0 will be awarded the score from L+1, L+2 will be awarded the score from L+3 and L+4 will be awarded the score from L+5. Symmetry will also be applied to the other side of the vehicle.

L+5	L+4	L+3	L+2	L+1	L0	L-1	L-2	L-3	L-4	L-5
0.0	0.0	0.422	0.422	0.500	0.500	0.500	0.422	0.422	0.0	0.0

The score for each individual grid point is then summed, this produces a score in terms of the maximum achievable percentage of 3.188/11 = 28.981%
The final upper legform score is 28.981% x 6 = **1.739 points**

3.3.3 Visualisation of results

3.3.3.1 Headform results

The protection provided by each grid location is illustrated by a coloured area, on an outline of the front of the car. Where no grid is used in the assessment and the fall back scenario is adopted, the same 5 colour boundaries and HIC650 – HIC 1700 values will be applied. The headform performance boundaries are detailed below.

Green		$HIC_{15} < 650$
Yellow	$650 \leq$	$HIC_{15} < 1000$
Orange	$1000 \leq$	$HIC_{15} < 1350$
Brown	$1350 \leq$	$HIC_{15} < 1700$
Red	$1700 \leq$	HIC_{15}

3.3.3.2 Legform & upper legform results

The protection provided by each grid location is illustrated by a coloured point on an outline of the front of the car. The colour used is based on the points awarded for that test site (rounded to three decimal places), as follows:

Green	*grid point score = 1.000*
Yellow	*0.750 <= grid point score < 1.000*
Orange	*0.500 <= grid point score < 0.750*
Brown	*0.250 <= grid point score < 0.500*
Red	*0.000 <= grid point score < 0.250*

Manufacturers must always provide full points performance prior to the assessment. Latin NCAP will also inform in the final report if the car passes or not regulation UN 127 or GTR 9 requirements.

4 ASSESSMENT OF AEB VULNERABLE ROAD USER SYSTEMS

4.1 Introduction

AEB Vulnerable Road User (VRU) systems are AEB systems that are designed to brake autonomously for pedestrian and/or cyclists crossing the path of the vehicle. Evidence and data collection from OEM and suppliers highlighted the need for AEB VRU systems in Latin America to have a particular setup for the region. Road user behaviour differs from predictable models than in other regions of the world where AEB VRU systems and algorithms were developed.

By the end of 2022, Latin NCAP plans to develop a new AEB VRU protocol adapted to the region's reality based in the Euro NCAP 9.0.2 AEB VRU Assessment Protocol, along with technical working groups composed by technology suppliers and car manufacturers. Until then, the assessment will be based in validation process following manufacturers suggested scenarios under certain conditions.

A minimum pedestrian protection (passive) performance of 14 points is required to be eligible to score AEB VRU points[1].

4.2 Definitions

Throughout this protocol the following terms are used:

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

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

Vehicle width – the widest point of the vehicle ignoring the rear-view mirrors, side marker lamps, tyre pressure indicators, direction indicator lamps, position lamps, flexible mud-guards and the deflected part of the tyre side-walls immediately above the point of contact with the ground.

Car-to-Pedestrian Farside Adult 50% (CPFA-50) – a collision in which a vehicle travels forwards towards an adult pedestrian crossing its path running from the farside and the frontal structure of the vehicle strikes the pedestrian at 50% of the vehicle's width when no braking action is applied.

Car-to-Pedestrian Nearside Adult 25% (CPNA-25) – a collision in which a vehicle travels forwards towards an adult pedestrian crossing its path walking from the nearside and the frontal structure of the vehicle strikes the pedestrian at 25% of the vehicle's width when no braking action is

1 Note that this requirement can be affected by the balance factor described in section 4.4

applied.

Car-to-Pedestrian Nearside Adult 75% (CPNA-75) – a collision in which a vehicle travels forwards towards an adult pedestrian crossing its path walking from the nearside and the frontal structure of the vehicle strikes the pedestrian at 75% of the vehicle's width when no braking action is applied.

Car-to-Pedestrian Nearside Child 50% (CPNC-50) – a collision in which a vehicle travels forwards towards a child pedestrian crossing its path running from behind and obstruction from the nearside and the frontal structure of the vehicle strikes the pedestrian at 50% of the vehicle's width when no braking action is applied.

Car-to-Pedestrian Longitudinal Adult 25% (CPLA-25) – a collision in which a vehicle travels forwards towards an adult pedestrian walking in the same direction in front of the vehicle where the vehicle strikes the pedestrian at 25% of the vehicle's width when no braking action is applied or an evasive steering action is initiated after an FCW.

Car-to-Pedestrian Longitudinal Adult 50% (CPLA-50) – a collision in which a vehicle travels forwards towards an adult pedestrian walking in the same direction in front of the vehicle where the vehicle strikes the pedestrian at 50% of the vehicle's width when no braking action is applied.

Car-to-Bicyclist Nearside Adult 50% (CBNA-50) – a collision in which a vehicle travels forwards towards a bicyclist crossing its path cycling from the nearside and the frontal structure of the vehicle strikes the bicyclist when no braking action is applied.

Car-to-Bicyclist Longitudinal Adult 25% (CBLA-25) – a collision in which a vehicle travels forwards towards a bicyclist cycling in the same direction in front of the vehicle where the vehicle would strike the cyclist at 25% of the vehicle's width when no braking action is applied or an evasive steering action is initiated after an FCW.

Car-to-Bicyclist Longitudinal Adult 50% (CBLA-50) – a collision in which a vehicle travels forwards towards a bicyclist cycling in the same direction in front of the vehicle where the vehicle would strike the cyclist at 25% of the vehicle's width when no braking action is applied.

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

Euro NCAP Pedestrian Target (EPTa) – means the adult pedestrian target used in this protocol as specified in the Articulated Pedestrian Target Specification document version 2.0.

Euro NCAP Child Target (EPTc) – means the child pedestrian target used in this protocol as specified in the Articulated Pedestrian Target Specification document version 2.0.

Euro NCAP Bicyclist and bike Target (EBT) – means the bicyclist and bike target used in this protocol as specified in the Bicyclist Target Specification document version 1.0.

Time To Collision (TTC) – means the remaining time before the VUT strikes the EPT, assuming that the VUT and EPT would continue to travel with the speed it is travelling.

T_{AEB} – means the time where the AEB system activates. Activation time is determined by identifying the last data point where the filtered acceleration signal is below -1 m/s^2, and then going back to the point in time where the acceleration first crossed -0.3 m/s^2

T_{FCW} – means the time where the audible warning of the FCW starts. The starting point is determined by audible recognition.

Vimpact – means the speed at which the profiled line around the front end of the VUT coincides with the square box around the EPTa, EPTc and EBT.

4.3 Criteria and Scoring

To be eligible for scoring points in AEB VRU, the AEB system must be default ON at the start of every journey. It may not be possible to switch off the system with a single push on a button. Test should be performed with dynamic articulated dummy (not static).

AEB VRU will be assessed with validation tests under manufacturer testing crossing scenario from 2020 to 2022, until a local protocol is developed by December 2022 based in the AEB VRU Euro NCAP Assessment protocol. This protocol will be applied as from 2023 onward.

AEB VRU scoring is conditional to the total points achieved in subsystem tests, i.e. the sum of pedestrian Headform, Upper Legform & Lower Legform scores. If the subsystem total test score is lower than 14 points, no points will be awarded for AEB VRU, regardless whether the system is fitted and would achieve a good score.

Temporarily (in all cases target should be moving):

A. AEB systems that avoid impact between 20 to 30km/h will score a total of 6 points in the AEB VRU.
B. AEB systems that avoid impact between 30 to 40km/h will score a total of 9 points in the AEB VRU. A is a precondition.
C. AEB systems that avoid impact over 40km/h will score a total of 12 points in the AEB VRU. A and B are preconditions.

Three runs at each speed range will be assessed, two out of the three runs should pass in order to be awarded with points.

4.4 Scoring and Visualization

The AEB VRU scores are presented separately using a top view of the validated scenario; adult crossing, child crossing and longitudinal (where applicable).

Only until 1st January 2022 Pedestrian protection subsystems (passive safety) score will have a point balance factor of 15% that will equally affect head, upper and lower leg score over the AEB VRU (active safety) scoring as follows:

Total score of passive safety (subsystems) (Head score + upper leg score + lower leg score), maximum possible score 36 to be multiplied by 1.15 and AEB VRU total score, maximum possible score 12 need to be multiplied by 0.55.

(Head score + upper leg score + lower leg score) x 1.15 + (AEB VRU) x 0.55 = Total PP box score

5 REFERENCES

1 Prasad, P. and H. Mertz. *The position of the US delegation to the ISO Working Group 6 on the use of HIC in the automotive environment.* SAE Paper 851246. 1985

2 Mertz, H., P. Prasad and G. Nusholtz. *Head Injury Risk Assessment for forehead impacts.* SAE paper 960099 (also ISO WG6 document N447)

3 EEVC WG17 Report, 'Improved Test Methods to Evaluate Pedestrian Protection Afforded by Passenger Cars', September 2002.