

HGV Assessment Protocol

Crash Avoidance

Implementation November 2024

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PREFACE

During the test preparation, vehicle manufacturers are encouraged to liaise with the laboratory and to check that they are satisfied with the way cars are set up for testing. Where a manufacturer feels that a particular item should be altered, they should ask the laboratory staff to make any necessary changes. Manufacturers are forbidden from making changes to any parameter that will influence the test, such as dummy positioning, vehicle setting, laboratory environment etc.

It is the responsibility of the test laboratory to ensure that any requested changes satisfy the requirements of Euro NCAP. Where a disagreement exists between the laboratory and manufacturer, the Euro NCAP secretariat should be informed immediately to pass final judgment. Where the laboratory staff suspect that a manufacturer has interfered with any of the set up, the manufacturer's representative should be warned that they are not allowed to do so themselves. They should also be informed that if another incident occurs, they will be asked to leave the test site.

Where there is a recurrence of the problem, the manufacturer's representative will be told to leave the test site and the Secretary General should be immediately informed. Any such incident may be reported by the Secretary General to the manufacturer and the person concerned may not be allowed to attend further Euro NCAP tests.

DISCLAIMER: Euro 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, Euro NCAP reserves the right to make corrections and determine the assessment and subsequent result of the affected requirement(s).

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1. TRUCK-TO-VEHICLE COLLISIONS

1.1. Introduction

An analysis of European road traffic crash data (where at least one HGV was involved) revealed that Heavy Goods Vehicle (HGV) front-to-rear collisions account for 9 % of passenger car and Light Commercial Vehicle (LCV or van) occupant fatalities and 17 % of HGV occupant fatalities. Considering all injury severities, those figures increase to 20 % and 49 % respectively.

Typical incidents include the HGV colliding with the rear of slow moving or stationary traffic on highways at high relative speeds because of a range of factors including driver distraction, fatigue or misjudgement. Where the HGV collides with a light vehicle the large difference in weight means that the light vehicle sees almost all of the change in velocity putting the occupant(s) of that vehicle at very high risk. Where the collision partner is a heavy vehicle, the large collision energy presents a risk of serious injury to the HGV driver and the occupants of the struck vehicle(s).

To support the driver in avoiding front-to-rear collisions, vehicle manufacturers offer collision avoidance technology that monitors the road and traffic environment and has the ability to warn the driver of an imminent collision, support adequate braking and/or ultimately stop the vehicle by itself. Euro NCAP call this technology Autonomous Emergency Braking (AEB).

Teoh (2021) found that AEB reduced HGV front-to-rear crashes in the US by 41 %. Sander (2021) similarly found a 37 % reduction in HGV front-to-rear crashes with AEB on German highways.

Whilst regulation makes AEB a mandatory requirement for new HGVs, Euro NCAP strives to drive performance improvements to ensure robust and effective operation in a broad range of real-world collision types. To this end, the Euro NCAP scheme builds on the regulatory requirement by:

- Incorporating additional challenging real-world collision scenarios with braking lead vehicles and also offset lead vehicles which are only partly obstructing the HGV path. This can particularly occur on highways without 'hard shoulders' where broken down vehicles try to move the vehicle as far out of the path of other traffic as possible.
- Encouraging full speed range performance by offering maximum reward for avoiding collisions up to the maximum permitted HGV speed of 90 km/h.
- Promoting real-world operation robustness by investigating the AEB system response to modest driver inputs insufficient to avoid the imminent collision

This protocol specifies the HGV-to-Car Rear (HCR) assessment procedure for the truck safety rating scheme. Two areas of assessment are considered: the HCR function addressing front-to-rear collisions and the Human Machine Interface (HMI).

1.2. Definitions

Throughout this protocol the following terms are used:

Heavy Goods Vehicle (HGV) – a category N2 or N3 vehicle with gross mass exceeding 3,500 kg.

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.

HGV-to-Car Rear (HCR) – a collision in which a vehicle travels forwards towards another vehicle and the frontal structure of the vehicle strikes the rear structure of the other.

HGV-to-Car Rear Stationary (HCRs) – a collision in which a vehicle travels forwards towards another stationary vehicle and the frontal structure of the vehicle strikes the rear structure of the other.

HGV-to-Car Rear Moving (HCRm) – a collision in which a vehicle travels forwards towards another vehicle that is travelling at constant speed and the frontal structure of the vehicle strikes the rear structure of the other.

HGV-to-Car Rear Braking (HCRb) – a collision in which a vehicle travels forwards towards another vehicle that is travelling at constant speed and then decelerates, and the frontal structure of the vehicle strikes the rear structure of the other.

Vehicle Under Test (VUT) – means the vehicle, or vehicle and trailer combination, tested according to this protocol with a pre-crash collision mitigation or avoidance system on board.

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 mudguards and the deflected part of the tyre sidewalls immediately above the point of contact with the ground.

Global Vehicle Target (GVT) – means the vehicle target used in this protocol as defined in ISO 19206-3:2021

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

T_{AEB} – 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_{impact} – the time at which the VUT hits the GVT.

V_{impact} – the speed at T_{impact}.

V_{rel_impact} – the relative speed at which the VUT hits the GVT by subtracting the velocity of the GVT at T_{impact} from V_{impact}.

1.3. Frontal Collisions Criteria and Scoring

1.3.1. Eligibility

To be eligible for scoring points in HCR, the effective system(s) must be default on at the start of every journey.

1.3.2. Scoring

1.3.2.1. HCRs and HCRb Scenarios

For HCRs and HCRb tests, the assessment criteria used is the impact speed V_{impact}. For each test configuration, the V_{impact} result is given a colour based on the scheme illustrated in Figure 1-1. HCRb tests are considered to be equivalent to an HCRs test with 50 and 80 km/h VUT test speeds.

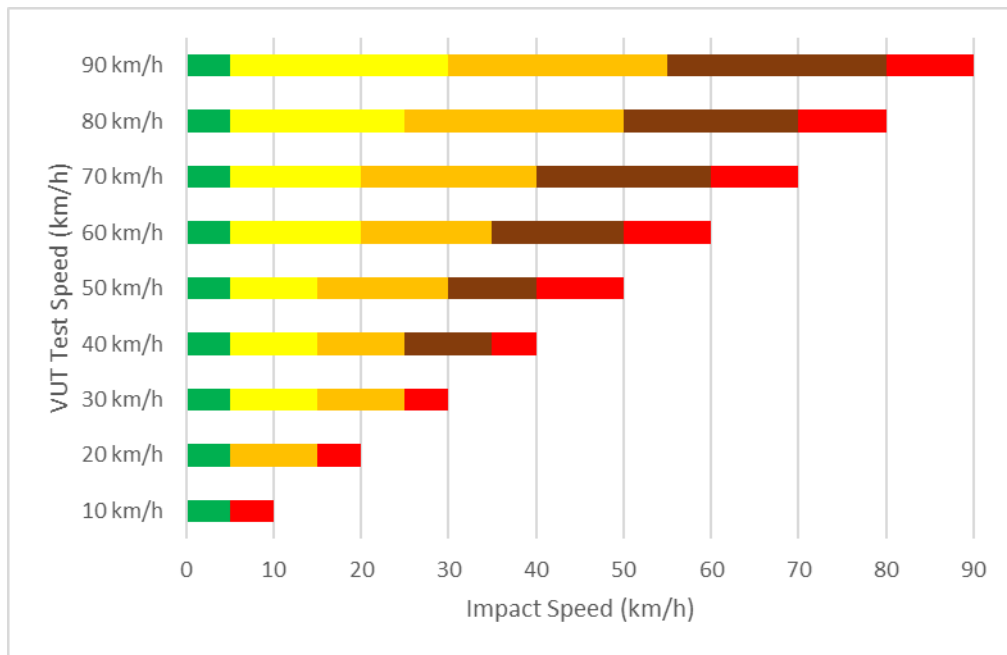


Figure 1-1 HCRs and HCRb performance

To aid understanding, Table 1-1 illustrates the speed range for each colour in an HCRs and an HCRb test configuration with a VUT test speed of 50 km/h.

Colour	Impact speed range (km/h)
Green	$0 < V_{\text{impact}} < 5$
Yellow	$5 \leq V_{\text{impact}} < 15$
Orange	$15 \leq V_{\text{impact}} < 30$
Brown	$30 \leq V_{\text{impact}} < 40$
Red	$40 \leq V_{\text{impact}}$

Table 1-1 Speed range for each colour in a HCRs and HCRb 50 km/h test

1.3.2.2. HCRm Scenarios

For HCRm tests, the assessment criteria used is the relative impact speed $V_{\text{rel_impact}}$. For each test configuration, the $V_{\text{rel_impact}}$ result is given a colour based on the scheme illustrated in Figure 1-2.

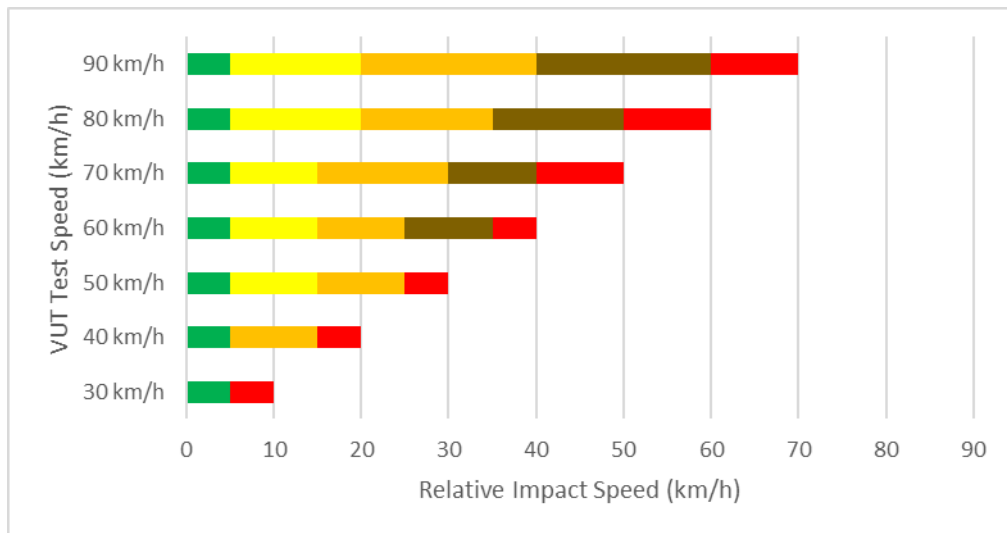


Figure 1-2 HCRm performance

1.3.2.3. All HCR Scenarios

For each test configuration result, Table 1-2 shows the scaling applied to the points available.

Colour	Scaling
Green	1.000
Yellow	0.750
Orange	0.500
Brown	0.250
Red	0.000

Table 1-2 Points scaling for each colour for HCR

The points available for each HCR scenario test configuration are shown in Table 1-3. Note that the 50% impact location score is six times weighted for HCRs and HCRm.

VUT Test Speed (km/h)	HGV-to-Car Rear (HCR)						
	HCRs Impact Location			HCRm Impact Location			HCRb
	0%	50%	100%%	0%	50%	100%	50%
10	1	1	1	-	-	-	-
20	1	1	1	-	-	-	-
30	1	1	1	1	1	1	-
40	1	1	1	1	1	1	-
50	2	2	2	1	1	1	4 x 1
60	2	2	2	1	1	1	-
70	2	2	2	2	2	2	-
80	2	2	2	2	2	2	4 x 1
90	2	2	2	2	2	2	-
Weighting	1	6	1	1	6	1	1
Total	112			80			8

Table 1-3 HCR points available per scenario and test speed

The proportion of points scored in each scenario, known as the normalised scenario score, are carried forward for calculating the final HCR score. To aid understanding, if 50 points are scored out of the total of 80 available for HCRm, a normalised scenario score of 0.625 is carried forward.

1.3.3. Sensitivity to Driver Inputs

If any one or more of the three HCRs tests with a modest steering, accelerator or braking input used to assess system sensitivity to driver inputs results in a collision between the VUT and the GVT, a yellow scaling factor of 0.750 is applied to the sum of the normalised HCRs, HCRm and HCRb test scores. If all collisions continue to be avoided a green scaling factor of 1.000 is applied.

1.3.4. Human Machine Interface

HMI points can be achieved for the following features:

- Deactivation of the HCR system not possible with a momentary single push on a button
1 point
- In case the HCR system is deactivated, automatic full reactivation of the system after a maximum of 15 minutes
1 point

The proportion of points scored in HMI, known as the normalised HMI score, are carried forward for calculating the final HCR score. To aid understanding, if 1 point is scored out of the total of 2 available, a normalised HMI score of 0.500 is carried forward.

1.3.5. Final HCR Score

A maximum of 35 points is available for HCR in Crash Avoidance. The final HCR score is calculated using the weighted sum of the normalised scenario scores acknowledging the sensitivity to driver inputs scaling factor, and the normalised HMI score.

$$\text{Final HCR score} = 35 * \sum \left(\text{sensitivity to driver inputs scaling factor} * \sum \begin{matrix} 0.3 * \text{normalised HCRs score} \\ 0.3 * \text{normalised HCRm score} \\ 0.3 * \text{normalised HCRb score} \\ 0.1 * \text{normalised HCR HMI score} \end{matrix} \right)$$

1.4. Visualisation

The final HCR score is presented to one decimal place and visualised using the colour scheme shown in Table 1-4.

Colour	Verdict	Applied to Score
Green	Good	26.251 to 35.000 points
Yellow	Adequate	17.501 to 26.250 points
Orange	Marginal	8.751 to 17.500 points
Brown	Poor	0.001 to 8.750 points
Red	Weak	0.000 points

Table 1-4 HCR scoring visualisation

2. TRUCK-TO-VRU COLLISIONS

2.1. Introduction

An analysis of European road traffic crash data revealed that collisions with pedestrians account for 16 % of fatalities in HGV collisions, and bicyclists a further 10 %. International crash data does not offer easy breakdowns of crash type. However, a Euro NCAP study of police reported collisions occurring in the UK generally, and London specifically, identified that circa 40 to 45 % of all HGV-to-pedestrian fatalities occur when an HGV moving at normal traffic speeds collides with a pedestrian crossing in front of it, or walking ahead of it longitudinally. In urban areas about 20 % of pedestrian fatalities occur in those situations. Regarding bicyclists, circa 17 % of all HGV-to-bicyclist fatalities fall within the scope of the crossing and longitudinal scenarios, and circa 2 % of those occurring in urban areas.

Incidents also occur at moderate speeds with crossing pedestrians in urban areas, and at high speeds on highways involving vehicle occupants who have become pedestrians having exited their immobile vehicle, and highways construction and maintenance operatives when vehicles stray into their restricted work areas. The vast majority of HGV-to-VRU collisions occur in daylight.

Regarding HGV near side turning, the study identified that circa 3 % of all HGV-to-pedestrian fatalities fall within the scope of the nearside turning scenarios, and circa 6 % of those occurring in urban areas. Regarding bicyclists, circa 22 % of all HGV-to-bicyclist fatalities fall within the scope of the nearside turning scenarios, and circa 40 % of those occurring in London. Highway infrastructure is a defining factor in the nature of HGV-to-bicyclist nearside turning collisions, affected by junction size and whether the HGV and bicyclist share the same road space or if a dedicated cycle lane is provided, offset from the vehicle lane.

Typical incidents in occur in busy urban environments when the HGV is moving off or turning at low speed and enters into conflict with a pedestrian or bicyclist crossing or passing alongside. The vast majority of such collisions occur in daylight. The initial collision often occurs at low speed and regularly goes undetected because of the large HGV-to-VRU mass ratio and vehicle noise masking signs of the impact, and the large vehicle size and elevated driving position meaning the event is remote from the driver and/or not directly visible. The near-vertical front and sides of the HGV regularly cause the VRU to be knocked down and the significant injury mechanism is often the wheels overrunning the VRU, especially when turning as the rear axle(s) cut in.

To support the driver in avoiding collisions with VRUs, vehicle manufactures offer collision avoidance technology that monitors the road and traffic environment and has the ability to warn the driver of an imminent collision, support adequate braking and/or ultimately stop the vehicle by itself. Where this technology is sensitive to VRUs like pedestrians and bicyclists, Euro NCAP call this technology Autonomous Emergency Braking for Vulnerable Road Users (AEB VRU).

Whilst regulation makes AEB VRU a mandatory requirement for new HGVs in 2028, Euro NCAP strives to accelerate fitment ahead of this time and drive performance improvements to ensure robust and effective AEB VRU operation in a broad range of real-world collision types. To this end, the Euro NCAP scheme builds on the regulatory requirement by:

- Incorporating additional challenging real-world collision scenarios with walking and running adult and child pedestrians, cycling bicyclists, impact locations offset from the centreline of the HGV and line of sight obstructions reminiscent of urban environments
- Rewarding systems that automatically intervene to apply braking when an HGV is in conflict with a VRU in critical near side turning collisions (Regulation only requires information and warning in this scenario)
- Encouraging higher speed operation and performance by offering maximum reward for avoiding collisions at higher test speeds

This protocol specifies the HGV-to-VRU assessment procedures for the HGV safety rating scheme. Four areas of assessment are considered: the VRU pedestrian (HP) and bicyclist (HB) functions addressing frontal collisions with crossing and longitudinal VRUs, the bicyclist low speed nearside turn (HBTA) function addressing side collisions with bicyclists and the Human Machine Interface (HMI).

2.2. Definitions

Throughout this protocol the following terms are used:

Heavy Goods Vehicle (HGV) – a category N2 or N3 vehicle with gross mass exceeding 3,500 kg.

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.

HGV-to-Pedestrian (HP) – a collision in which a vehicle strikes a pedestrian

HGV-to-Pedestrian Farside Adult 50% (HPFA-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.

HGV-to-Pedestrian Nearside Adult 25% (HPNA-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 applied.

HGV-to-Pedestrian Nearside Adult 75% (HPNA-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.

HGV-to-Pedestrian Nearside Child 50% (HPNCO-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.

HGV-to-Pedestrian Longitudinal Adult 25% (HPLA-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.

HGV-to-Pedestrian Longitudinal Adult 50% (HPLA-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.

HGV-to-Bicyclist (HB) – a collision in which a vehicle strikes a bicyclist

HGV-to-Bicyclist Nearside Adult 50% (HBNA-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.

HGV-to-Bicyclist Longitudinal Adult 25% (HBLA-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.

HGV-to-Bicyclist Longitudinal Adult 50% (HBLA-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 50% of the vehicle's width when no braking action is applied.

HGV-to-Bicyclist Nearside Turn Across Path (HBTA) – a collision in which a vehicle turns to the nearside across the path of a bicyclist travelling in the same direction at constant speed, and the cyclist strikes the side of the vehicle under test.

Vehicle Under Test (VUT) – means the vehicle, or vehicle and trailer combination, tested according to this protocol with a pre-crash collision mitigation or avoidance system on board.

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 mudguards and the deflected part of the tyre sidewalls immediately above the point of contact with the ground.

Euro NCAP Pedestrian Target (EPTa) – means the articulated adult pedestrian target used in this protocol as specified ISO 19206-2:2018.

Euro NCAP Child Target (EPTc) – means the articulated child pedestrian target used in this protocol as specified in ISO 19206-2:2018.

Euro NCAP Bicyclist and bike Target (EBT) – means the bicyclist and bike target used in this protocol as specified in ISO 19206-4:2020.

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

T_{AEB} – 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_{impact} – means the time at which the profiled line around the front end of the VUT coincides with the square box around the EPT or EBT as shown in the figure below.

V_{impact} – means the speed at which the profiled line around the front end of the VUT coincides with the square box around the EPT or EBT as shown in Figure 2-1 and Figure 4-2 below.

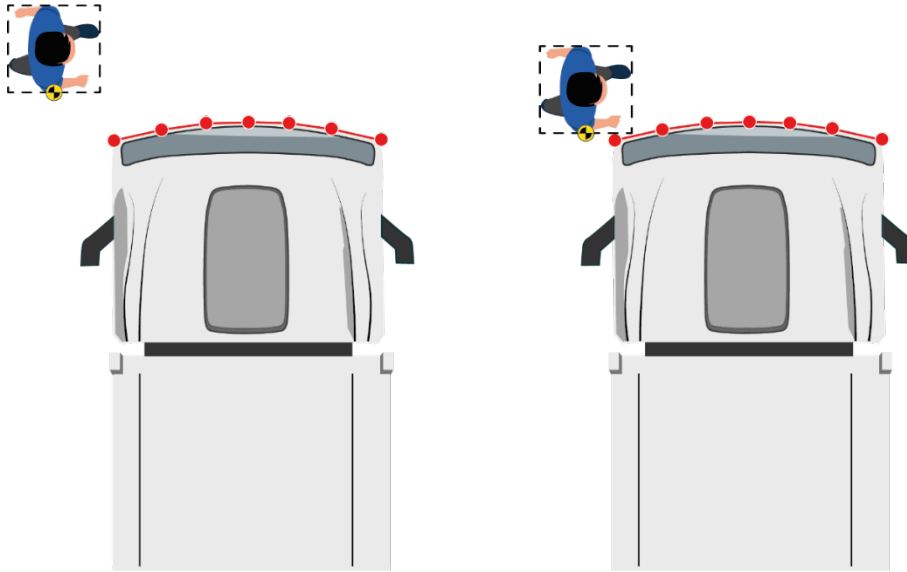


Figure 2-1 Front end profile and EPT

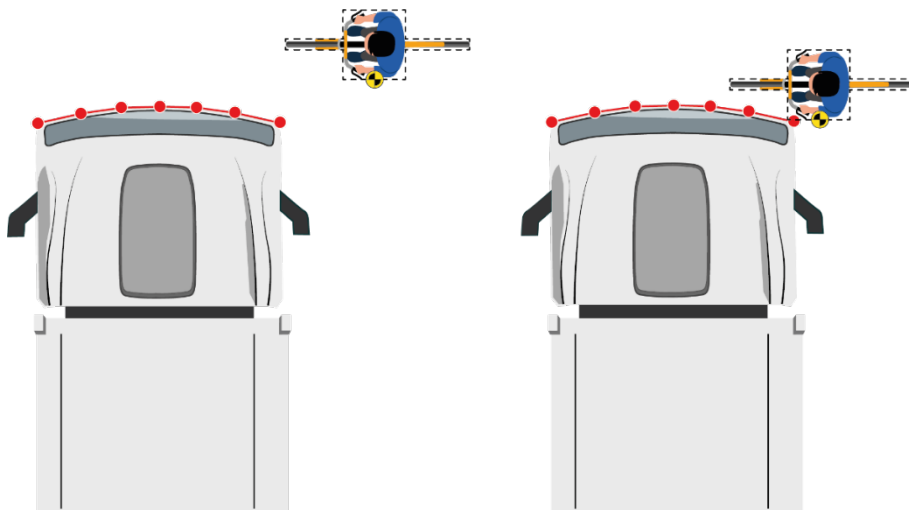


Figure 2-2 Front end profile and EBT

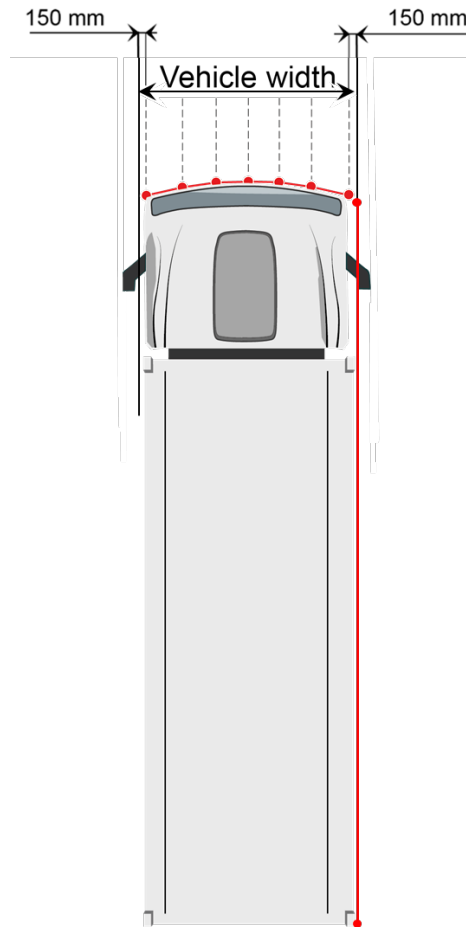


Figure 2-3 VUT front and near side virtual profile

V_{rel_test} – means the relative speed between the VUT and the EPT or EBT by subtracting the longitudinal velocity of the EPT or EBT from that of the VUT at the start of the test.

V_{rel_impact} – means the relative speed at which the VUT hits the EPT or EBT by subtracting the velocity of the EPT or EBT from V_{impact} at the time of collision.

2.3. Frontal Collisions Criteria and Scoring

2.3.1. Eligibility

To be eligible for scoring points in HP and HB crossing and longitudinal, the effective system(s) must be default on at the start of every journey.

2.3.2. Scoring

2.3.2.1. VRU Crossing Scenarios

For the following crossing test scenarios, the assessment criteria used is V_{impact} :

- HPFA-50, HPNA-25, HPNA-75 and HPNCO-50
- HBNA-50

For each pedestrian and bicyclist crossing test configuration, the V_{impact} result is given a colour based on the scheme illustrated in Figure 2-4.

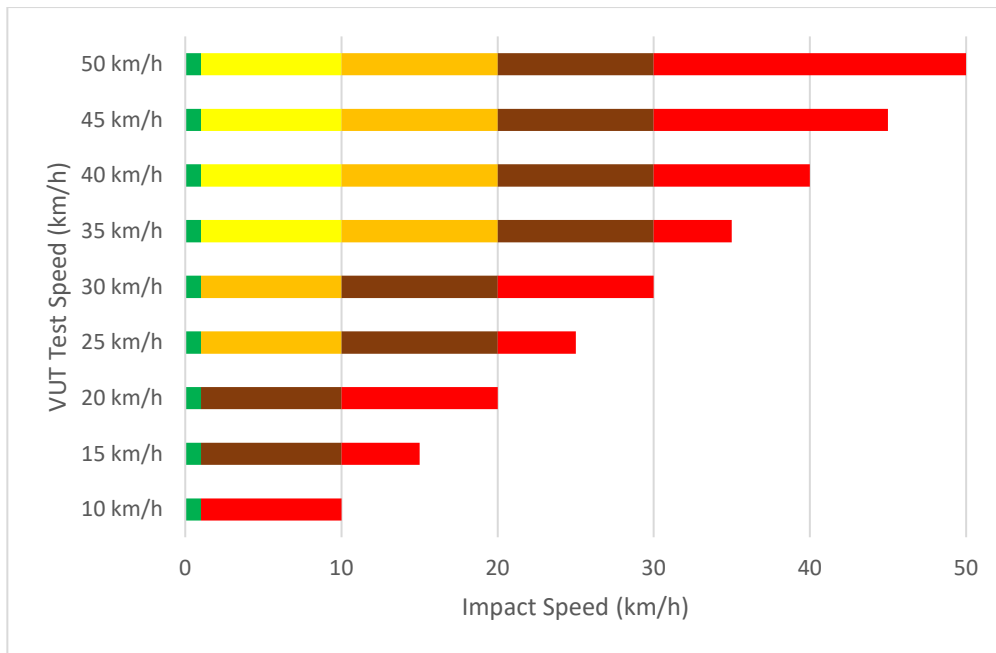


Figure 2-4 HPFA-50, HPNA-25, HPNA-75, HPNCO-50 and HBNA-50 scenario performance

To aid understanding, Table 2-1 illustrates the speed range for each colour in a crossing test configuration with a VUT test speed of 50 km/h.

Colour	Impact speed range (km/h)
Green	$V_{\text{impact}} = 0$, collision avoided
Yellow	$0 < V_{\text{impact}} < 10$
Orange	$10 \leq V_{\text{impact}} < 20$
Brown	$20 \leq V_{\text{impact}} < 30$
Red	$30 \leq V_{\text{impact}}$

Table 2-1 Speed range for each colour in a VRU crossing 50 km/h test

In any scenario the VUT may enter the path of the VRU target after the VRU target has completely passed the path of the VUT.

2.3.2.2. VRU Longitudinal Scenarios

For the following longitudinal test scenarios, the assessment criteria used is $V_{\text{rel_impact}}$:

- HPLA-25 and HPLA-50
- HBLA-25 and HBLA-50

For each pedestrian longitudinal test configuration, the $V_{\text{rel_impact}}$ result is given a colour based on the scheme illustrated in Figure 2-5.

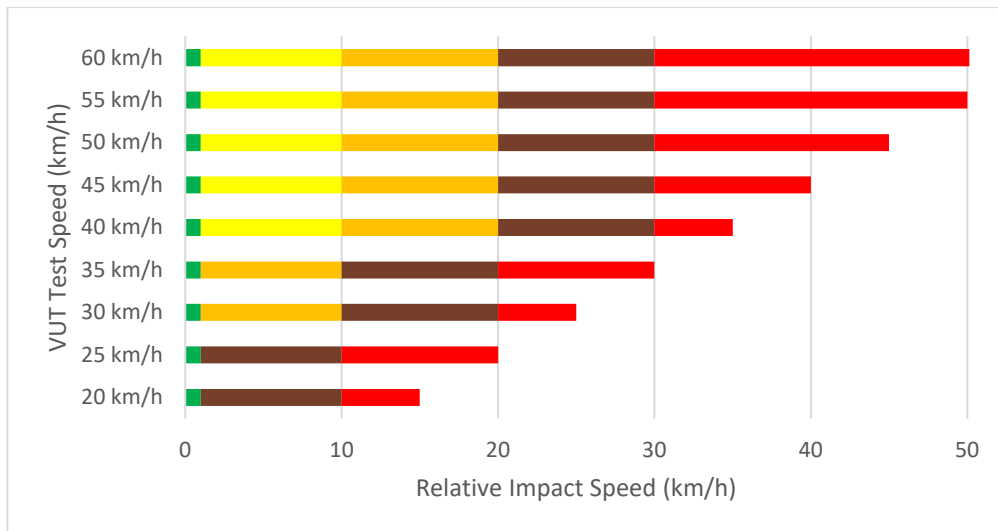


Figure 2-5 HPLA-25 and HPLA-50 scenario performance

For each bicyclist longitudinal test configuration, the V_{rel_impact} result is given a colour based on the scheme illustrated in Figure 2-6.

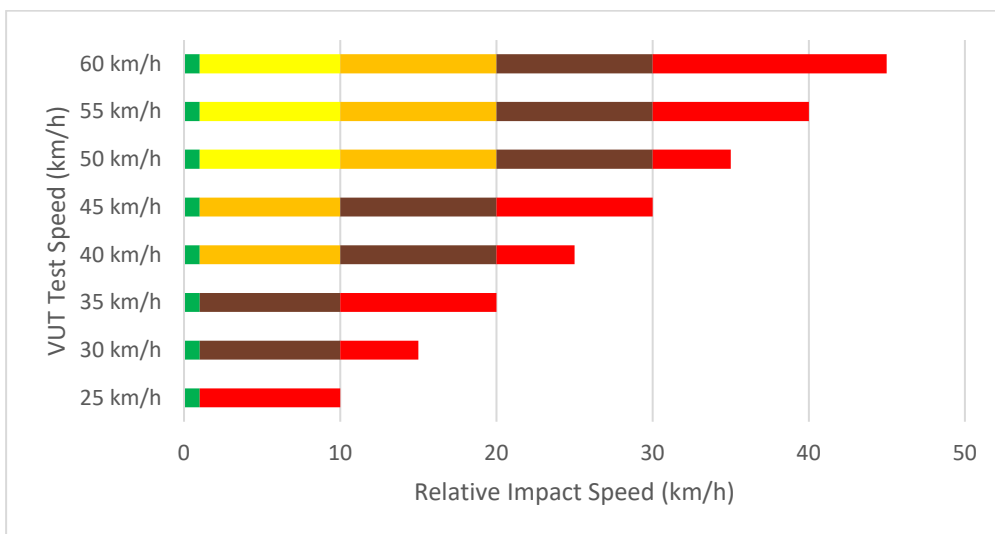


Figure 2-6 HBLA-25 and HBLA-50 scenario performance

For the HPLA-25 and HBLA-25 longitudinal FCW test scenarios, the assessment criteria used is the TTC at which the FCW commences. The available points per test speed are awarded when the warning is issued at a $TTC \geq 2.20$ s.

2.3.2.3. All VRU Crossing and Longitudinal Scenarios

For each test configuration result, Table 2-2 shows the scaling applied to the points available.

Colour	Scaling
Green	1.000
Yellow	0.750
Orange	0.500
Brown	0.250
Red	0.000

Table 2-2 Points scaling for each colour in a VRU crossing and longitudinal test

2.3.3. VRU Pedestrian Crossing and Longitudinal

The points available for each HP crossing and longitudinal scenario test configuration are shown in Table 2-3.

VUT Test Speed (km/h)	HGV-to-Pedestrian (HP) Frontal						FCW
	HPFA-50	HPNA-25	HPNA-75	HPNCO-50	HPLA-25	HPLA-50	HPLA-25
10	1	1	1	1	-	-	-
15	1	1	1	1	-	-	-
20	1	1	1	1	1	1	-
25	2	2	2	2	1	1	-
30	2	2	2	2	1	1	-
35	2	2	2	2	2	2	-
40	2	2	2	2	2	2	-
45	2	2	2	2	2	2	-
50	2	2	2	2	2	2	1
55	-	-	-	-	2	2	1
60	-	-	-	-	2	2	1
65	-	-	-	-	-	-	1
70	-	-	-	-	-	-	1
75	-	-	-	-	-	-	1
80	-	-	-	-	-	-	1
85	-	-	-	-	-	-	1
90	-	-	-	-	-	-	1
Weighting	2	2	2	1	1	1	1
Total	144						

Table 2-3 HP crossing and longitudinal points available per scenario and test speed

The proportion of the total points scored for all HP frontal scenarios, known as the normalised HP frontal score, is carried forward for calculating the final HP/HB frontal score. To aid understanding,

if 96 points are scored out of the total of 144 available for HP frontal, a normalised scenario score of 0.667 is carried forward.

2.3.4. VRU Bicyclist Crossing and Longitudinal

The points available for each HB crossing and longitudinal scenario test configuration are shown in Table 2-4.

VUT Test Speed (km/h)	HGV-to-Bicyclist (HB) Frontal			FCW
	HBNA-50	HBLA-25	HBLA-50	HBLA-25
10	1	-	-	-
15	1	-	-	-
20	1	-	-	-
25	2	1	1	-
30	2	1	1	-
35	2	1	1	-
40	2	2	2	-
45	2	2	2	-
50	2	2	2	1
55	-	2	2	1
60	-	2	2	1
65	-	-	-	1
70	-	-	-	1
75	-	-	-	1
80	-	-	-	1
85	-	-	-	1
90	-	-	-	1
Weighting	1	1	1	1
Total	50			

Table 2-4 HB crossing and longitudinal points available per scenario and test speed

The proportion of the total points scored for all HB frontal scenarios, known as the normalised HB frontal score, is carried forward for calculating the final HP/HB frontal score. To aid understanding, if 40 points are scored out of the total of 50 available for HP frontal, a normalised scenario score of 0.800 is carried forward.

2.3.5. Human Machine Interface

HMI points can be achieved for the following features:

- Deactivation of the HP/HB frontal system not possible with a momentary single push on a button 1 point
- In case the HP/BP frontal system is deactivated, automatic full reactivation of the system after a maximum of 15 minutes 1 point

The proportion of points scored in HMI, known as the normalised HP/HB frontal HMI score, are carried forward for calculating the final HP/HB frontal score. To aid understanding, if 1 point is scored out of the total of 2 available, a normalised HP/HM frontal HMI score of 0.500 is carried forward.

2.3.6. Final HP/HB Frontal Score

A maximum of 25 points is available for HP/HB frontal in Crash Avoidance. The final HP/HB frontal score is calculated using the weighted sum of the normalised HP and HB scenario scores and the normalised HMI score.

$$\text{Final HP/HB frontal score} = 25 * \sum \begin{matrix} \text{normalised HP frontal score} * 0.7 \\ \text{normalised HB frontal score} * 0.2 \\ \text{normalised HP/HB frontal HMI score} * 0.1 \end{matrix}$$

2.4. Low Speed Manoeuvring Collisions Criteria and Scoring

2.4.1. Eligibility

To be eligible for scoring points in HBTA, the effective system(s) must be default on at the start of every journey.

2.4.2. Scoring

For the HBTA scenarios, the assessment criteria illustrated in Table 2-5.

Colour	HBTA assessment criteria	
	Front corner (0.0 m)	Near side (3.0 m)
Green	VUT intervention prevents a collision between the VUT and EBT	VUT intervention brakes the VUT to stationary before the EBT would impact the side of the VUT
Yellow	An impact occurs between the VUT and the EBT* and the VUT intervention prevents the VUT overrunning the EBT	An impact occurs between the VUT and the EBT and the VUT and intervention prevents the VUT overrunning the EBT
Red	No VUT system intervention and the VUT impacts the EBT and would continue to overrun the EBT	No VUT system intervention and the VUT impacts the EBT and would continue to overrun the EBT

Table 2-5 HBTA assessment criteria for each colour in near side turning scenarios

* For assessment purposes, although indirect vision devices are excluded from the VUT profile, contact between the EBT and protruding indirect vision devices, evidenced by testing media, is considered as an impact and will be awarded the yellow colour band.

For each test configuration result, Table 2-6 shows the scaling applied to the points available.

Colour	Scaling
Green	1.000

Yellow	0.750
Red	0.000

Table 2-6 Points scaling for each colour in an HBTA test

The points available for each HBTA scenario test configuration are shown in Table 2-3.

HBTA Trajectory			1	2	3
			Borrow From Source	Large Radius Turn	Borrow From Destination
Without turn signal applied	2.8m lateral distance	Front corner (0.0m)	1	1	1
		Near side (3.0m)	1	1	1
	4.3m lateral distance	Front corner (0.0m)	1	1	1
		Near side (3.0m)	1	1	1
With turn signal applied	2.8m lateral distance	Front corner (0.0m)	1	1	1
		Near side (3.0m)	1	1	1
	4.3m lateral distance	Front corner (0.0m)	1	1	1
		Near side (3.0m)	1	1	1
Weighting			1	1	1
Total			24		

Table 2-7 HBTA points available per trajectory and collision scenario configuration

Note that the points are awarded in scenario configurations without the turn signal applied are also awarded in the same scenario configurations with the turn signal applied unless testing results indicate different points should be awarded.

2.4.3. Final HBTA Score

A maximum of 15 points is available for HBTA in Crash Avoidance. The final HBTA score is the sum of the points scored, capped to a maximum of 15 points. To aid understanding, if 8 points are scored out of the total of 24 available, the final HBTA score is 8 points. If 20 points are scored out of the total of 24 available, the final HBTA score is 15 points.

2.5. Visualisation

The final HP/HB frontal score is presented to one decimal place and visualised using the colour scheme shown in Table 2-8.

Colour	Verdict	Applied to Score
Green	Good	18.751 to 25.000 points
Yellow	Adequate	12.501 to 18.750 points
Orange	Marginal	6.251 to 12.500 points
Brown	Poor	0.001 to 6.250 points
Red	Weak	0.000 points

Table 2-8 HP/HB frontal scoring visualisation

The final HBTA score is presented to one decimal place and visualised using the colour scheme shown in Table 2-9.

Colour	Verdict	Applied to Score
Green	Good	11.251 to 15.000 points
Yellow	Adequate	7.501 to 11.250 points
Orange	Marginal	3.751 to 7.500 points
Brown	Poor	0.001 to 3.750 points
Red	Weak	0.000 points

Table 2-9 HBTA scoring visualisation

3. LANE DEPARTURE COLLISIONS

3.1. Introduction

HGV lane departure is one of the main causes of single vehicle and frontal head-on collisions. Incidents can be severe because of the vehicle mass and regular highway driving speeds. An analysis of European road traffic crash data revealed that head-on and single vehicle collisions involving an HGVs account for 7 % of all road traffic fatalities. Lane changing collision on highways, whilst often less severe in their outcome, also have the potential to cause serious injury and major disruption. Therefore Euro NCAP has expanded its safety testing programme to HGVs to help countries across Europe to achieve their 'Vision Zero' target and end traffic-related fatalities.

Typical incidents include the HGV drifting out of lane on highways and colliding with stationary or adjacent moving vehicles, roadside furniture or temporary roadworks equipment because of a range of factors including driver distraction, fatigue or misjudgement. Incidents on rural roads include drifting out of lane into the path of oncoming vehicles or running off the road, frequently resulting in HGV rollover. The high energy of the HGV presents a risk of serious injury to the HGV driver and the occupants of the struck vehicle(s).

To support the driver in avoiding lane departure collisions, vehicle manufactures offer collision avoidance technology that monitors the road and traffic environment and has the ability to warn the driver of imminent lane departure and support the directional control of the vehicle by itself.

A Euro NCAP study of Swedish in-depth accident data identified that, accounting for loss of control and other limiting factors, lane departure systems had the potential to have a beneficial effect in 45 % of fatal heavy truck single vehicle crashes. This effect was relevant to all of the highway collision cases and half of the rural road collision cases.

Whilst regulation makes Lane Departure Warning (LDW) a mandatory requirement for new HGVs, Euro NCAP strives to drive performance improvements to ensure robust and effective lane departure systems operation in a broad range of real-world collision types. To this end, the Euro NCAP scheme builds on the regulatory requirement by:

- Recognising systems that actively intervene to correct the HGV path in case of imminent lane departure, returning the HGV back in line with the road ahead
- Incorporating additional challenging real-world collision scenarios with adjacent vehicles in hard to see locations to encourage imminent collision threat detection
- Rewarding features that promote driver acceptance through effective and efficient real-world operation

This protocol specifies the HGV lane departure assessment procedure for the HGV safety rating scheme. Three areas of assessment are considered: the Lane Keeping Assist (LKA) function, the Emergency Lane Keeping (ELK) overtaking function and the Human Machine Interface (HMI). To be eligible to score points for lane departure, the vehicle must be equipped with an ESC system meeting the regulatory requirements.

3.2. Definitions

Throughout this protocol the following terms are used:

Emergency Lane Keeping (ELK) – heading correction that is applied automatically by the vehicle in response to the detection of the vehicle that is about to change lane into other traffic in the adjacent lane.

Lane Keeping Assist (LKA) – heading correction that is applied automatically by the vehicle in response to the detection of the vehicle that is about to drift beyond a delineated edge line of the current travel lane.

Vehicle Under Test (VUT) – means the vehicle tested according to this protocol with a Lane Keeping Assist and/or Emergency Lane Keeping system.

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

Lane edge – means the inner side of the lane marking or the road edge.

Distance To Lane Edge (DTLE) – means the remaining lateral distance (perpendicular to the lane edge) between the lane edge and outermost edge of the tyre, before the VUT crosses lane edge, assuming that the VUT would continue to travel with the same lateral velocity towards it.

3.3. Criteria and Scoring

3.3.1. Eligibility

To be eligible for scoring points in lane departure, the driver must be able to override the intervention of the system.

To be eligible for scoring points in LKA and/or ELK, it is required that the effective system(s) must be default on at the start of every journey.

3.3.2. Scoring

3.3.2.1. Lane Departure Scenarios

For lane departure tests, the assessment criteria used is the DTLE. Note that a positive DTLE indicates that the outermost edge of the tyre did not cross the lane edge. A negative DTLE indicates that the outermost edge of the tyre crossed the lane edge. For each test configuration, the DTLE result is given a colour based on the scheme illustrated in Table 3-1.

Colour	Distance To Lane Edge (DTLE) (m)
Green	$-0.30 \leq \text{DTLE}$
Orange	$-0.50 \leq \text{DTLE} < -0.30$
Red	$\text{DTLE} < -0.50$

Table 3-1 DTLE for each colour in lane departure scenarios

For each test configuration result, Table 3-2 shows the scaling applied to the points available.

Colour	Scaling
Green	1.000
Orange	0.500
Red	0.000

Table 3-2 Points scaling for each colour in a lane departure test

The points available for each lane departure scenario test configuration are shown in Table 3-3.

Lateral Velocity (m/s)	Solid Line		Dashed Line	
	Left	Right	Left	Right
0.20	1	1	1	1
0.30	1	1	1	1
0.40	1	1	1	1
0.50	1	1	1	1
Weighting	1	1	1	1
Total	16			

Table 3-3 Lane departure points available per scenario and lateral velocity

The proportion of the total points scored for all lane departure scenarios, known as the normalised lane departure score, is carried forward for calculating the final lane departure score. To aid understanding, if 10 points are scored out of the total of 16 available for lane departure, a normalised scenario score of 0.625 is carried forward.

3.3.2.2. Lane Change With Adjacent Vehicle Scenarios

For lane change with adjacent vehicle tests, the assessment criteria used impact avoided or impact occurred. For each test configuration, the impact result is given a colour based on the scheme illustrated in Table 3-4.

Colour	Distance To Lane Edge (DTLE) (m)
Green	Impact avoided
Red	Impact occurred

Table 3-4 Impact outcome for each colour in lane change with adjacent vehicle scenarios

For each test configuration result, Table 3-5 shows the scaling applied to the points available.

Colour	Scaling
Green	1.000
Red	0.000

Table 3-5 Points scaling for each colour in a lane change with adjacent vehicle test

The points available for each lane change with adjacent vehicle scenario test configuration are shown in Table 3-6.

Lateral Velocity (m/s)	Lane Change With Adjacent Vehicle	
	Near side front corner	Far side blind spot
0.50	1	1
0.60	1	1
0.70	1	1
Weighting	1	1
Total	6	

Table 3-6 Lane change with adjacent vehicle points available per scenario and lateral velocity

The proportion of the total points scored for all lane change with adjacent vehicle scenarios, known as the normalised lane change with adjacent vehicle score, is carried forward for calculating the final lane departure score. To aid understanding, if 3 points are scored out of the total of 6 available for lane departure, a normalised scenario score of 0.500 is carried forward.

3.3.3. Human Machine Interface

HMI points can be achieved for the following features:

- Deactivation of the effective system(s) not possible with a momentary single push on a button 1 point
- Secondary departure prevention – a feature that acts after the initial heading correction to maintain DTLE ≥ 0 relative to the opposite side lane marking in all test scenarios for which lane departure points were awarded (note this is a discrete input and does not constitute assisted driving continuous vehicle guidance steering support) 1 point
- Novel features promoting driver acceptance – for the OEM to submit a description of the feature illustrating how it promotes driver acceptance whilst maintaining or enhancing safety 1 point

The proportion of points scored in HMI, known as the normalised lane departure HMI score, are carried forward for calculating the final lane departure score. To aid understanding, if 1 point is scored out of the total of 3 available, a normalised lane departure HMI score of 0.333 is carried forward.

3.3.4. Final Lane Departure Score

A maximum of 25 points is available for lane departure in Crash Avoidance. The final lane departure score is calculated using the weighted sum of the normalised lane departure and lane change with adjacent vehicle scenario scores and the normalised HMI score.

$$\text{Final lane departure score} = 25 * \sum \begin{matrix} \text{normalised lane departure score} * 0.5 \\ \text{normalised lane change with adjacent vehicle score} * 0.4 \\ \text{normalised lane departure HMI score} * 0.1 \end{matrix}$$

3.1. Visualisation

The final lane departure score is presented to one decimal place and visualised using the colour scheme shown in Table 3-7.

Colour	Verdict	Applied to Score
Green	Good	18.751 to 25.000 points
Yellow	Adequate	12.501 to 18.750 points
Orange	Marginal	6.251 to 12.500 points
Brown	Poor	0.001 to 6.250 points
Red	Weak	0.000 points

Table 3-7 Lane departure scoring visualisation

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