CLIENT PROJECT REPORT CPR2277

Assessing the Direct Vision Performance of Heavy Goods Vehicles (HGVs)

Summary Report

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Report details

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Executive summary

Transport for London's Safer Trucks Programme aims to accelerate the development, supply and wider uptake of safer Heavy Goods Vehicles (HGVs). A particular goal is to improve the safety performance of vehicles during low speed manoeuvres that result in the death or serious injury of pedestrians and cyclists in London.

Blind spots around HGVs have long been identified as a potentially significant contributor to the cause of serious collisions with pedestrians and cyclists. A range of up to six mirrors and other field of view aids are already required to improve the view of these areas. However, these measures rely on the driver looking at the correct mirror or vision aid at the right time to be successful and there are concerns that further increases in the number of devices would overload the driver during critical manoeuvres.

Seeing a pedestrian or cyclist directly through the windows of the vehicle is likely to have several advantages over indirect view through mirrors or camera monitors. The image is full size, free from distortions, substantial movement may be visible, which would help attract the attention of the driver, and direct eye contact is possible between both parties.

Regulations exist to define the minimum standard of direct vision from passenger cars to ensure a minimum size of clear glazed area and particularly to control the number and size of pillars obscuring vision in the 180-degree forward field of view. International standards (e.g. ISO 5006) exist for earth moving machinery. However, no technical standards exist which prescribe minimum standards of direct vision from HGVs.

Cyclists killed and seriously injured at the nearside of trucks turning left have historically been the highest profile collisions related to HGVs in low speed manoeuvres. However, the research has identified that the area of greatest risk extends across the full width of the front of the vehicle and 5 metres back down the nearside of the vehicle. Within this area of greatest risk, the nearside zone is considered relevant to a larger number of London pedestrian and pedal cyclist casualties than the front zone (this is reversed if GB is considered as a whole where the front zone is more relevant).

Two manoeuvres are responsible for these collisions, the vehicle moving off from rest and the vehicle turning left.

- In collisions during moving off from rest, a vulnerable road user (VRU) - usually a pedestrian, occasionally a cyclist - is crossing in front of a stationary HGV and can't be seen directly by the driver (i.e without the aid of mirrors). Traffic lights turn to green, or traffic ahead moves off, and the HGV moves forward running over the vulnerable road user. Casualties are disproportionately elderly. Vehicles with good direct vision performance would enable the vast majority of these vulnerable road users to be seen by an attentive driver directly at a time that would permit the collision to be avoided.
- Turning left collisions usually involve cyclists but occasionally involve pedestrians. The impacts typically occur at the nearside towards the front, though some also occur further back down the side of the vehicle. The dynamics of the pre-collision motion can be complex and can mean that a significant proportion of bicycles will have been positioned to the rear of the HGV cab at the key moment that would permit an attentive driver to avoid the collision. Direct vision is less feasible in this area. Thus, only

the proportion of these casualties positioned nearer to the front of the vehicle would be expected to be visible to an attentive driver at the key moment required to avoid collisions.

This research project carried out as part of the Safer Trucks Programme, funded by TfL, has defined a direct vision assessment for HGVs. This assessment will allow the VRU relevant direct vision in close proximity to any HGV to be reliably and robustly measured and its performance in relation to VRU safety to be categorised using a five star rating scheme. The five star rating rewards incremental improvements to the direct vision performance and avoids the use of descriptive category titles that could be open to interpretation.

The assessment protocol defines:

- A measurement method based on a 'virtual assessment' of the available view through the windows using 3D Computer Aided Design (CAD) techniques.
- Assessment zones based on collision data and the range of human dimensions in the population.
- Vehicle performance rating scheme from zero to five stars.

Application of the rating scheme to a sample of HGVs showed that:

- A typical, off-road specification HGV cab, assessed in its basic form would achieve zero stars. Modifications such as adding a low side window or re-shaping the dashboard may improve their performance to achieve one star.
- Typical on-road specification vehicles achieved two or three stars.
- A vehicle with a low-entry, panoramic cab achieved five stars.

1 Introduction

In Greater London, the number of vulnerable road users (pedestrians and pedal cyclists) that are killed or seriously injured in collisions involving Heavy Goods Vehicles (HGVs) is disproportionate to those involving other types of vehicle. Construction type vehicles (e.g. 4 axle rigid tippers) are substantially over-represented in the data regarding these collisions.

Transport for London is committed to a target of a 50% reduction in the number of people killed or seriously injured on London's roads by 2020 (from the 2005-9 baseline). Reducing vulnerable road user casualties caused by collisions with HGVs is seen as a key contributor towards meeting that goal.

TfL is exploring the options available to encourage the use of vehicles with improved direct vision through both voluntary and contractual measures. It is also considering efforts to encourage legislation to provide minimum standards of direct vision for HGVs through the European Type Approval framework. A technical standard is therefore required for immediate use by TfL; with the possibility that the assessment protocol may also form the basis for contractual conditions and a directive or regulation in the future.

The overall aim of this project was to develop a direct vision assessment protocol that allowed reliable and precise measurement of the direct vision from HGVs and categorised the vehicle vision performance in terms relevant to vulnerable road user safety. The assessment protocol was expected to categorise the vehicles based on the ability of the driver to see vulnerable road users in close proximity to the vehicle where there is potential for conflict between the two.

The objectives specified by TfL were that 3 categories of direct vision should be defined and that even the lowest level would produce an increased view in comparison to a standard construction sector HGV with off-road specifications. TfL identified three classes of vehicle with different standards of direct vision that they would like the direct vision protocol to discriminate between:

- Off-road specification construction vehicles and a variant by which they were equipped with small enhancements such as the addition of a low level side window in the passenger side door.
- Typical on-road specification vehicles.
- Specialist low entry vehicles with panoramic windows such as a Mercedes Econic or a Dennis Eagle Elite, typically used in the refuse sector.

The project involved:

- Analysing collision data, the dynamic events leading to relevant collision mechanisms and road geometries in order to define areas around the vehicle where it was important to be able to see; the area of greatest risk.
- Modelling eight vehicle designs in order to assess how the vision performance of the vehicle could be quantified into appropriate performance bands.
- A review of the scientific literature and existing standards with respect to the measurement of field of view and definition of human visual characteristics.

- Engaging with stakeholders to ensure the protocol developed was well suited to its expected use.

For this research, the relevant stakeholder groups were identified as vehicle manufacturers, vehicle operators and regulators, all of which have a vested interest in the outcomes of this project. One to one meetings or telephone interviews were completed with the major UK manufacturers of HGVs. Vehicle operators were consulted through telephone interviews and involvement in Construction Logistics and Cyclist Safety (CLOCS) meetings.

TfL and TRL would like to thank all those who contributed to this process, which has helped to define the proposed Direct Vision Protocol for HGVs.

This report summarises the main findings and conclusions of the work. A separate technical report is available, which describes in detail how the direct vision assessment protocol was developed. A separate technical protocol document has been prepared in a format consistent with ISO standards in order to allow those assessing the vehicles to undertake testing in accordance with the process described here.

2 Where and what do drivers need to see?

An analysis of where and what drivers need to see was based on reviews of high level collision data, in-depth analysis of the detailed motion of the parties in individual cases and data defining the typical and extreme sizes of people, to allow assessment of how much of a short, average, or tall person can be seen in any particular position around the vehicle. The result was the definition of 3-dimensional zones at the front and nearside, where direct vision would allow the driver to see a vulnerable road user at the time required to enable them to react appropriately and avoid a collision.

2.1 Horizontal location – Where do drivers need to see?

The location of pedestrians around the vehicle at the critical moment at which the driver would need to take action to avoid a collision was found to typically fall into the horizontal zones on the ground defined in Figure 2-1, below.

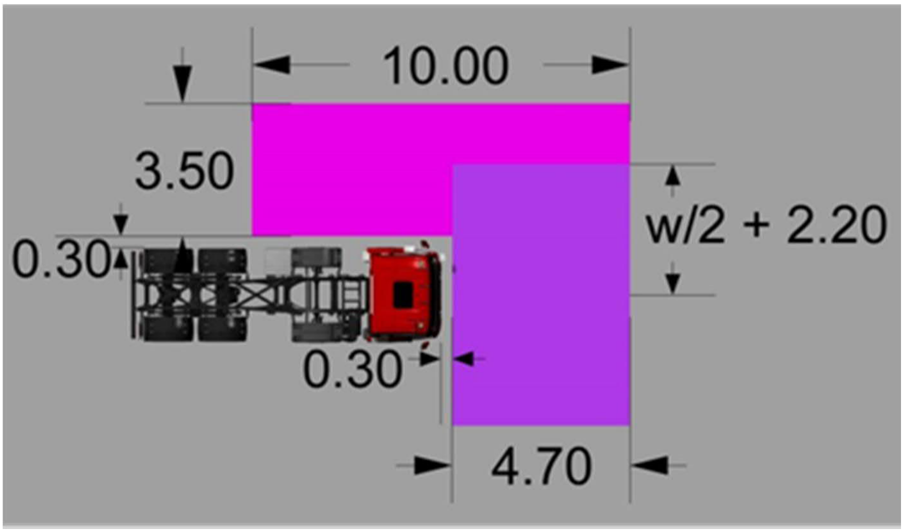


Figure 2-1. Front and nearside zones where direct vision is required[1].

The dimensions are based on consideration of where the centre-line of a vulnerable road user might be, which is why the position closest to the vehicle is 0.3m. This allows space for the width of the shoulder from the centre of the chest while still allowing for some clearance between the widest part of the person and the vehicle.

The remaining dimensions were based on the analysis of collision data. Firstly, the high level statistics in London showed that vulnerable road users (mainly pedal cyclists) killed in collisions with the nearside of an HGV represented the largest group of close proximity HGV collisions involving vulnerable road users. Those (mainly pedestrians) killed during collisions with the front of the HGV, when it started to move off from stationary, were the next most significant group.

This analysis showed that, in London, more pedestrians were killed in low speed manoeuvres (excluding reversing) than pedal cyclists. Very few collisions involved the offside of the vehicle and the nearside of the vehicle was, overall, slightly more

[1] The lighter shaded area is the nearside zone, the darker is the frontal zone. In the dimensions, W designates the width of the vehicle, which may of course vary for different models.

important than the front. This distribution differs to Great Britain (GB) as a whole, where pedestrians (13) are more frequently killed than cyclists (9) in low speed manoeuvres, with a greater proportion of the collisions occurring to the front of the vehicle (55%) compared with the nearside (40%).

Table 2-1. London vulnerable road user fatalities by manoeuvre group and impact point. Source: Stats 19 2005-2014[2]

<table>
<tr><th colspan="6">10 year annual average 05-14</th></tr>
<tr><th rowspan="2">VRU Type</th><th rowspan="2">HGV Manoeuvre</th><th colspan="3">1st point of impact (HGV)</th><th rowspan="2">Total</th></tr>
<tr><th>Nearside</th><th>Front</th><th>Offside</th></tr>
<tr><td rowspan="4">Pedestrian</td><td>Moving off</td><td>0.4</td><td>2.1</td><td>0.1</td><td rowspan="3">3.6</td></tr>
<tr><td>Turning left</td><td>0.5</td><td>0.2</td><td>0.1</td></tr>
<tr><td>Turning Right</td><td>0</td><td>0.1</td><td>0.1</td></tr>
<tr><td>Not vision relevant</td><td>0.9</td><td>2.5</td><td>0.3</td><td>3.7</td></tr>
<tr><td rowspan="4">Pedal Cyclists</td><td>Moving off</td><td>0.4</td><td>0.2</td><td>0.1</td><td rowspan="3">3.3</td></tr>
<tr><td>Turning left</td><td>2.2</td><td>0.1</td><td>0.1</td></tr>
<tr><td>Turning Right</td><td>0</td><td>0.1</td><td>0.1</td></tr>
<tr><td>Not vision relevant</td><td>0.8</td><td>0.2</td><td>0</td><td>1</td></tr>
<tr><td rowspan="3">All</td><td>Not vision relevant</td><td>1.7</td><td>2.7</td><td>0.3</td><td>4.7</td></tr>
<tr><td>Vision Relevant[3]</td><td>3.5</td><td>2.8</td><td>0.6</td><td>6.9</td></tr>
<tr><td>Weighting (VR)</td><td>50.7%</td><td>40.6%</td><td>8.7%</td><td>100.0%</td></tr>
</table>

The dynamics of ‘moving off’ collisions are relatively simple. When reaction times are considered, the pedestrian could be inside or outside of the path of the vehicle at the time the driver needs to see them to avoid the decision to pull away. They can be very close to the front of the vehicle, or they can be some distance away, depending at least partly on their height. Improvements to direct vision have are likely to offer benefits to this group of casualties.

The turning left scenario is dynamically more complex and the in-depth collision data studied allowed for at least three sub-types to be considered:

1. <u>The pedal cycle moves up the nearside of an HGV stationary at traffic lights</u>. This is the most common scenario (40% to 70% depending on data source). It is characterised by high speed differences between vehicles and significant changes in relative position of vehicles throughout the manoeuvre, particularly in the early stages. Impact points are typically at the nearside front, around the area of the front and second axles of a traditional 4 axle tipper. However, at the moment

[2] Note that figures for London are based on collisions reported by Metropolitan and City of London Police forces and the vehicles involved are all coded as an HGV>7.5 tonnes. Research has suggested that a significant number of construction bodied HGVs (e.g. tippers/cement mixers) get incorrectly coded in Stats 19 as Other Motor Vehicles. Data available for pedal cyclists only suggests that including incorrectly coded HGVs would add an average 2.1 fatalities/yr to the total to make 5.4. Data is not available for pedestrians and similar proportions of mis-coded vehicles are quite possible.

[3] Vision relevant collisions are a group of collisions that involve the HGV moving off, turning left or turning right

when the driver would need to react to avoid a collision the cycle can be positioned further back, up to around 5 or 6m rear of the front of the vehicle.

2. Both vehicles are stationary before moving off from rest together. This scenario is characterised by lower speed differentials and smaller changes in relative position of vehicles. The cycle was sometimes initially positioned ahead of the vehicle with the HGV, then overtaking slightly in the moments before collision. Other times the HGV was initially ahead with the pedal cycle undertaking slightly before the collision. Impact points were almost all at the nearside front of the vehicle, typically around the position of the front axle.

3. Both vehicles moving. These collisions are also characterised by lower speed differentials and smaller changes in relative position of vehicles in the moments immediately prior to impact. However, impact positions varied randomly along the length of the side of the vehicle from the front to the position of the rear axle. Thus, the position of the cyclist at the critical moment for detection could be anywhere from the nearside front corner to quite close to the rear of the vehicle, around 8.5m rear of the front of a rigid tipper but potentially much further rearward for an articulated vehicle.

Improved direct vision may or may not enable the cyclist in Scenario 1 collisions to be seen at the critical moment. Those with impact points further back and/or higher relative speeds will be positioned quite far back with the cyclist potentially moving through the zone. The load carrying body of the HGV will limit the line of sight in this area even if the cab were engineered with windows theoretically allowing the view. In addition to this, to exploit the view available, the driver would have to undertake a substantial turn of the head. It is unlikely that all drivers would do this in all turns and, if they did, it would increase workload and may distract attention from other important areas of view. However, it will allow the cyclist to be seen in direct vision at points further forward which will allow the opportunity to avoid some of the collisions and for some others the opportunity to stop the vehicle before the victim is subsequently run over by the wheels.

Collisions in Scenario 2 involve a zone all the way along the side of the vehicle but with only slow relative movement through that zone. Thus, those collisions with impact points towards the front of the vehicle could be affected by improvements to direct vision. However, those with impact points to the rear will clearly not be affected because it will not be possible to provide direct vision in that area.

Collisions in Scenario 3 include vision zones that extend forward of the vehicle to the same extent as the moving off zone and back to around the mid-point between the front two axles. The relative speed through these zones should be relatively low in most cases and hence most of these cases could be affected by improvements to direct vision.

Collision data from GB did not typically identify the distance between the side of the HGV that was about to turn left and the pedal cyclist. This lateral separation distance was identified in some German data that was analysed. (Schreck & Seiniger, 2014) found that accidents typically involved up to 5m sideways distance between the HGV and the cyclist prior to the turn, which is in excess of a full UK lane width and would have implied the need for a wider vision zone at the nearside. However, this may be influenced by the fact that many of the collisions recorded in the German data occurred in situations where a segregated cycle lane was present (example shown in Figure 2-2, below), which would tend to increase separation. This situation may be less relevant in the UK, where most roads where collisions occur do not have separated cycle lanes.

It should be noted that (Schreck & Seiniger, 2014) stated that conclusions on the effectiveness or safety of segregated cycle lanes could not be drawn on the basis of their analysis because there was no comparison between collision rates with and without segregated cycle lanes and these were considered particularly prevalent in the region the accident study was undertaken.

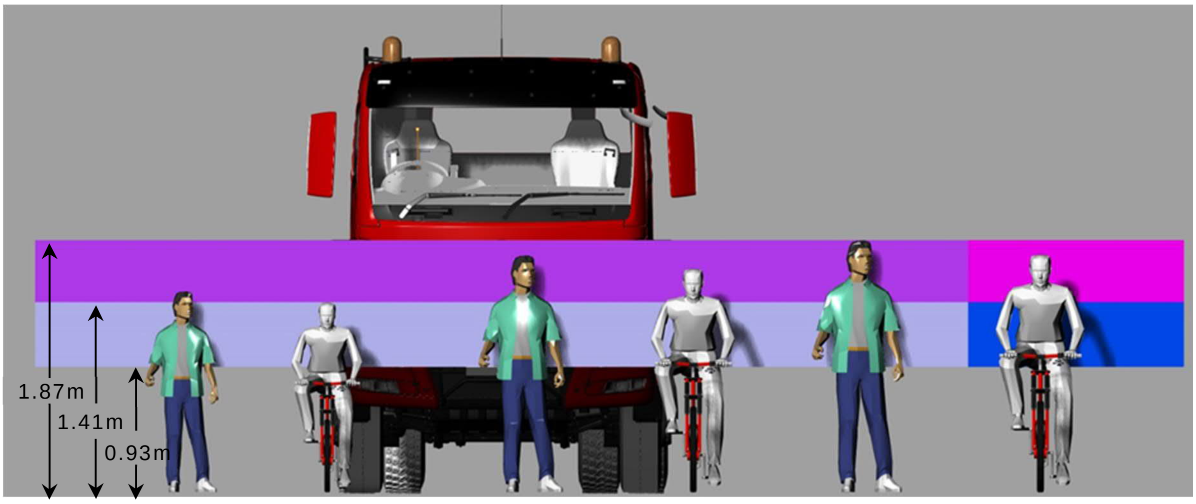
Figure 2-2. Examples of separated cycle lanes with potential line of sight obstruction in Germany. Source (Schreck & Seiniger, 2014).

2.2 Vertical location – What do drivers need to see?

The analysis of horizontal location defined where it is important to assess direct vision around the vehicle. However, it is also important to consider what must be seen. For example, it is clear that just being able to see a thin slice of the top of a cyclist's head, or the feet of a pedestrian, may not be enough to attract the attention of an HGV driver quickly and reliably enough. It is also clear that you do not need see the whole of a vulnerable road user from head to foot to quickly recognise them and assess the risk of a collision with them. No scientific evidence was identified that quantified the likelihood, speed or accuracy of recognition, which will be studied in separate research under TfL's Safer Trucks programme. In the absence of specific information, it has been assumed that the maximum recognition rate will be achieved when a person could be seen from the waist up.

People come in a wide variety of shapes and sizes, such that their waist height and their overall height vary considerably. Analysis of collision data showed that children were very rarely involved in these types of collision either as pedestrians or cyclists. For pedestrians there was a strong bias towards elderly people, in particular females. This led to the vertical definition of the zones as illustrated in Figure 2-3, below.

The lowest height (0.93m) corresponds to the waist height of a 5th percentile female, 1.41m to the overall height of a 5th percentile female and 1.87m to the overall height of a 95th percentile male. As such, if the upper zone is completely visible, then 95 % of all adult VRUs can be seen at least to some extent. However, only the tallest 5% will be visible to a level at the centre of the chest or below. Visibility in the lower zone is required to allow the smallest 5% of the adult population to be visible at all and will increase the proportion of each larger person that can be seen, thus potentially helping them to be quickly and correctly recognised.



Small adult female (5th percentile) Average adult male (50th percentile) Large adult male (95th percentile)

Figure 2-3. Vertical definition of visibility zones.

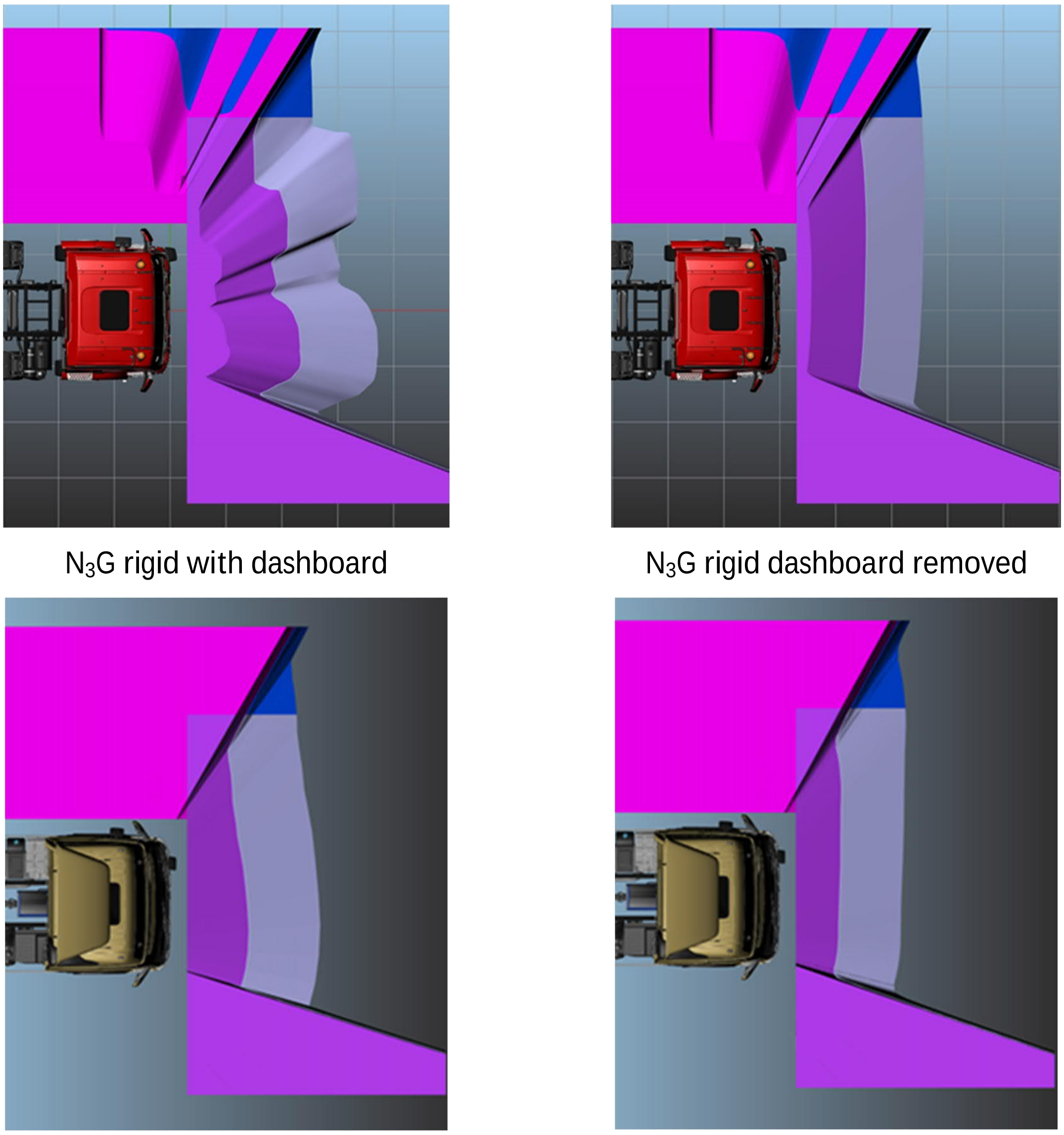
3 Direct Vision Performance

The vision performance of a vehicle is quantified within the Direct Vision Protocol document. The method defined is intended to take the physical measurements of the glazed areas and convert these to a five star rating scheme that categorises the view available. The assessment is intended to correlate closely to the likelihood of a driver being able to see and recognise a vulnerable road user in close proximity to the vehicle in the two key manoeuvres that lead to fatalities in London.

It was also important to consider how each of these performance bands would align with the vehicle types identified by TfL as benchmarks. Thus, a modelling exercise was undertaken and four vehicles were assessed according to the principles that were considered for inclusion in the final assessment protocol. These vehicles were; an off-road specification N_3G[4] construction vehicle, a typical on road specification rigid vehicle, an on-road specification tractor unit for an articulated vehicle; and a low-entry panoramic cab. The N_3G and N_3 rigid vehicle models were also assessed in two modified states. The first of these was to assess the effect of adding a low level window in the passenger door. Secondly, the potential effect of re-shaping the dashboard was assessed because in many cases this is the factor that first limits the view of vulnerable road users in close proximity to the front of the vehicle. For these examples, the maximum effect of that measure was simulated by the simplistic method of removing the dashboard entirely. As a stand-alone measure, removing the dashboard is not realistic, but it illustrates the maximum possible benefit of cleverly designing the dashboard without changing the fundamental geometry of the cab structure to lower the bottom edge of the windscreen. The results of the assessment of the influence of the dashboard are shown in Figure 3-1.

The images on the left show the standard dashboard and the rounded areas represent space that is not visible as a result of parts of the dashboard obscuring the view. The 'bulge' directly in front of the driver for the N_3G vehicle is clearly large enough to hide a small pedestrian and could be eliminated by dashboard re-design without affecting cab structure as shown in the image on the right.

[4] N_3 is a type approval definition of vehicle category meaning a goods vehicle in excess of 12 tonnes gross weight. The sub-category G designates an off-road specification.



N$_3$G rigid with dashboard

N$_3$G rigid dashboard removed

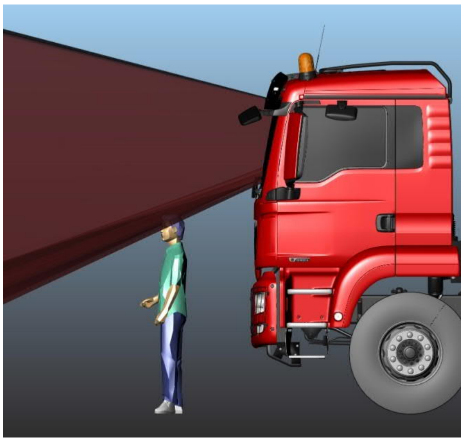
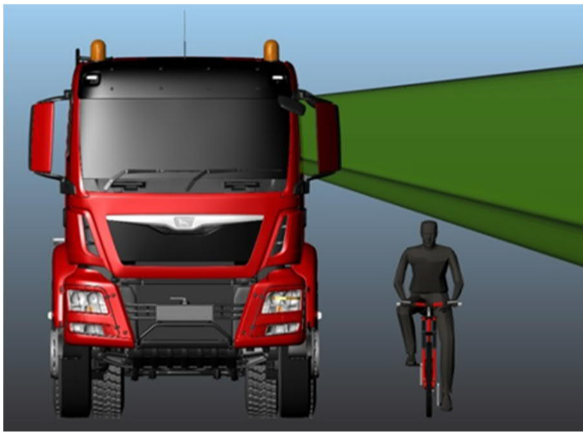
N$_3$ rigid with dashboard

N$_3$ rigid dashboard removed

Figure 3-1. Maximum effect of remodelling the dashboard of N$_3$G (top) and N$_3$ (bottom) vehicles on visible space (shaded volumes are not visible).

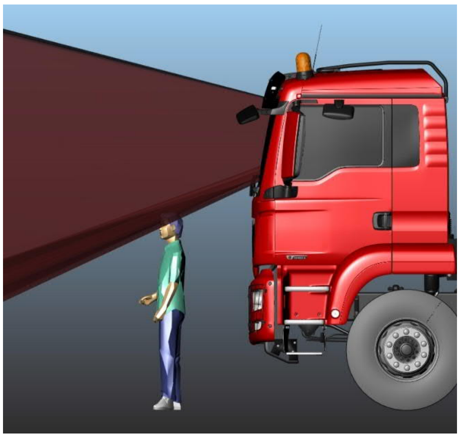
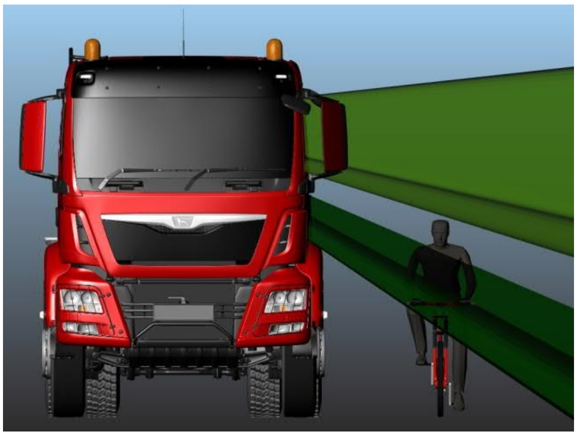
The following images illustrate the front and side view available to the remaining vehicle specifications. A 95th percentile male pedestrian/cyclist is positioned where they would just be invisible to the driver of a standard N$_3$G vehicle.

Table 3-1. Comparison of vehicles from different vision bands based on the TfL Direct Vision Standard

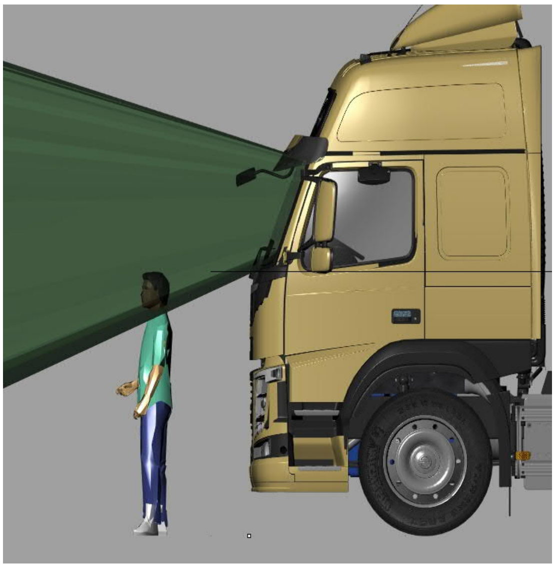
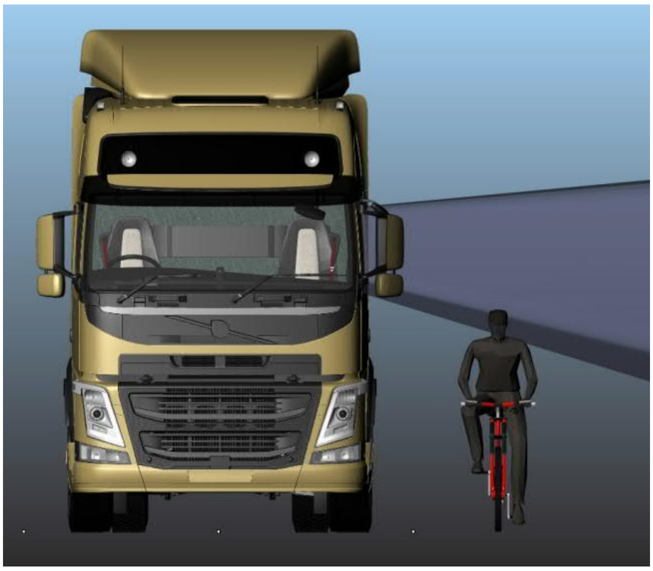
Standard N_3G off-road vehicle

Part of the pedestrian's head is visible at some positions along the front of the vehicle but not at others. This is a function of the variable profile of the dashboard, which was illustrated in Figure 3-1 left. None of the cyclist can be seen at this location.

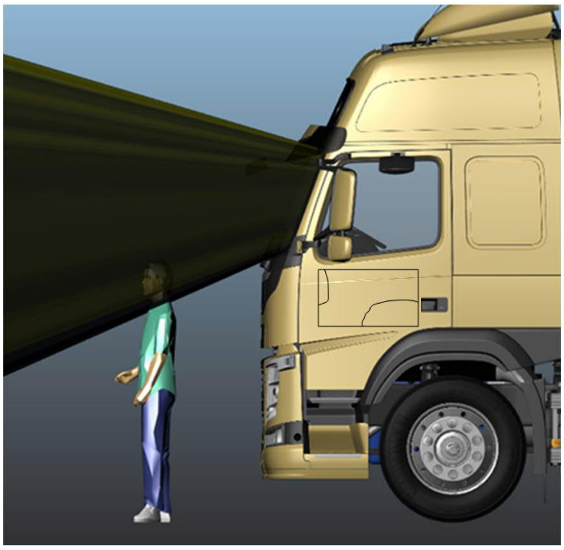
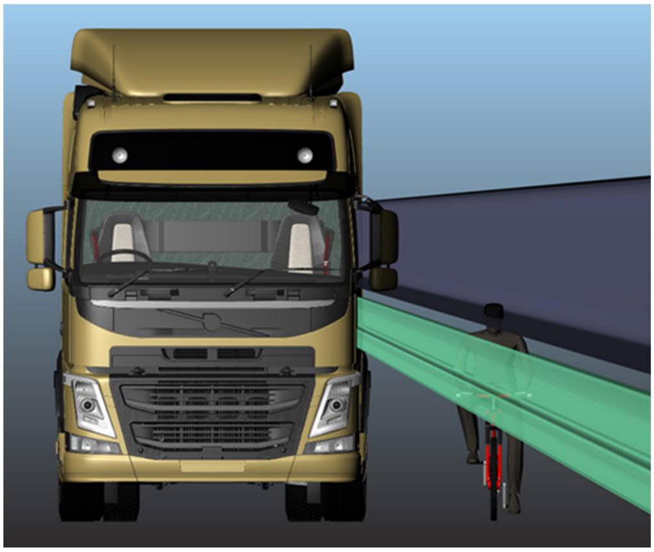
N_3G vehicle – modified to add low level passenger door window

As expected, the addition of a low side window does not affect vision directly in front of the vehicle. The torso of the cyclist is now partially visible when positioned directly alongside the cab, but this additional effect does not extend very far to the rear of the door position.

Standard N_3 on-road rigid vehicle

The head of both the pedestrian and the cyclist are visible from this vehicle

N_3 on-road rigid vehicle – modified to add low level passenger door window

As expected, the addition of a low side window does not affect vision directly in front of the vehicle. The torso of the cyclist is now partially visible when positioned directly alongside the cab, but this additional effect does not extend very far to the rear of the door position. The obstruction to the field of view caused by the passenger seat means that only the arms and front of the cyclists torso have become visible with the addition of the side window (Figure 3-2)

Standard N_3 on road articulated vehicle

The head and shoulders of both the pedestrian and cyclist are visible

Low entry panoramic cab

The pedestrian in this position is visible from the waist up

The cyclist is fully visible in this position, although it should be noted there is the possibility that the cyclist could be partly obscured if they were positioned further back in the blind spot created by the door hinge.

It can be seen that the view from the standard N_3G vehicle is very limited in respect of vulnerable road users in close proximity. Introducing a passenger door window at a low level increases the amount of a VRU that is visible but only in a very defined location immediately adjacent to the door. The potential benefit is also strongly correlated to the size of the window. While the front view of the cyclist suggest that the additional side window will allow a proportion of the cyclist to be visible, Figure 3-2 shows that it is only the front part of the torso and the arms that can be seen because of obstruction caused by the passenger seat. Cyclists may not be in this position at the critical moment the driver needs to see them to avoid the collision.

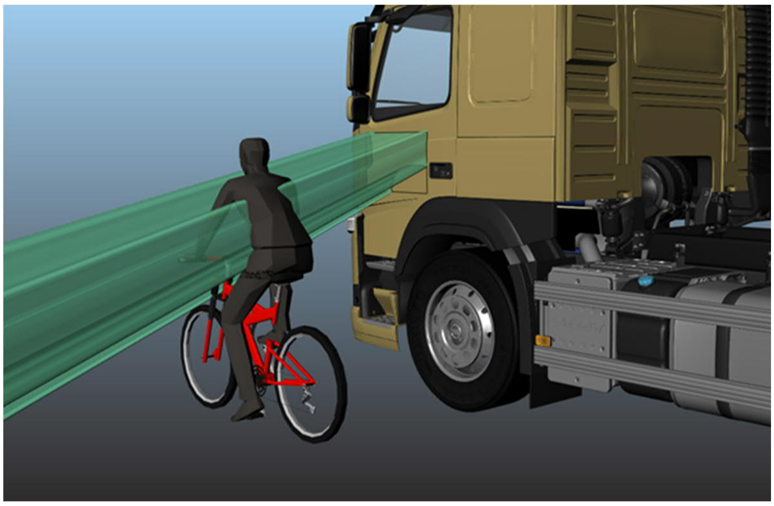


Figure 3-2. N_3 rigid vehicle with side window – view of cyclist from rear

Re-modelling the dashboard has the potential for similar improvements at the front of the vehicle without major structural change. Lower, on-road cabs give substantially greater improvement and the greatest improvement can be seen for the low entry cab.

The above images show the volume of space that is visible from the different vehicles. The previous section showed both the horizontal and vertical areas where vision was required to see vulnerable road users of different sizes, resulting in three-dimensional volumes of space where vision is required, as illustrated in Figure 3-3, below. Thus, the basic metric used to determine the vision performance is the proportion of the space within the area of greatest risk that can actually be seen from the vehicle. Figure 3-4 shows a comparison of vehicles with the smallest and largest proportions of the assessment zones visible to the driver (note the coloured zones shown represent what is not visible to the driver). The standard N_3G vehicle has a lower proportion of the assessment zone visible to the driver and there is a greater variation between the proportion of the upper zones visible when compared to the lower zones. The low entry panoramic cab has a higher proportion of each of the assessment zones visible, with less variation when the height of the assessment zone is considered.

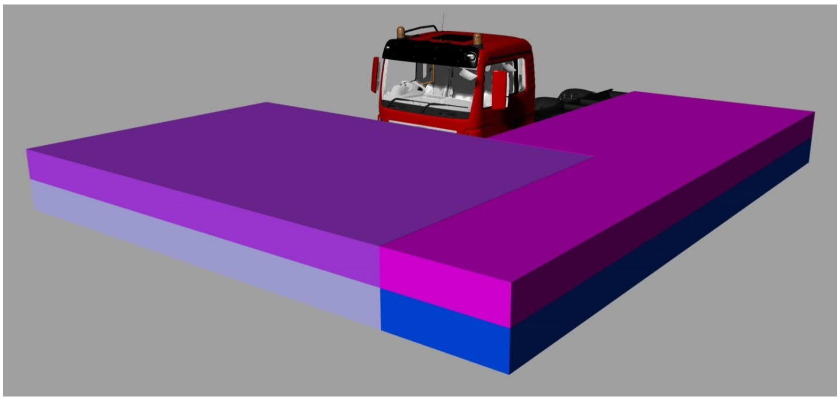
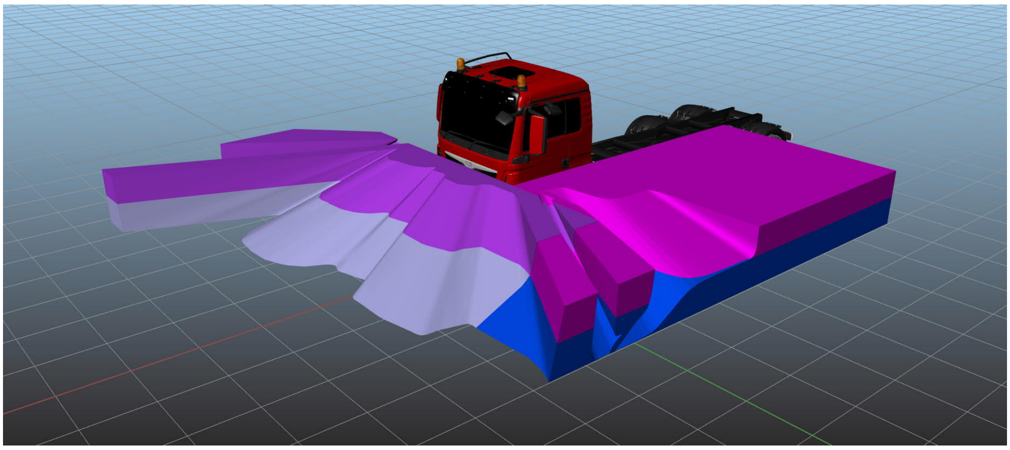


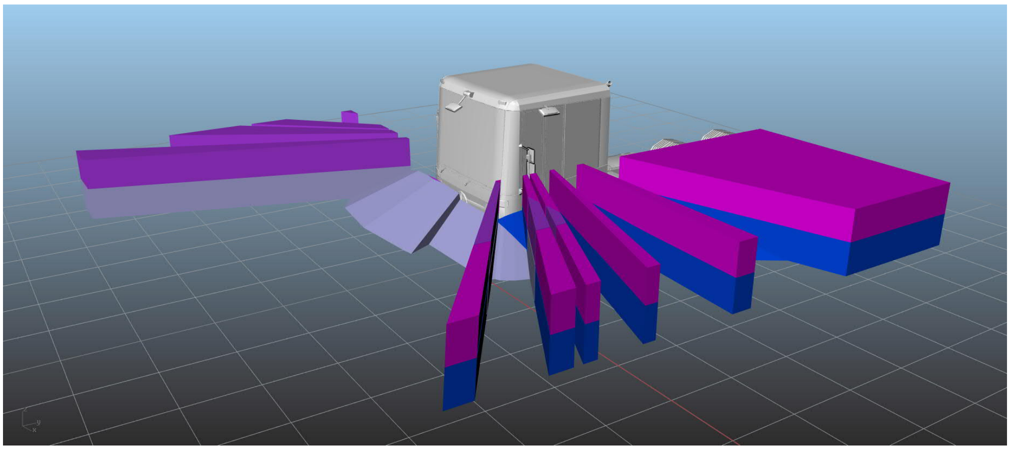
Figure 3-3. Front and nearside zones where direct vision is required.



Standard N_3G :

Front Upper 74.44% visible, Front Lower 54.58% visible

N/S Upper 30.21% visible, N/S Lower 19.79% visible



Low Entry Panoramic Cab:

Front Upper 86.53% visible, Front Lower 81.05% visible

N/S Upper 54.55% visible, N/S Lower 50.61% visible

Figure 3-4. Comparison of non-visible proportions of assessment zones.

However, each zone within the area of greatest risk (front/nearside, upper/lower) can have differing levels of importance. From the collision data it is known that, for London, the nearside zone is slightly more important than the frontal zone, so a weighting was applied to the percentage of each zone that was visible. The score for the nearside zone was considered to be worth 56% of the total mark and the front was 44%. Similarly, consideration of the proportion of vulnerable road users that could be seen, showed that the upper zones enabled a large adult male to be seen to the waist but only allowed head and shoulders of an average male to be seen and left a small female invisible. Therefore the lower zone is of greater importance and was defined as contributing three times more than the upper zone when calculating the overall scores.

The relative importance of each zone can be expressed as a percentage as shown in Table 5-2.

Table 5-2. Weightings applied to each assessment zone

Front Upper	Front Lower	Nearside Upper	Nearside Lower
11%	33%	14%	42%

Thus, the final score can be anywhere between 0 and 1 and varies continuously with changes to the geometry of the vehicle. Score boundaries have been selected such that the vehicle with least vision just fails to achieve one star and the vehicle with the best vision achieves five stars The same score can be achieved by a variety of different designs, which leaves the manufacturers free to innovate and produce improved designs they think will both improve vision and meet other market needs. Table 3-2 shows the defined rating boundaries for the direct vision standard.

Table 3-2. Definition of star rating boundaries

Star rating	Rating boundaries
0 Stars	≥0 and ≤0.40
1 Star	>0.40 and ≤0.45
2 Stars	>0.45 and ≤0.50
3 Stars	>0.50 and ≤0.55
4 Stars	>0.55 and ≤0.60
5 Stars	>0.60 and ≤1.00

Converting the assessments of the vehicles shown above using this method of performance rating gives the results shown in Table 3-3, below.

It can be seen that the performance rating follows the expectation based on the earlier images of what could be seen from the vehicles but it is worth re-stating that it is not design dependant. The on-road specification vehicles achieve two and three stars primarily because of their lower height. However, combining door window, dashboard re-modelling and some other small change may well be sufficient to enable the N_3G vehicle to reach a higher star rating.

Table 3-3. Results from the application of the assessment protocol[5]

Star rating	Vehicle type assessed	Actual score
0 Stars	Standard N_3G vehicles	0.39
1 star	N_3G vehicle + single vision enhancement	0.41-0.42
2 stars	N_3 rigid vehicle baseline N_{3+} single vision enhancement	0.46 0.49
3 stars	N_3 rigid vehicle + multiple vision enhancements[6] N_3 articulated vehicle	0.52 0.53
4 stars	None of vehicles assessed	N/A
5 stars	N_3 Low entry cab	0.65

The star rating described above is intended to assess vision in the areas where vulnerable road users are most frequently killed by HGVs in low speed forward manoeuvring. It should be noted that some designs of low entry cab, which can have benefits for sighting of vulnerable road users, employ several additional pillars for roof support and window and door division as illustrated in Figure 3-5.

These pillars do not have a substantial effect in terms of obscuring the view of vulnerable road users in close proximity because the blind spots remain small when close to the vehicle, particularly at the nearside where the angle that is obstructed is smaller. A person close to the vehicle is too big to hide in the resultant blind spot. However, the size of the blind spot caused will grow as it gets further from the vehicle as illustrated in Figure 3-6, below, such that it might become relevant to interactions with cars and motorcycles when emerging from T-junctions or entering large roundabouts.

Unlike the blind spots caused by being too high, it is possible for the driver to eliminate these more distant blind spots simply by moving their head slightly. These low entry designs have been in service for 10-15 years and there has not been any identified collision problems associated with this characteristic at this point in time. However, this represents a possible risk that should be monitored over time if the number of such vehicles increases in response to the introduction of this assessment. If problems are identified, then countermeasures can be introduced that would incentivise or mandate vehicles with fewer or smaller pillars.

[5] It should be noted, assessments are made in an 'as new' condition. Dirt and clutter have the potential to degrade view in service and glass must remain clean and clear in service to remain effective.

[6] Estimate based on combing scores for additional side window and removed dashboard – not fully assessed.

Figure 3-5. Highlighting pillars in low entry design.

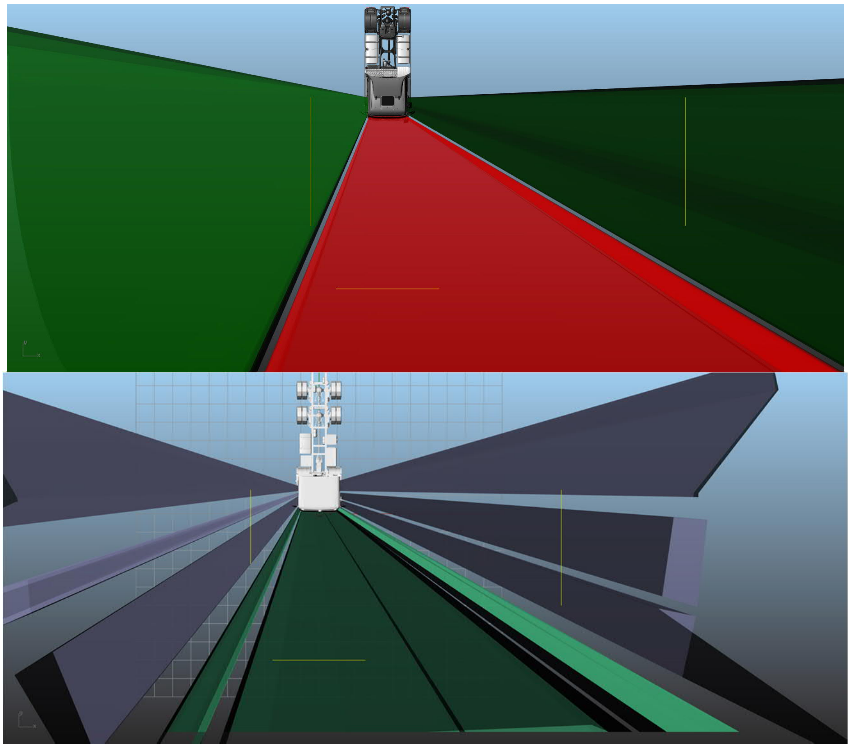


Figure 3-6. Comparison of distant view between a standard articulated vehicle (top) and a low entry cab design (bottom).

4 Measuring the view

The TfL Direct Vision Protocol defines a method for measuring the direct field of view from HGVs. The method is based on the technical standards and literature reviewed and the field of view modelling that has been completed. The following aspects of the measurement have been considered and defined:

Use of a digital vehicle model - Manufacturer-provided CAD models should be used where available and a method for verifying the performance of production vehicles against the ratings reported has been provided. To ensure repeatable methods are used, guidance is provided for generating 3D CAD models of vehicles where they are required.

Figure 4-1. Example vehicle model – Mercedes Econic

Vehicle setup – Several items that affect the field of view can be adjusted by the driver, for example suspension settings, tyre pressures, fuel load, cargo carried etc. Wherever possible, the position or setting that the measurements should be undertaken in has been defined as the one that is considered likely to represent the most common usage on the road. Where this was not possible, the protocol will require the position or setting to be made that most restricts the field of view, that is, a worst case.

Vision point – The vision point is the position of the eyes from which the view will be assessed. In defining this, it is possible to consider different sizes of driver with different preferences for seat positioning, and different ways of looking (move eyes, rotate head, rotate from waist). It is also possible to consider different approaches to calculating the area visible. For example, you could measure the view from one eye only (monocular), you could count only the view that is visible to both eyes (binocular) or you could consider an area that is visible to at least one eye (ambinocular). The protocol aimed to strike the optimum balance between accurately representing how real humans see and the complexity and effort required for the assessment.

As such, the protocol is based on calculating the volume that can be seen by at least one of the two eyes (ambinocular vision) of a 50th percentile UK male driver, including rotation of the head but not the torso. The driver seating position (which can affect the vision point) is also defined based on an independent and objective seat positioning process developed in the USA, but adapted to use driver sizes based on the UK population. In this way, the measurement process is reasonably representative of the real world but is also repeatable and reproducible with manageable effort.

Visual obstructions - Items identified as visual obstructions, for example vehicle fascia, steering wheel, passenger seat, etc. are controlled for in the CAD based evaluation. Where applicable, a representative approach for adjusting the majority of these items has been proposed, for example positioning the passenger seat half way between its foremost and rear most positions and keeping it unoccupied, windscreen wipers in resting position, sun visors and blinds stowed away. For some of the items, such as armrests, passenger seat head restraint and any other equipment not explicitly mentioned, the worst-case adjustment (i.e. maximum obscuration) has been chosen because it is unknown what the most common adjustment position is. For the mirror housings a worst case approach is also proposed because the adjustment preferences between drivers can vary widely and no appropriate research was identified for repeatable, average driver-specific adjustment positions. The steering wheel is positioned using a similar approach to that used for the driver's seat. Criteria for defining semi-transparent items are also specified.

5 Implementation of the TfL Direct Vision Protocol

Consideration is required as to how the TfL Direct Vision Protocol will be implemented within a policy framework and in industry. A couple of exemplary aspects that require attention for the implementation of the protocol are described below.

5.1 Who will carry out the assessment?

The Direct Vision Protocol could be implemented through a self-certification approach by the vehicle manufacturers or through independent testing. While most vehicle manufacturers preferred the self-certification approach, more than one thought an independent approach would be better, at least initially until the process became established. For both approaches, deviations can occur between the reported rating and the actual performance of production vehicles, possibly because of deviations in production parts from the 3D CAD model used, undocumented changes in specifications, application of results to vehicle variants that are not covered by an assessment, etc. This makes it necessary to define a procedure for verifying the performance of a sample vehicle.

Two procedures have been defined with different stringency. The more stringent procedure fulfils a similar function to legislative market surveillance measures:

- A vehicle spot check procedure: A brief physical inspection to determine whether important direct vision characteristics of an individual vehicle are in accordance with those of the rating certificate presented. This check is intended to be carried out, for example, at construction sites to test samples of contractors' fleets. Key dimensions such as overall vehicle height, height to lower edge of the windscreen etc are measured manually and compared to those documented in the test report, which is generated in support of that vehicle's certification. This shall give assurance that a presented rating certificate is applicable to the vehicle being used and that it is kept and maintained in a compliant condition. Any substantial deviation can be flagged for a full compliance check if it causes concern.
- A compliance test procedure: A comprehensive verification of the performance of an actual production vehicle as representation of that vehicle model. Carried out, for example, by an independent test house after failed vehicle spot checks or at random. This shall give independent assurance that a production vehicle model indeed achieves the reported performance band of that model.

5.2 How does the assessment apply to a range of vehicle specifications?

For practical reasons, not every individual vehicle driving on the road and also not every possible combination of chassis, cab and cab equipment can be scanned (in 3D), evaluated and assessed.

A best-case approach for applicability of ratings would be to test only the variant of a vehicle or cab model that offers the best field of view and then to allow the manufacturer to advertise the achieved performance banding for all other variants. This would show what is possible for the vehicle range, but may not be true for all variants. A worst-case approach would test only the worst variant, thereby ensuring that the direct vision will be no worse throughout the range than for the variant assessed. An alternative would be the selection of the best-selling variant, which would require sales information from the manufacturer.

It remains possible that the performance of one variant is equally applicable to another variant. However, to define which variants can share the assessment would require the definition of a set of technical criteria to which the variants do not deviate, making the direct vision assessment applicable to all such variants. This approach is commonly taken in vehicle type-approval legislation to define what constitutes the same vehicle ‘type’.

Vehicle design factors that affect direct vision performance of a vehicle are:

- Number and size of windows, because these directly influence the view of the road afforded by the cab.
- Height above ground and width of the cab, because these were found in research to have a strong influence on blind spots around the vehicle (Summerskill, Marshall , Paterson, & Reed, 2015).
- Engine tunnel height, because this may obscure the view through low-mounted side windows (door panel windows) to a greater or lesser extent.
- Additional cab equipment because this might present visual obscuration for parts of the windows.

The choice of variants to test will largely be a policy decision for TfL and the industry. However, the Direct Vision Protocol includes a technical definition of the properties that must not vary if the assessment is to be considered applicable to more than the tested variant.

6 Conclusions & future considerations

The following conclusions can be drawn from this research:

A wide variety of technical standards exist for measuring the field of view from vehicles. No individual existing technical standard or method for measuring direct vision entirely met the objectives of this research programme.

A TfL Direct Vision Assessment Protocol has been designed that measures and categorises the direct field of view using a five star rating scheme. The scoring system is designed as a flexible system that allows the vehicle industry scope to innovate, in the way they see best, in order to achieve the highest possible performance for their vehicle while continuing to meet the needs of the market. It does not prescribe a particular design solution to improve direct vision. The five star rating rewards small improvements to the direct vision performance and avoids the use of descriptive category titles that could be open to interpretation.

The Direct Vision Assessment Protocol was applied to eight vehicles models (four standard vehicles and two vehicles to which two different modifications were applied).

- An example of a standard off-road vehicle (N_3G) achieved zero stars.
- The same off-road (N_3G) vehicle could achieve one star if modified to add a window in the lower panel of the passenger door or by re-modelling the dashboard such that it did not intrude on the forward vision at the lower edge of the windscreen
- Two N_3 on-road specification vehicles (one rigid, one articulated) achieved two and three stars respectively. It is likely that the N_3 rigid vehicle could achieve three stars by combining both the additional side window and re-modelled dashboard.
- The only vehicle assessed capable of achieving five stars was a specialist, low entry design.

While the results for these vehicles are as may have been expected, the sample of vehicles to which the assessment protocol has been applied is limited with respect to the range of vehicle models within the vehicle fleet.

Implementation of a five star performance requirement would be expected to make visible an easily recognisable proportion of most pedestrians killed in relevant HGV collisions, at a time when the driver should be able to avoid the collision. This is also true for a number of the cyclists killed in relevant collisions. However, in the case of cyclists, based on the data analysed, there is a significant proportion that will not be within the scope of improved direct vision because they are positioned too far to the rear of the cab at the critical moment when the driver would need to act to allow the collision to be avoided.

The assessment is currently based on the weighted proportions of the visibility zones that can be seen by a driver. There is currently no requirement that the driver must be able to see a defined proportion of each zone. A minimum proportion for each zone could be implemented to allow progression between bands, but this will require analysis of a larger number of vehicle models.

The proposed protocol allows the categorisation of HGVs in relation to their ability to allow vision of vulnerable road users in close proximity at a time that would allow fatal collisions to be avoided. It has been written for potential use in procurement procedures for TfL. The protocol is based on an internationally recognised format to allow it to be considered for a wider audience. Extending the scope of application of the TfL Visibility Protocol, for example to apply across Europe, may require changes to the size of people considered and different collision data may be needed to ensure the geometry of zones and their weighting fully represented the wider population.

The effect of the proposal should be monitored in terms of the prevalence of new cab designs, such as low entry cabs with increased numbers of pillars, and their relative involvement in collisions. If necessary, the assessment methods can be refined to maximise the benefits achieved.

7 References

Schreck, B., & Seiniger, P. (2014). Turn Assist Systems for Goods Vehicles. Bergisch Gladbach: German Federal Highway Research Institute (BaST).

Summerskill, S., Marshall , R., Paterson, A., & Reed, S. (2015). Understanding direct and indirect driver vision in heavy goods vehicles.: Final Report. Loughborough Design School, Loughborough University, Loughborough.

Assessing the Direct Vision Performance of Heavy Goods Vehicles (HGVs)

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