

UNDERSTANDING DIRECT AND INDIRECT DRIVER VISION IN HEAVY GOODS VEHICLES

Final Report

Prepared on behalf of Transport for London

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1 EXECUTIVE SUMMARY

The research described in this report has been performed by Loughborough Design School (LDS) under the CLOCS programme funded by TfL. The project was specified to allow an understanding of the variability of blind spots in direct vision through windows and indirect vision through mirrors for the top selling HGVs in the UK. The impetus for the research was the increasing number of accidents between Vulnerable Road Users (VRUs) and HGVs in London. The aim was to compare the manufacturers' most sold vehicle specifications to determine which vehicle design variables can affect the size of blind spots, and to explore issues that have been raised in previous research including the potential for construction HGVs to be involved in more accidents with VRUs than distribution variants of HGV designs. The LDS team have utilised a virtual modelling technique to explore this issue. This virtual approach allows multiple accident scenarios to be modelled and simulated. In order to allow the analysis of vehicle blind spots 19 vehicle models have been created by digitally scanning the real world vehicles. The vehicles that have been modelled include construction, distribution and long haul HGV designs, as well as 'high vision' low entry cab designs. These models have been used in combination with simulations of cyclist and pedestrian VRUs in a manner which recreates critical accident scenarios that have been defined through the analysis of accident data. This involves placing the simulated VRUs in a number of defined locations adjacent to the vehicle. Subsequently the simulated VRUs are moved away from the vehicle into a position where they 'just can't be seen' by the driver of the vehicle, i.e. moving them further away would allow them to be partially visible. The distance that the VRU is away from the side or front of the vehicle cab determines the size of the direct vision blind spot. In this way vehicle designs and configurations can be compared. In addition to this further testing was performed to determine if the VRUs located in the direct vision blind spots could be viewed by the driver through the use of mirrors. A further analysis technique utilised a method which projects the volume of space that can be seen by a driver through the windows and mirrors on to the surface of sphere. This provides a field of view value which can be used to compare the glazed area of HGVs and provides a method to distinguish between vehicles that perform at the same level in the VRU simulation. The results of the work highlight the follow key issues.

1. All standard vehicle configurations have blind spots which can hide VRUs from the driver's direct vision
2. The height of the cab above the ground is the key vehicle factor which affects the size of direct vision and indirect vision blind spots
3. The design of window apertures and the driver location in relation to these window apertures can reduce the size of the identified blind spots. i.e. two different vehicle designs with the same cab height can have different results for blind spot size due to window design and driver seat location
4. Low entry cab designs, which are the lowest of the 19 vehicles tested, demonstrated real benefits in terms of reducing direct vision blind spots when compared to standard vehicle designs
5. The construction vehicles assessed in the project are on average 32% higher than the same cab design in the distribution configuration
6. For construction vehicles the distance away that a pedestrian in front of the vehicle can be hidden from the driver's view is on average nearly three times greater than the distribution vehicles
7. For the construction vehicles the distance away that a cyclist to the passenger side of the vehicle can be hidden is on average more than two times greater than the distribution vehicles
8. The work has highlighted the need for a new standard which defines what should be visible through direct vision from the vehicle. Such a standard does not currently exist, and is seen as a key mechanism for improving future vehicle designs

2 ACKNOWLEDGMENTS

The project described in this report would not have been possible without with considerable support provided by vehicle manufacturers. Each manufacturer has allowed access to their vehicles to allow data to be captured, and provided additional information that relates the vehicle specifications. We would like to thank the following manufacturers and their representatives for their support, DAF, Dennis, MAN, Mercedes, Volvo and Scania.

3 INTRODUCTION

This report has been prepared by the Loughborough Design School (LDS) Design Ergonomics Group (DEG) as the main output for the 'Modelling of HGV Blind Spots and Safety Features' project, Transport for London (TfL) Internal Reference Number: tfl_scp_000905 as part of the CLOCS research programme.

The project proposal highlighted that the recent growth in cycling in London has been accompanied by concerns about cyclist safety. Recent research conducted by LDS¹ highlights that whilst there has been a general improvement in road safety in the UK with casualties falling 49% between 2000 and 2012, and the numbers of those killed and seriously injured (KSI) falling 40% in the same period, cyclist casualties have not followed the national trend. Data shows that over the same period the numbers of killed or seriously injured cyclist casualties have increased by 21% nationally and in Greater London by 59%.

It is acknowledged that cycling has become increasingly popular and thus the exposure to risk of this group has also increased. This trend appears likely to continue with a continuing emphasis on the potential benefits from cycling including healthy lifestyles, reduced environmental impact of transport and reduced congestion. Further increased rates of cycling resulting in increased exposure are expected to result in an increase of cyclist casualties unless levels of risk can be reduced at a greater rate.

A factor in accidents involving cyclists and other vulnerable road users (VRUs) is the overrepresentation of HGVs. One of the significant characteristics of these larger vehicles is the higher driving position.

Currently CAT. N₂/N₃ (goods vehicles between 7.5 tonnes and 12 tonnes, (N₂) and above 12 tonnes (N₃)) vehicle design is constrained by EC regulation 96/53/EC² which limits maximum values for overall vehicle length for the tractor unit and trailer to 16.5m, the length of the trailer to 13.6m and the distance from the king pin connection of the tractor unit to the foremost wall of the trailer to 2.04m. This indirectly limits the length of the cab section to 2.9m, however a clearance is required between the rear cab wall and the foremost wall of an articulated trailer to allow rotation about the king pin during turning which, reduces the available space for the cab section to approximately 2.2m for an articulated vehicle configuration.

This has led to a vehicle design process where the driver cab is placed above the engine bay to allow the length constraints to be met, with flat fronted vehicles. A key safety issue that is derived from the height of the driver position of current Category N₃ vehicles is the ability of the driver to view vulnerable road users (VRUs), cars and motorcycles that are in close proximity to the vehicle directly through the windows. This is

¹ Pedal Cyclist Fatalities and Serious Injuries in London: Analysis of Police Collision Files (2007- 2011), a report by the TSRC, Loughborough University and the Centre for Transport Studies UCL. As yet unpublished.

² 96/53/EC. Council directive 96/53/EC laying down for certain road vehicles circulating within the Community the maximum authorized dimensions in national and international traffic and the maximum authorized weights in international traffic. The Council of the European Union. 1996.

currently mitigated through the use of Class II, Class IV, Class V and Class VI mirrors which provide indirect vision of the space around the vehicle.

These mirrors are regulated by standards which provide specified radii of curvature of the mirror surface between 200mm (Class VI) and 1250mm (Class II). These curved mirrors have the potential to distort the view of the locations around the vehicle and so it is considered to be preferable to use direct vision to allow VRU's and other vehicles to be identified by the driver. In addition there are blind spots in mirror coverage when combined with direct vision that have been identified in research performed for the UK Department for Transport by the Loughborough Design School (LDS) team³. This research highlighted that there is considerable variability in the design of window apertures and mirror designs between vehicle makes, and that the problem of direct vision from the vehicle cab is worsened by vehicle height, i.e. the higher the driver is above the ground, the more difficult it is to use direct vision to identify VRUs around the vehicle.

One solution to this issue is to reduce the height of the driving position by lowering the cab and increasing direct vision. Buses, and more recently, refuse lorries exhibit this lower driving position and the increase in driver vision / reduction in blind spots afforded by this configuration.

Whilst a change to vehicle design in the construction industry may be a way forward it can only be a mid to long term aim. It is likely that a development period will be required for a lower cab that can be integrated into all vehicle configurations used within the industry. In addition, HGVs have relatively long working lives (often 7+ years). Even if the industry were to begin change immediately, by the time that all HGVs on UK roads had changed to a new lower-cab configuration the existing vehicles are likely to continue being involved in cyclist accidents whilst the rate of cycling continues to increase.

It is therefore important to understand the issue of blind spots and restrictions to driver vision, for a range of existing vehicle types, allowing vehicle operators to understand the variability between the currently available models and makes, and to provide recommendations for iterations of existing designs.

With this background the project was defined in a manner which would allow the variability in the performance of existing category N₃ vehicles in terms of direct vision (through windows) and indirect vision (through mirrors) to be objectively compared.

The method for this comparison involved the use of Digital Human Modelling Software, SAMMIE that has been developed and used by the project team at Loughborough University for the past 20 years. The fundamental methodology for the project has been defined in previous research performed by the LDS team for the UK Department for Transport.

The TfL project has involved the evolution of the analysis technique used in the previous work including the methods used for data capture from vehicles and the use of existing techniques for the projection of direct and indirect vision. Figure 1 provides an example of the projection technique that can be used to visualise the volume of space that is visible to a driver through a mirror or through a window. In the example shown in Figure 1 the cyclist with the yellow top is next to a MAN TGS N3G vehicle cab. The purple volume encloses the space that can be seen through the Class V mirror which allows the driver to look down the side of the vehicle. The red volume encloses the space that can be seen through the passenger window. The cyclist does not intersect with the purple volume and so cannot be seen in that mirror, but does

³ Cook, S. E., et al., (2011). The development of improvements to drivers' direct and indirect vision from vehicles. Phase 2. Loughborough University. Report for Department for Transport.

intersect with the red volume and so can be seen through the window. This technique can be used to explore complex situations with multiple mirrors and windows being projected simultaneously to allow an understanding of blind spots in the vision of the driver caused by the body of the vehicle.

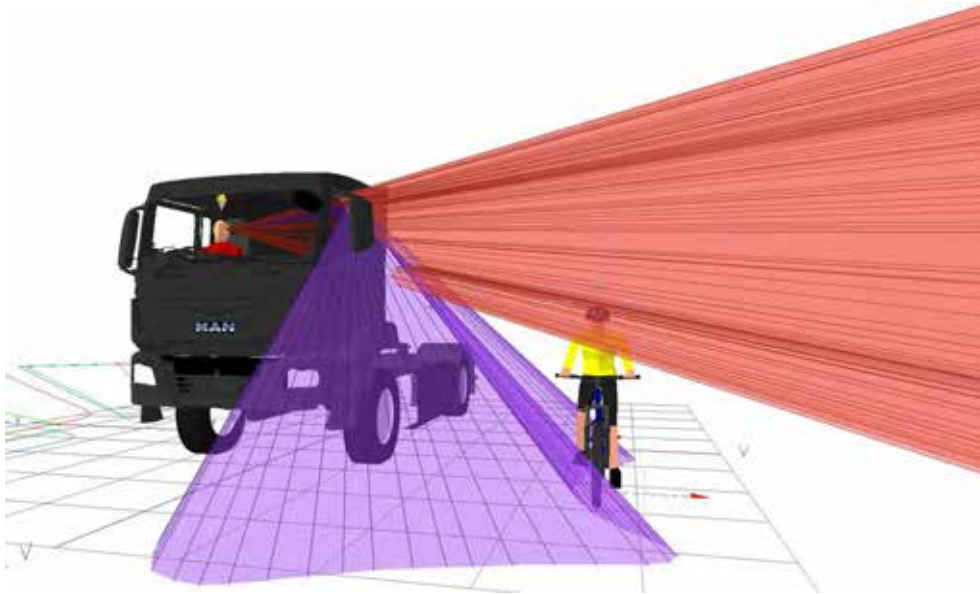


Figure 1. The projection of the Class V (look down) mirror (the purple volume) and the space visible through the passenger window (the red volume)

The following report describes how the technique, combined with other features of the SAMMIE Digital Human Modelling System, has been used to quantify the size of direct and indirect vision from a range of top selling category N₃ vehicles.

3.1 THE VEHICLE SAMPLE

The stated primary focus of the project is to understand the driver's ability to see vulnerable road users from the cab of heavy goods vehicles in both construction and non-construction variants. It is the variability in cab design (window size and shape, mirror configuration and cab height above the ground) that determines the direct and in-direct vision capabilities of any vehicle. The categories that are used to describe construction and distribution vehicles in Europe are defined by the United Nations Economic Commission for Europe (UNECE) standards⁴ as follows;

- Category N₃: Vehicles used for the carriage of goods and having a maximum mass exceeding 12 tonnes
- Category N₃G: an off road variant of the N₃ which must meet the following criteria in order to be defined as an N₃G
 - At least half of the wheels are driven
 - The vehicle can climb a 25% gradient
 - The vehicle is equipped with a differential lock
 - At least four of the six following requirements are satisfied:
 - Front incidence angle (approach angle) $\geq 25^\circ$
 - Rear incidence angle (departure angle) $\geq 25^\circ$

⁴ <http://www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29classification.html>

- Ramp angle $\geq 25^\circ$
- Ground clearance under the front axle $\geq 250\text{mm}$
- Ground clearance rear the front axle $\geq 250\text{mm}$
- Ground clearance between axles $\geq 300\text{mm}$

The variables that differentiate the category N₃G (construction) variants from the standard N₃ vehicles are associated with the ability to have improved ground clearance and suitable power to allow steep gradients to be climbed.

The criteria for establishing which vehicles should be tested in the project were defined as follows;

1. The vehicle makes and models should be defined by UK registration figures to ensure that they are representative of vehicles that are in use
2. In addition to standard vehicles, the benefits of low entry cab vehicles in terms of the ability of the driver to use direct vision (through windows) should be explored
3. The sample should include specifications of vehicles which represent appropriate variability in vehicle height as defined by their use case e.g. general haulage and construction use

With the support of the UK Society of Motor Manufacturers and Traders (SMMT) the data for the registrations of new category N₃/N₃G vehicles were obtained and examined to determine which makes and models of vehicles were to be tested in the project. These data established that DAF, SCANIA, Volvo, Mercedes and MAN were the top five manufacturers.

A review of the vehicles available from these manufacturers established that there are distinct configurations which are available to meet the demands of specific applications. With a project focus on the differences between makes and models, but also between construction and non-construction vehicles, a balanced sample was identified which included the following models and configurations (See Table 1):

- DAF XF - N3 General long distance haulage
- DAF CF - N3/N3G distribution and construction
- SCANIA P - N3/N3G distribution and construction
- Scania R - N3 General long distance haulage
- MAN TGX - N3 General long distance haulage
- MAN TGS - N3/N3G distribution and construction
- Mercedes AROCS - N3G construction
- Mercedes ANTOS - N3 distribution
- Volvo FH - N3 General long distance haulage
- Volvo FM - N3 distribution
- Volvo FMX – N3G construction









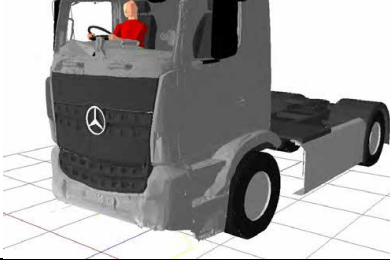






		
DAF CF N ₃	DAF CF N ₃ G	DAF XF N ₃
		
MAN TGS N ₃	MAN TGS N ₃ G	MAN TGX N ₃
		
Mercedes ANTOS N ₃	Mercedes AROCS N ₃ G	Mercedes ACTROS N ₃
		
VOLVO FM N ₃	VOLVO FM N ₃ G	VOLVO FH N ₃
		
SCANIA P N ₃	SCANIA P N ₃ G	SCANIA R N ₃

Table 1. The N3 and N3G designs that were selected for the vehicle sample

In addition to these standard configurations the available low entry cab configurations in the UK were examined and the following vehicles were selected (See Table 2):

- Dennis Eagle Elite 6
- Volvo FE LEC
- Mercedes Econic
- Scania LEC

With the vehicle makes and models established discussions were held with representatives from each manufacturer to explore the variability of the available specification options for each model. This highlighted that there are dozens of available vehicle configurations due to the number of combinations of suspension, type, cab type, axel configurations, and engine size. These variables result in a wide range of cab mounting heights within a vehicle model. Initially it was proposed that the highest and lowest cab height configurations should be selected for the analysis, however a review of sales data with two key manufacturers highlighted that the highest and lowest vehicle cab heights were sold in low volumes as they had specific, and limited application.

This resulted in a strategy where the ‘most sold’ configuration for each vehicle was selected for analysis. Each manufacturer was asked to provide the height of the cab for the most sold configurations of the vehicles listed above.

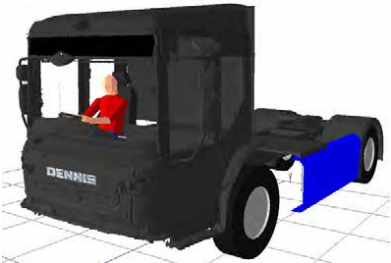



	
<p>Dennis Eagle Elite 6</p>	<p>SCANIA P LEC</p>
	
<p>Mercedes Econic</p>	<p>Volvo FE LEC</p>

Table 2. The low entry cab designs that were selected for the vehicle sample

This method had the advantage of representing the largest number of vehicles that are in operation, in a fair and equitable manner, but has the limitation that the more extreme vehicle heights are excluded from the analysis. The effects of high cabs on the vision of the world around the driver has still been examined in the form of the analysis of long distance haulage vehicles, the window and mirror configurations of which are often the same as the taller construction vehicles from the same manufacturer. For the purposes of illustration each vehicle cab that was produced in the project has been shown in a tractor configuration (4X2). The ‘most sold’ configurations would most likely be different to this, including rigid and articulated configurations.

3.2 DATA CAPTURE TO ALLOW THE CREATION OF VEHICLE MODELS

The SAMMIE DHM technique that has been established for the analysis of direct and indirect vision from vehicles requires specific information from the vehicles being tested, including:

1. The general form of the exterior and interior of the vehicle to support the understanding of how vulnerable road users can interact with the exterior of the vehicle, and how the interior of the vehicle may provide visual obscuration of the outside world
2. The shape, radius of curvature and range of adjustability of the mirrors that are attached to each vehicle
3. The shape and configuration of the window apertures

Enquires were made with vehicle manufacturer representatives in the UK which highlighted that sourcing CAD data of the vehicles would be possible, but with lead times that would be beyond the project duration. Therefore the project was defined in manner which involved the LDS team producing vehicle models using 3D scanning facilities. In order to gather the required information a team of researchers were commissioned to source access to the vehicles in the sample list and perform a series of scanning operations using different techniques and equipment. This involved the manufacturers providing access to the vehicles for scanning, and providing additional information.

3.2.1 THE SCANNING OF THE EXTERIOR AND INTERIOR OF THE VEHICLES

The exterior and interior of the vehicles were digitised using a FARO Photon 120 scanner. This scanner has a maximum resolution of 2mm up to 20m away from the scanner. In effect this means that the data produced varies from the scanned object by up to 2mm. This is considered to be small enough to be negligible and would not affect the tests performed on each vehicle. The method that was defined through a piloting exercise involved taking six scans of each vehicle, four exterior and two interior. The four exterior scans were captured using reference sphere objects which are attached to the vehicle using magnets. These are then used in the post processing technique to align the six scans.



Figure 2. An example FARO Photon 120 scan of the interior of a vehicle

Figure 2 shows an example of the scan data as viewed in the FARO SCENE LT software. The image shows how the interior of the cab was digitised, with an SAE standard H-point manikin being used to provide seating reference data. The two interior scans were taken through the driver and passenger door of the vehicle in order to capture interior detail, and allow the adjustability of the seat and steering wheel to be defined. This was achieved by moving the seat and steering wheel to the maximum and minimum adjustment positions between the scans taken through each door.



Figure 3. Example exterior scans showing the reference spheres which are used to combine four scan into one vehicle object

Figure 3 shows the four exterior scans which were taken and subsequently combined with the interior and exterior scans to create a vehicle model. The white spheres that can be seen attached to each scan are the alignment spheres which show common locations between scans which are then used to align and combine the scans. The combination process was performed in Geomagic software along with data reduction and data cleaning techniques to allow the data to be imported into the SAMMIE DHM system. Figure 4 shows a screen shot from the Geomagic software after the combination of six scans to create the Scania P cab.

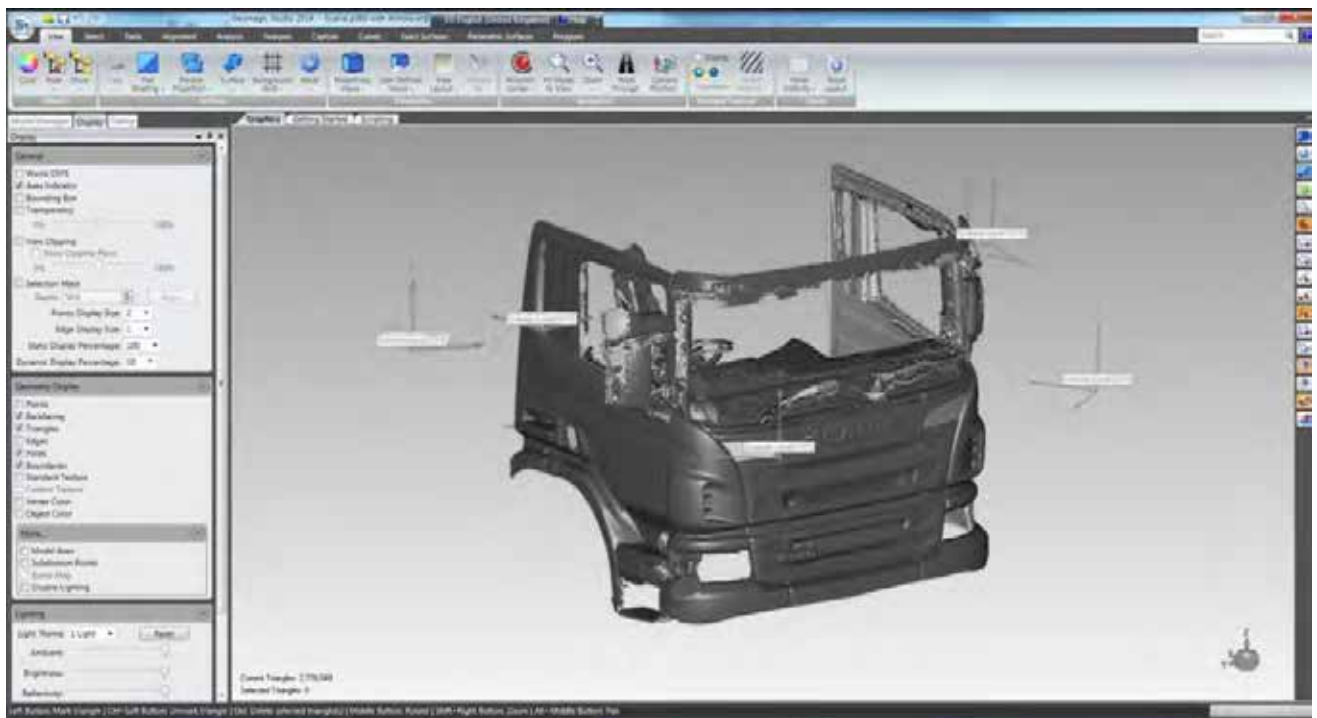


Figure 4. The four scans shown in Figure 3, combined into one object using Geomagic data

3.2.2 THE SCANNING AND CREATION OF THE MIRROR MODELS

A key aspect of the data requirements for the project is the accurate reproduction of the mirrors and how they operate in both a mechanical manner for adjustment and an optical manner for the projection system. The projection technique in the DHM system requires the shape of the outer edge of the mirror glass, and the radius of curvature of the mirror surface to allow a ray tracing technique to produce the volume of space that is enclosed by what can be seen from the driver's point of view. In order to accurately capture this data for all mirrors, a ZCORP hand scanner with a resolution of less than 1mm was used to capture the mirror surfaces and their mounting structures. The mirror surfaces were taped to allow a laser scanner to capture a reflective surface. Each mirror was orientated within its housing to the four extreme adjustment positions of top left, top right, bottom left and bottom right, and these four scans of each mirror surface were combined to allow the centre of rotation of the adjustment to be identified. Geomagics CAD data processing software was used to identify the radius of curvature of the mirror surfaces, and four readings were taken on the mirror glass surface using a spherometer to validate the digital results.



Figure 5. An example of the data that was captured from a mirror arm holding the Class II and Class IV mirrors, using a ZCORP Hand laser scanner

Figure 5 shows an example scan of a mirror arm, with the Class II mirror in the top right adjustment position. The result of this process is a mirror in the SAMMIE DHM system which can be adjusted as it would be in the real world, and that can be projected to show the volume of space that is visible to the driver.

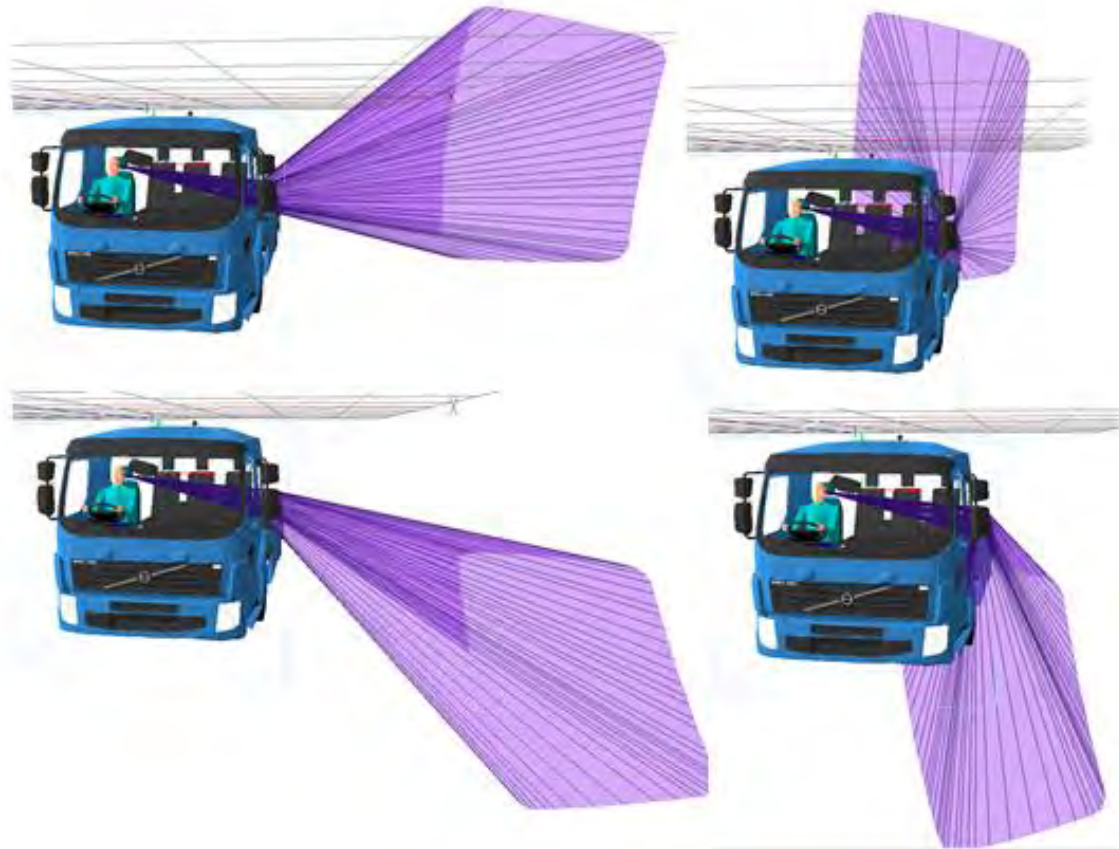


Figure 6. The adjustment of the Class II mirror within the DHM software that is made possible through the mirror data capture process.

Figure 6 shows the final result of this process, with a mirror that can be adjusted in increments between the four maximum adjustment positions.

3.2.3 THE CAPTURE OF WINDOW APERTURES

The projection technique for windows relies upon data which defines the edge of the visible area of the window glass. This can be easily identified with windows that have a rubber surround, but many of the windows that were encountered in the project were bounded by a black enamel strip (called the frit) which defined the visible area of the glass. The frit is an enamel section that is baked into the glass to cover and protect the adhesive used to fit the window screen. The frit does not digitise when using the FARO scanner, and so this required the use of tape that is visible to the scanner being used to define the edge of the visible area, with the edge of the tape providing a clear line to follow in the 3D scanned data. The window apertures were processed separately from the other three dimensional data to provide path data that is compatible with the SAMMIE DHM projection technique. The reference spheres used to align the four exterior scans were retained in the window edge definition files in order to allow realignment with the vehicle. Figure 7 shows FARO scanned data for the taped windscreen for the SCANIA P cab.



Figure 7. The scan of the taped windscreen to allow the visible area of the glass to capture and digitised

3.3 SETTING UP VEHICLES IN THE DHM SYSTEM

3.3.1 DEFINING THE EYE POINT OF THE VIRTUAL DRIVERS.

The SAMMIE DHM window and mirror projection techniques rely upon an understanding of the variability in driver's eye location as this is the origin of the rays used in the projection method. The eye position variability of the driver population is defined by a number of factors including the anthropometry of the driver population, the available seat and steering wheel adjustability in vehicles, and the driving posture that results from the available adjustability. The DfT FOV project previously performed by the LDS team highlighted that driver eye point variability was large enough to warrant the adjustment of all mirrors if the eye point of small driver and the eye point of large driver is to allow the areas of the floor to be visible in mirrors as defined by 2003/97/EC⁵. It is therefore important to use a range of eye points that represent the size variability of drivers if a full understanding of vehicle blind spots is to be achieved through an analysis technique.

⁵ 2003/97/EC. Directive 2003/97/EC of the European Parliament and of the Council on the approximation of the laws of the Member States relating to the type-approval of devices for indirect vision and of vehicles equipped with these devices. Official Journal of the European Union. 2004.



Figure 8. An example of the postures that were defined by the location of the Eyellipse and the available adjustability of the seat and steering wheel

The process of vehicle design and assessment is supported by a number of International Standards Organisation (ISO), Society of Automotive Engineers (SAE) and European Community Standards. The variability of eye location within the vehicle due to driver size variability is specifically covered by SAE J941 (SAE, 1997) with the definition of an Eyellipse (a contraction of the words eye and Ellipse used to describe a contour within which a range of driver eye locations are contained) contours which illustrate the eye point variability in different vehicle types. Unfortunately the Eyellipse data available for HGVs in SAE J941 is outdated in that it does not take into account truck designs with height adjustable seats and is therefore not applicable to modern HGV designs. However, subsequent research has defined new Eyellipse data which does account for seat height variability (Reed, M. 2005⁶). The technique defined by Reed requires the user to have key dimensions that relate to the adjustability of the seat and steering wheel with reference to the standardised accelerator heel point. Therefore these data were requested from all manufacturers. With these data it is possible to define an Eyellipse which is customised for each vehicle. These Eyellipses were generated using equations provided by Reed for each vehicle which places the Eyellipse within the three dimensional model of the vehicle cabs. Each Eyellipse was processed in a manner which provided eye points for the 5thile female driver, the 50thile male driver and the 95thile male driver at three key positions along the major axis of the Eyellipse. The DHMs were then postured in a manner which required the ball of foot marker to be correctly located on the accelerator pedal, the heel on the floor, the seat adjusted to a position to allow the thigh to be supported horizontally by the seat cushion and thoracic spine and other

⁶ Reed, M.P. (2005). Development of a New Eyellipse and Seating Accommodation Model for Trucks and Buses. Technical Report UMTRI-2005-30. University of Michigan Transportation Research Institute, Ann Arbor, Michigan.

DHM joint elements to be within comfortable posture limits, the steering wheel to be effectively reachable and finally, the eye point of the DHM located in the appropriate location with the Eyellipse. This process was successful for all vehicles, providing a range of driver eye positions based upon small female drivers (only 5% of UK females are shorter) and tall males (only 5% of UK males are taller), with an average sized driver also being incorporated.

The key benefit of this process is that a range of eye positions can be consistently defined for each vehicle being tested, providing a fair and equitable method for the comparison of vehicles in terms of direct and indirect vision for a range of driver sizes.

3.3.2 SETTING UP MIRRORS

A key aim of the project is provide a consistent method for the comparison of direct and indirect vision capabilities of driver's from a range of vehicles. The high range of mirror adjustment that is found in vehicles and demonstrated in Figure 6 means that a method was required to constrain the mirror adjustment positions in a manner that is repeatable across all vehicles. This was addressed by adjusting all mirrors to ensure that they meet the requirements of 2003/97/EC. The standard defines the locations on the ground plane (floor) that should be visible to the driver as shown in Figure 9, Figure 10, Figure 11 and Figure 12.

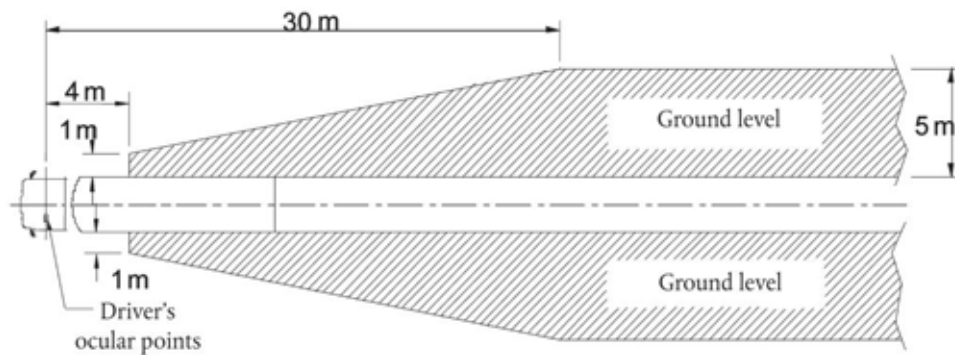


Figure 9. Field of vision of Class II mirrors as specified in 2003/97/EC

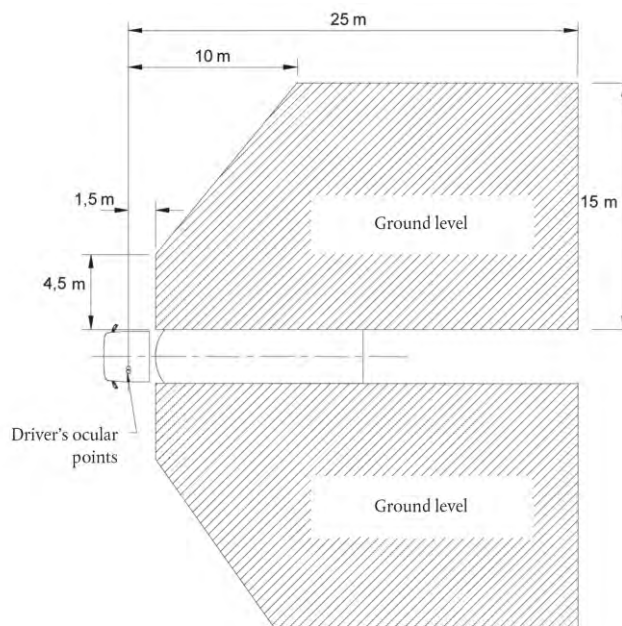


Figure 10. Field of vision of Class IV wide-angle mirrors as specified in 2003/97/EC

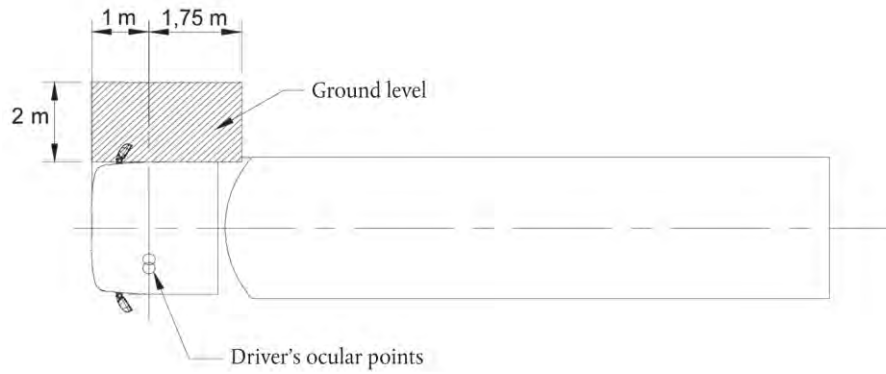


Figure 11. Field of vision of Class V close-proximity mirror as specified in 2003/97/EC

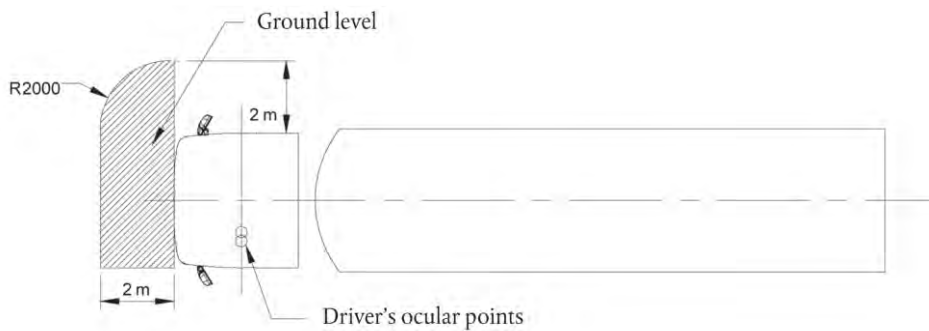


Figure 12. Field of vision of Class VI front mirror as specified in 2003/97/EC

To aid adjustment the mandated areas were recreated in the DHM system as 2D templates, and the mirrors were adjusted for each of the defined eye points to ensure that the standard is met. Figure 13 shows the FOV templates used, the green areas are those required by the Class II mirrors, the purple areas are those required by the Class IV mirrors, the combined blue / red areas are those required by the Class V mirror and the yellow area is that required for the Class VI mirror.

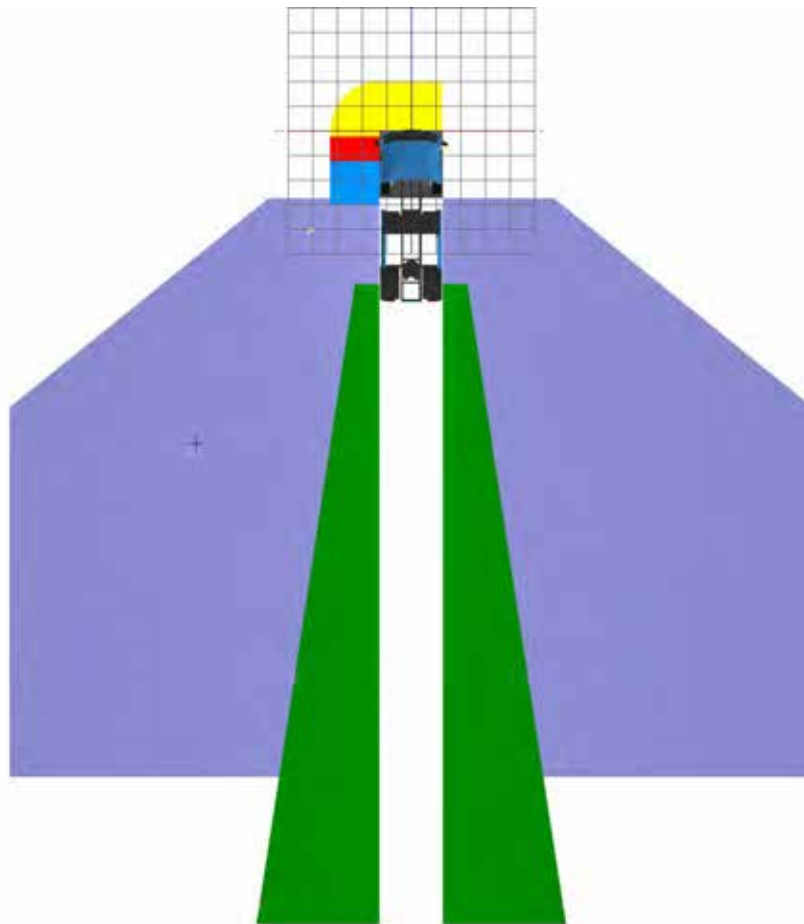


Figure 13. 2D mirror adjustment templates as specified in 2003/97/EC

In almost all cases multiple positions of the mirrors were able to cover the required standard. Therefore an approach was taken where the mirrors were adjusted so that the edge of the mirror projection was just in contact with the edge of the required area as shown in Figure 14. In addition mirrors were adjusted to avoid excessive view of the trailer. Figure 15 shows the mirror setup process completed for the Volvo FE LEC. It should be noted that the projected areas outlined in red, shown in the top right image in Figure 15 appear to not cover all of the mandated area for the Class II and Class IV mirrors. This is due to the projections being limited to a 20m distance for visualisation purposes and though the areas are trimmed to this limit they actually extend for an infinite distance and easily cover the entire mandated area.



Figure 14. Example of mirrors (coverage outlined in red) adjusted to mandated areas for the Volvo FE LEC: Class II (left), Class V (middle), Class VI (right).

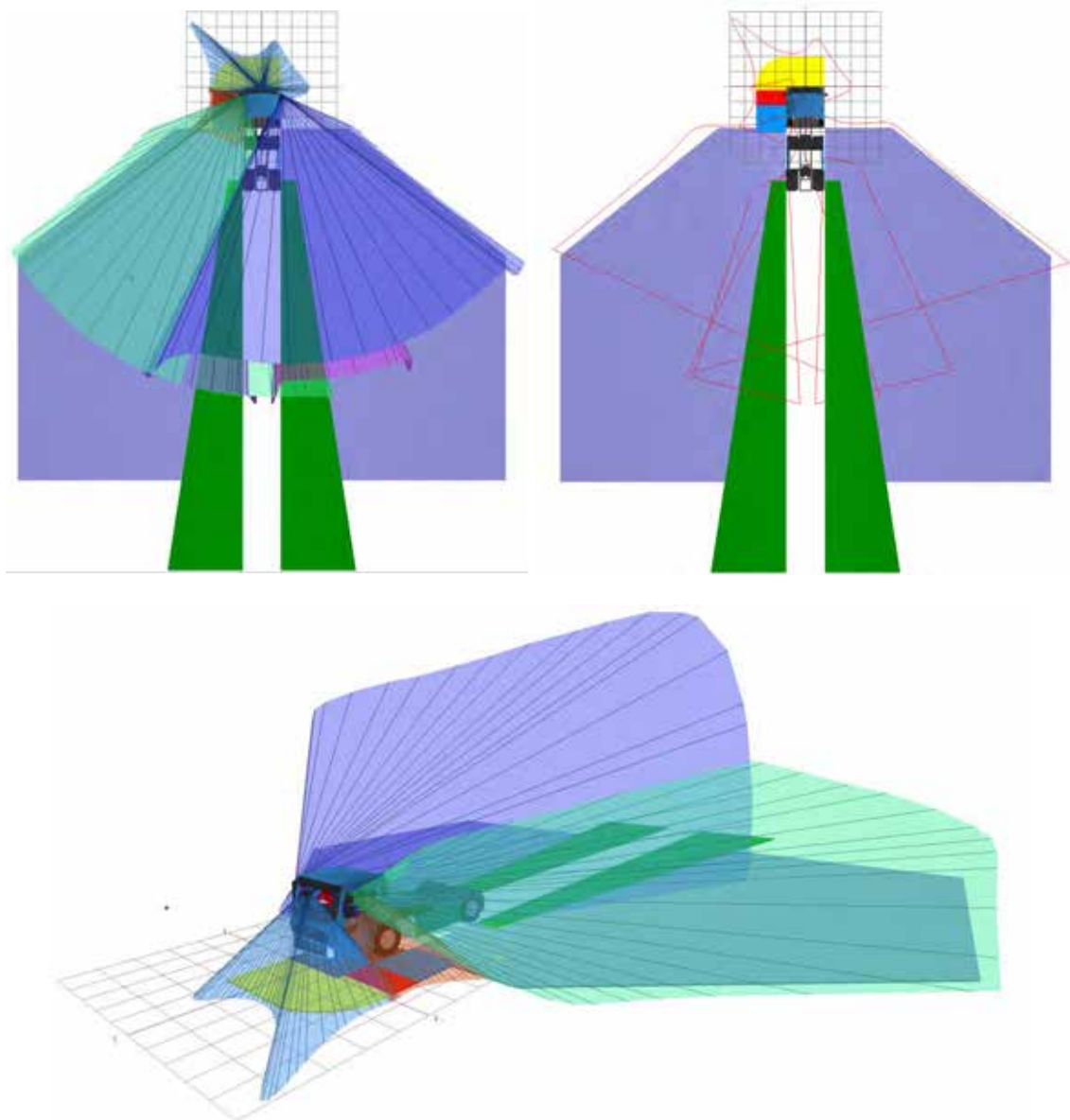


Figure 15. The use of the standard requirements laid out in 2003/97/EC in the definition of the mirror adjustment

3.4 APERTURE PROJECTIONS AND VRU VISIBILITY ANALYSIS

The methodology for assessing the visibility of VRUs was developed to evaluate the visible areas adjacent to each vehicle. The technique utilises three dimensional (3D) projections of the visible volume of space from the eye point of the driver through apertures (windows), and via mirrors. The volumetric projection involves extending a ray from the eye point of the driver through a series of vertices that define the boundary of a window aperture or the perimeter of a mirror surface. In the case of the window aperture the ray is extended directly, whereas with mirrors, the ray is reflected from the spherical mirror surface.



Figure 16. Volumetric projection of the nearside window.

For the purposes of this report a single driver and eye point is used for the VRU analysis. From the setup detail described in Section 3.3.1 the 50th %ile UK male human model and corresponding eye point was selected. The eye point is the mean value for the UK male population and serves as a comparative and consistent value for all analyses. However, it is important to note that the eye point will have an effect on the field of view afforded the driver and thus the nature and extent of any blind spots. To illustrate the differences in eye point across the 5th %ile UK female to 95th %ile UK male range, a comparison of the projections from all three eye points is shown at the end of each vehicle analysis.

The volumetric projection provides a visual means of evaluating field of view such that any part of an object in the driving environment, such as a VRU, that intersects with the projection would result in it being visible to the driver. Conversely anything falling outside of the projected volume would not be visible. However the volumetric projections often provide complex fields of view and a combination of 3D and 2D assessments are performed. 3D analysis consists of an evaluation of the interaction of the volumetric projections and a VRU model. Two VRU models are utilised in the analyses:

1. A 50th %ile UK male (stature 1755mm, equivalent to 63%ile German male, 72%ile French male, 26th %ile Dutch male) used to represent a pedestrian.
2. A 50th %ile UK male riding a standard sized adult mountain bike used to represent a cyclist with a top of head height of 1738mm.

Interpretation of the visibility of the VRUs and the judgment of visibility and / or blind spots around the test vehicles needs to be done with a full understanding of the implications of an assessment based on these standardised models. 50th %ile UK male data should be interpreted as a human that represents the mean stature in the UK for male adults aged 18-64. Thus half of the male population will be taller than this and so generally 'easier to see'. Half of the UK male population, and 98% of the UK female population would be smaller than this and so generally 'harder to see'. If other VRUs such as children and older people (<18 or >65 years) were included then an even greater proportion of the population would fall into this 'harder to see' group. As such these standardised evaluations are by no means the worst-case and the results should be interpreted with an appreciation that any blind spots shown will be larger for smaller VRUs. For European populations, equivalents of the UK data are provided above, e.g. a 50th %ile UK male is equivalent to a 63rd %ile German male and so a greater proportion of the German population would not be visible at this height. Alternatively, any blind spots around the vehicle would be larger than those shown if a 50th %ile German male VRU was used in the analysis. The methods has been defined to allow a comparison between the vehicles that have been selected for the sample. By comparing the distances away from the vehicle front and side at which VRUs can be hidden, the size of the blind spots can be quantified in a manner which relates to the real world implications. The further away that a VRU can be hidden the larger the blind spot is.

In addition to 3D projections, 2D visual areas representing the intersection of the projected volume and a 2D plane, such as the ground, can also be produced (see Figure 17). This 2D approach is a simplification of the FOV afforded to the driver but can be used to provide an overview of visibility at a critical height above the floor (see Figure 18). Anything that intersects with a 2D projection, at the height of the projection, can be seen by the driver.

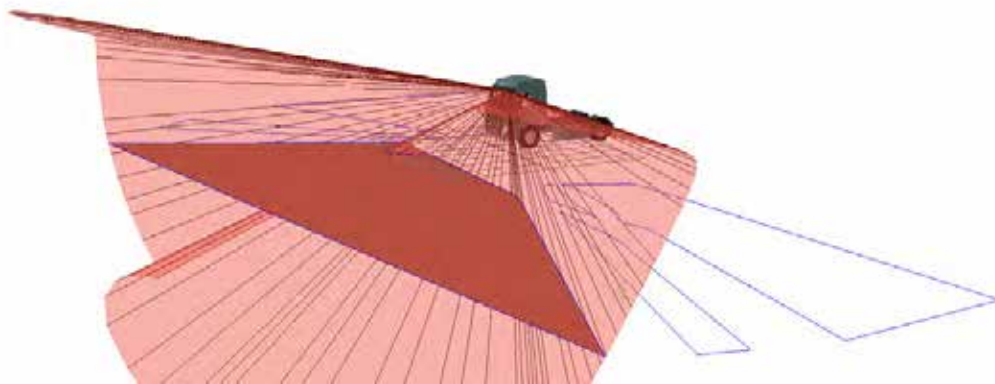


Figure 17. 3D Field of View Projection clipped to the ground plane. The projection of the windscreen is shown in red.

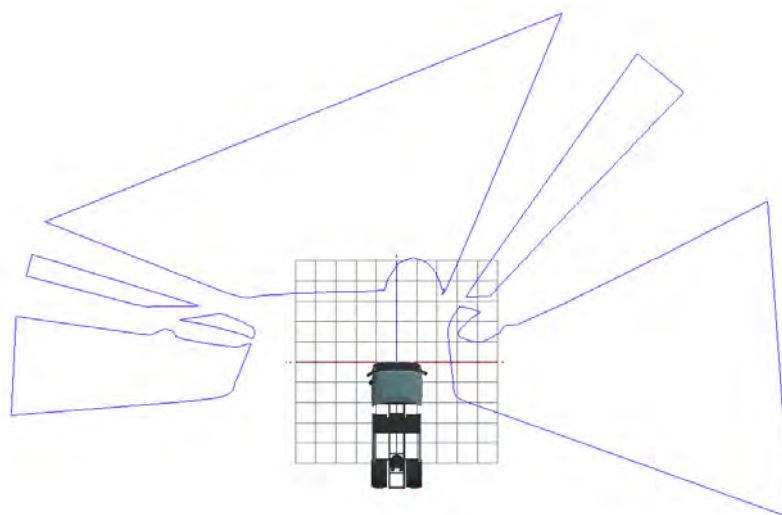


Figure 18. A complete set of 3D aperture projections clipped to form 2D ground plane projections for direct vision.

In addition this approach is used to define the necessary areas of visibility on the ground for indirect vision (through mirrors) in 2003/97/EC and UNECE Regulation 46⁷ and thus is a familiar methodological approach in FOV modelling. It should be noted that whilst the 2D projections are a familiar means of presenting FOV information they are subject to distortion and care should be taken in interpreting what is actually visible to the driver. For example, the 2D projection of the Class V in Figure 19 suggests that the cyclist would be visible to the driver as they are within the ground plane area. However, because the projections generated are largely conical volumes the majority of the cyclist is outside of the visible volume and thus only a very small part of the cyclist would be visible in the very bottom edge of the mirror.

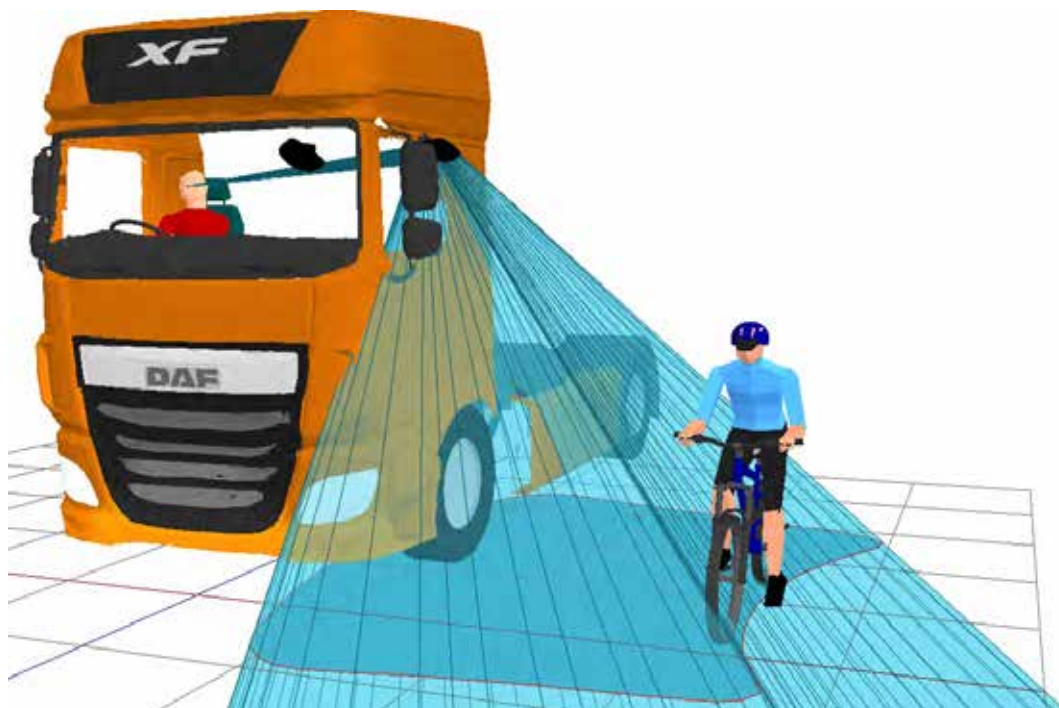


Figure 19. Image showing how objects within the 2D projection area, may not be visible to the driver

⁷ UNECE Regulation 46. Uniform Provisions for Devices for Indirect Vision and of Motor Vehicles with Regard to the Installation of these Devices. UN ECE Vehicle Regulations. 2009.

To partially address this issue the analyses uses three 2D plane heights:

1. Ground plane. This is used as a standardised projection to provide an overview of direct vision baseline for all test vehicles.
2. Ground plane + 1738mm. This is used to represent the FOV at a height coincident with the top of the cyclist model's head (helmet).
3. Ground plane + 1755mm. This is used to represent the FOV at a height coincident with the top of the pedestrian model's head.

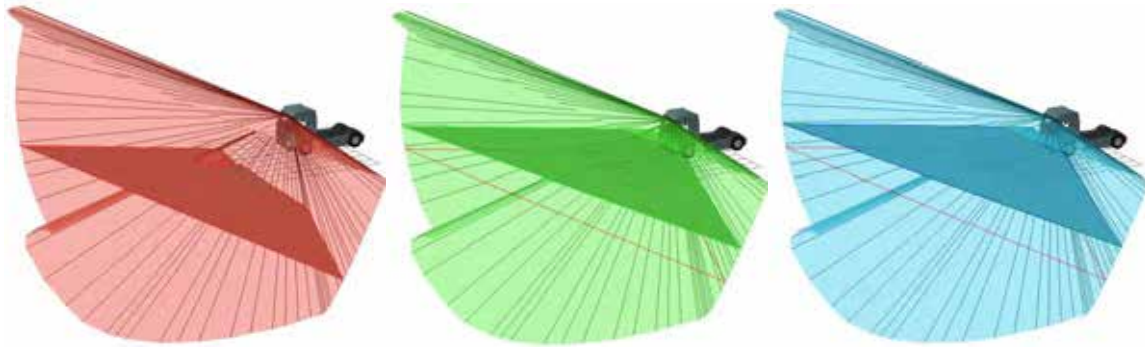


Figure 20. 3D Field of View Projection of the windscreen clipped to the ground plane (left), the ground plane +1738mm (middle) and the ground plane +1755mm (right)

Figure 20 shows the 2D plane intersections occurring at the three analysis heights. Figure 21 illustrates the difference in the resulting 2D visible areas when the visible volume of space is clipped at the different heights. For the higher planes e.g. ground +1755 (blue) the plane is much closer to the eye height of the driver and thus the visible areas are much closer to the vehicle and conversely the blind spots are much smaller.

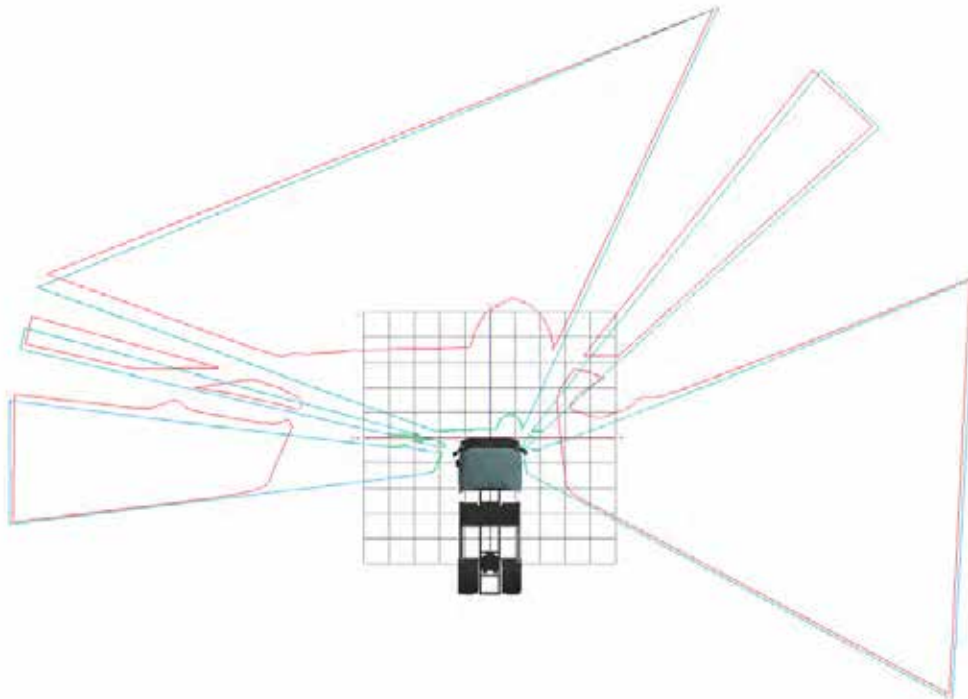


Figure 21. 2D ground plane projections for all windows at the three analysis heights ground (red), +1738mm (green), +1755mm (blue)

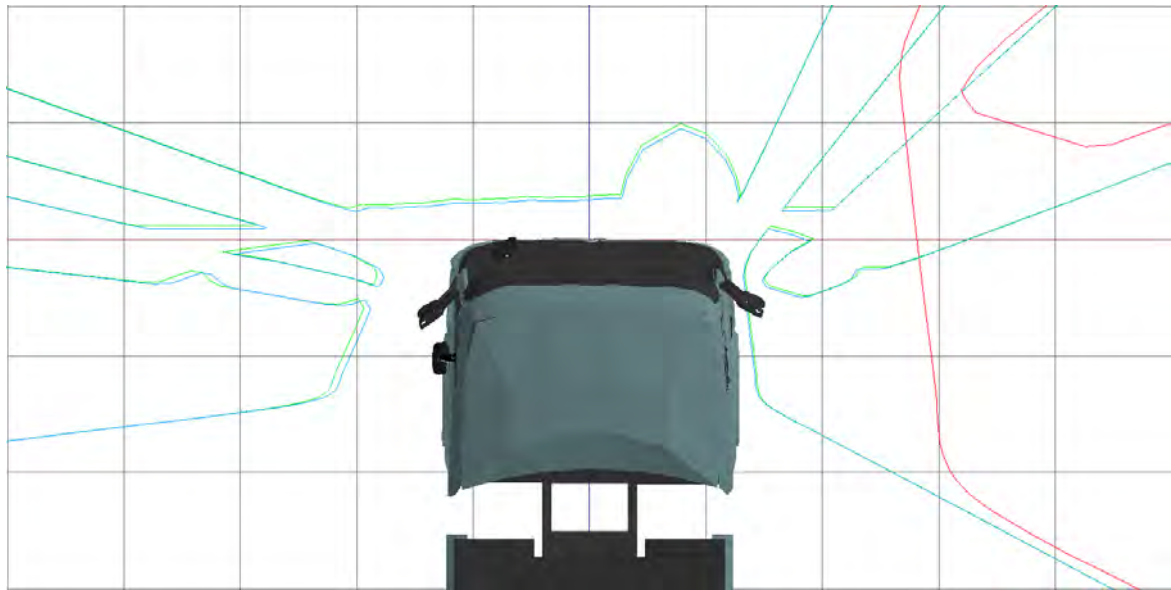


Figure 22. 2D ground plane projections at the three analysis heights ground (red), +1738mm (green), +1755mm (blue). The area differences between +1738 and +1755 are only apparent in close proximity to the vehicle.

For the 2D area projections, a final constraint applied is that all projections are limited in the distance they extend from the vehicle. Theoretically the field of view stretches from the driver's eye through a window, or via a mirror to an infinite distance. For illustration purposes these infinite rays are trimmed to a distance of 20m. 20m was selected to capture all details of the 2D area projections whilst focusing on the critical areas adjacent to the vehicle. Figure 23 shows the effect of this 20m limit. Using a greater limit of 50m provides unnecessarily large projections that cover areas of limited interest to this work. Using a smaller limit of 10m results in some areas being trimmed to a very small size and one projection (the top front corner of the nearside window) fails to intersect with the ground plane and so no projection is shown. It should be noted that this limit is mainly a convenience for reporting and has no bearing on the results.

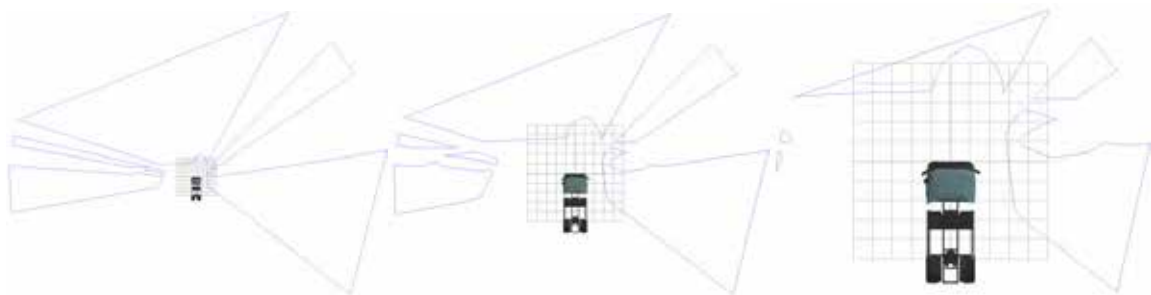


Figure 23. The effects of limiting the projection distances. 50m (left), 20m (middle), 10m (right)

Informed by the previous projects performed by the LDS team which included a review of UK STATS19 accident data analysis, a number of analysis configurations were identified for evaluation. These evaluations are detailed in the following sections. Appendix 1 shows an infographic which shows the key scenarios that were identified.

3.4.1 FORWARD VISIBILITY

This test evaluates the visibility of a pedestrian across the front of the assessment vehicle. Three pedestrian VRU models are positioned in line with the centre line of the vehicle and at each of the outer edges. This is designed to represent a pedestrian crossing in front of the test vehicle. Each pedestrian is positioned at a

point furthest away from the vehicle at which they are not visible to the driver. The linear distance from the front of the vehicle is then reported for each pedestrian. These values provide a measure of any blind spot to the front of the vehicle. Figure 24 shows the three pedestrian models positioned to the front of the test vehicle. The image on the right shows a top down view highlighting the different distances the pedestrians can be positioned from the front of the vehicle without being visible to the driver. It can be seen from the figure that the pedestrians can be between 0.7m and 1.2m from the front of the vehicle without being visible to the driver. The blue area represents the projection of the visible area of the windscreen at the 1755mm height as described previously. Thus the blue areas are directly visible, the white areas are effectively blind spots at this height (1755mm) and lower.

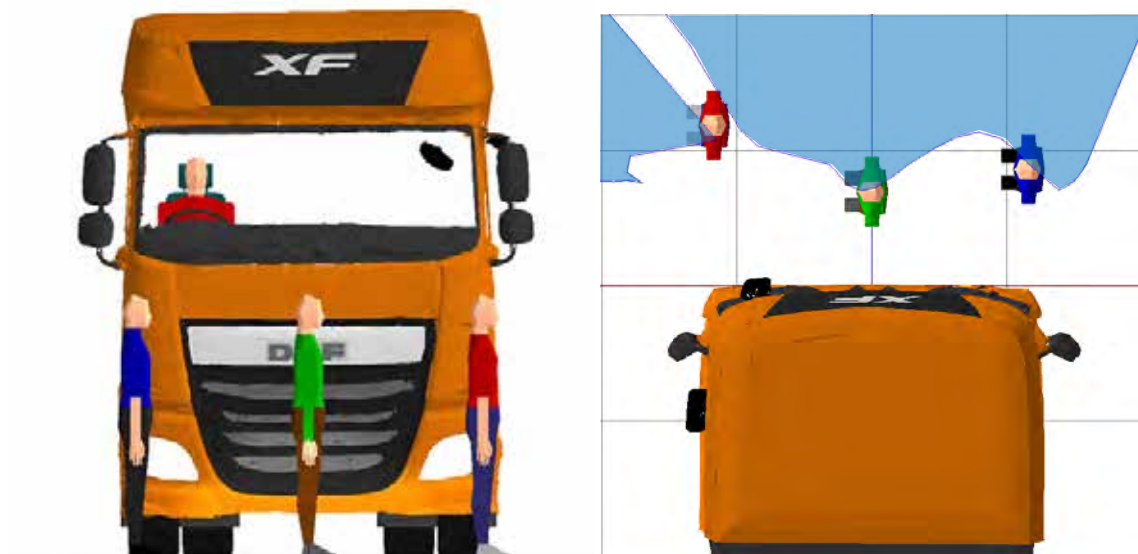


Figure 24. The configuration of the pedestrian models positioned in front of the vehicle. The image to the left shows a view to the front of the vehicle. The image to the right shows a plan (top-down) view.

3.4.2 OFFSIDE (DRIVER SIDE) VISIBILITY

This test evaluates the visibility of a cyclist to the offside of the vehicle. Two cyclist VRU models are positioned to the offside of the vehicle. The rear cyclist (blue) is positioned fore-aft to align the top of their head with the driver's eye-point, the front cyclist (yellow) is 1m in front of the first. This is designed to represent a cyclist overtaking the test vehicle. The models that represent the cyclists are positioned in these locations to represent common accident scenarios for blind spots known to exist around large goods vehicles. Each cyclist is positioned at a point furthest away from the vehicle at which they are not visible to the driver. The linear distance from the side of the vehicle is then reported for each cyclist. These values provide a measure of any blind spot to the offside of the vehicle. Figure 25 shows two cyclist models positioned to the offside of the test vehicle. The image on the right shows a top down view highlighting the different distances the cyclists can be positioned from the offside of the vehicle without being visible to the driver, in this case there is no location at which they are not visible (i.e. they are always visible). The blue area represents the projection of visible area of the offside windows at the 1738mm height as described previously.



Figure 25. The configuration of the cyclist models positioned to the offside of the vehicle. The image to the left shows a view to the offside of the vehicle. The image to the right shows a plan (top-down) view.

3.4.3 NEARSIDE (PASSENGER SIDE) VISIBILITY

This test evaluates the visibility of a cyclist along the nearside of the vehicle. Two cyclist VRU models are positioned to the nearside of the vehicle. As with the analysis of offside visibility, the rear cyclist (blue) is positioned fore-aft to align the top of their head with the driver’s eye-point, the front cyclist (yellow) is 1m in front of the first. This is designed to represent a cyclist either undertaking or waiting to the nearside (nearest the pavement) of the vehicle. Each cyclist is positioned at a point furthest away from the vehicle at which they are not directly visible to the driver. The linear distance from the side of the vehicle is then reported for each cyclist. These values provide a measure of the blind spot to the nearside of the vehicle. Figure 26 shows two cyclist models positioned to the nearside of the test vehicle. The image on the right shows a top down view highlighting the different distances the cyclists can be positioned from the side of the vehicle without being directly visible to the driver. In comparison to the situation seen for offside visibility the cyclist can be positioned between 1m and 1.5m from the nearside of the vehicle and not be directly visible to the driver. The blue area represents the projection of visible area of the nearside windows at the 1738mm height as described previously.

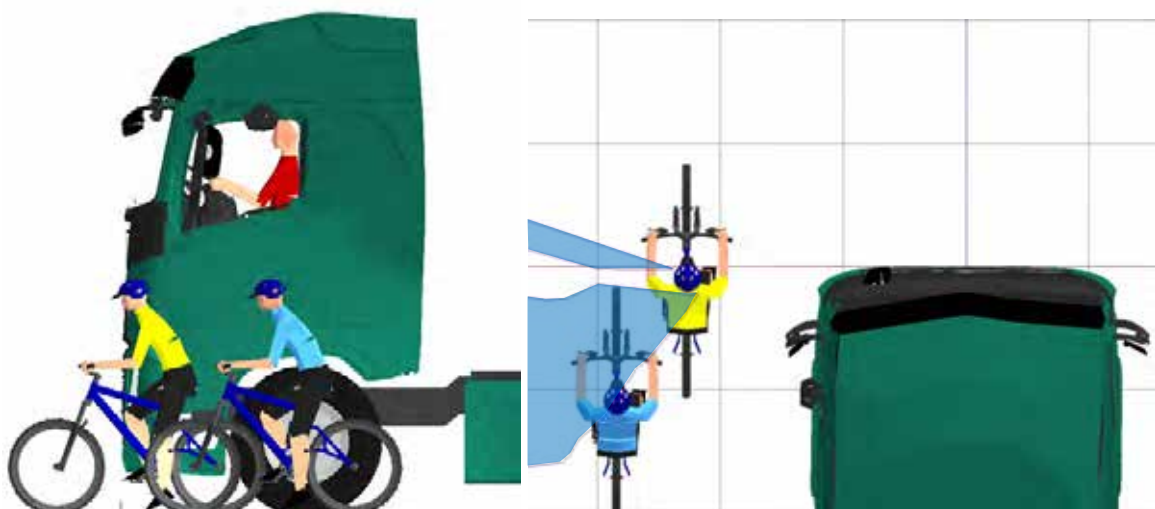


Figure 26. The configuration of the cyclist models positioned to the nearside of the vehicle. The image to the left shows a view to the nearside of the vehicle. The image to the right shows a plan (top-down) view.

3.4.4 INDIRECT VISION ANALYSES

Whilst the focus of this research prioritises direct vision (via windows), it is important that indirect vision (via mirrors) is also considered as they are currently a critical part of the regulations in addressing blind spots around the vehicle. For all of the analyses described in Section 3.4.1, Section 3.4.2 and Section 3.4.3 3D and 2D analyses are also performed for mirror projections. Figure 27 shows the projection of the Class VI mirror to the front of a vehicle. As with direct vision analyses, 3D projections (left image in Figure 27) are used together with 2D area projections (right image in Figure 27). In comparison to Figure 24 that shows the pedestrian VRU models can be located as shown and not be visible to the driver via direct vision, the pedestrians would be visible in the Class VI mirror. The middle (green) pedestrian is completely visible, the right (blue) pedestrian is visible from the shoulders down, the left (red) pedestrian is visible from the waist down. The red area represents the projection of visible area of the Class VI mirror at the 1738mm height as described previously. This indirect vision analysis is also performed for offside and nearside visibility using the appropriate mirrors.

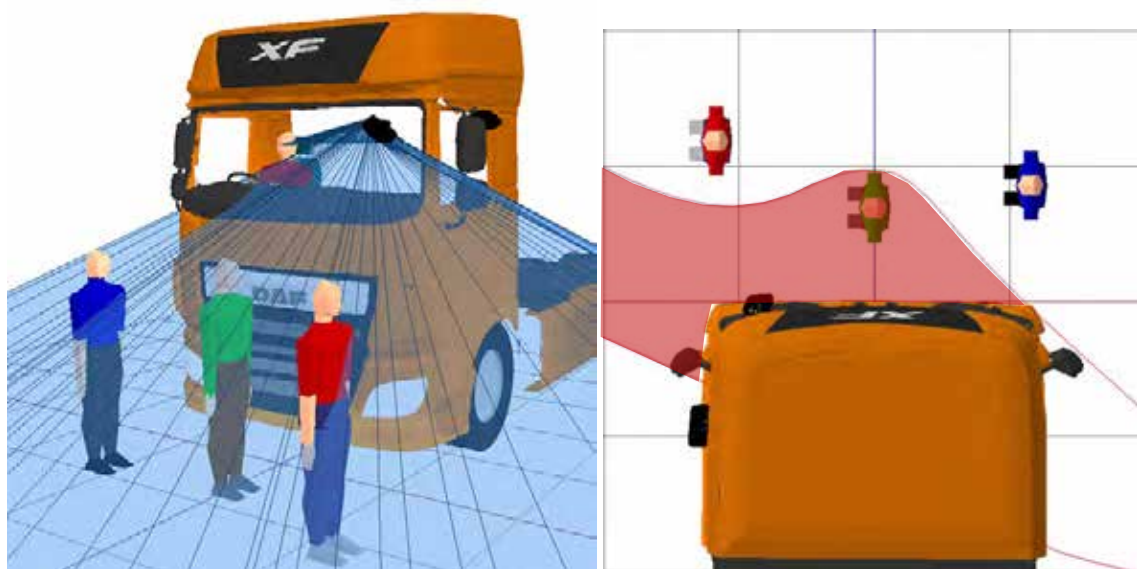


Figure 27. The configuration of the pedestrian models positioned in front of the vehicle for indirect vision analysis. The image to the left shows a 3D view to Class VI mirror projection. The image to the right shows a plan (top-down) view.

3.4.5 VRU ANALYSIS RATIONALE

For all of the analysis configurations the analysis will attempt to position the pedestrian or cyclist model at a point at which they are just *not* visible to the driver, i.e. they will be completely obscured from the driver's vision. This will highlight the limits of visibility for the driver of the VRUs around the vehicle. This method has been selected to avoid the ambiguity of defining how much of a VRU should be visible to the driver in order for them to be 'seen'.

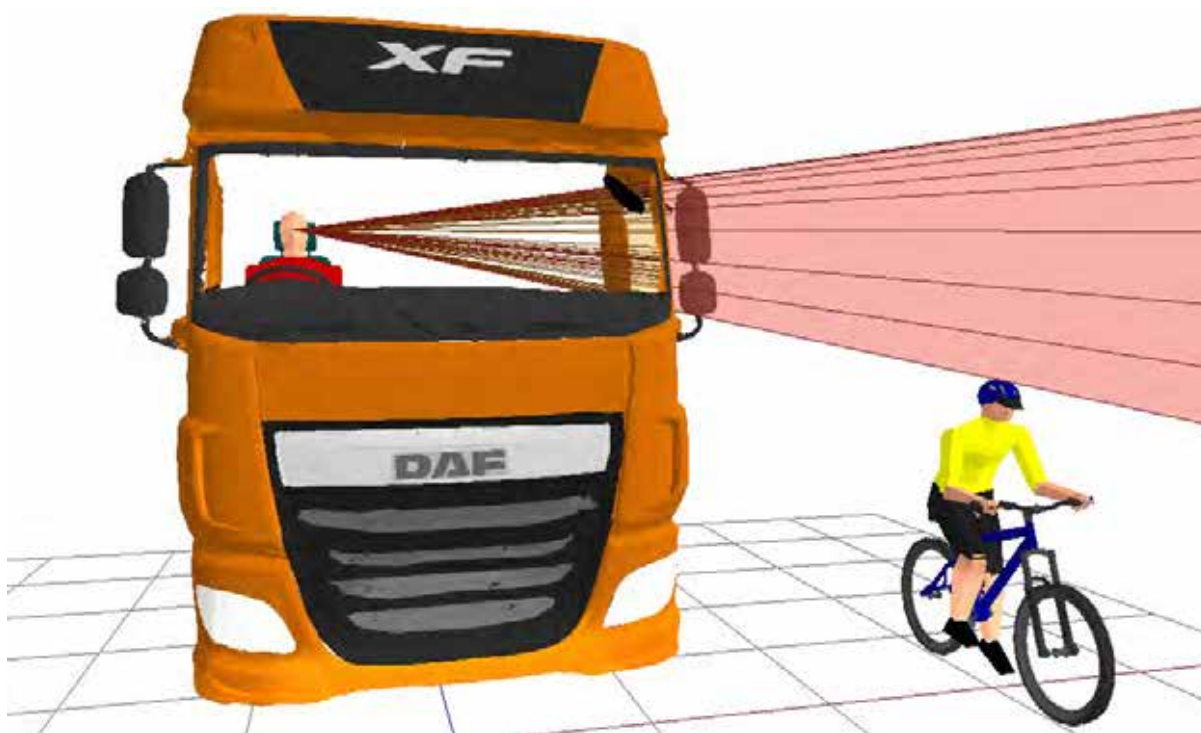


Figure 28. Positioning of cyclist model at a point where they are just not visible (against the projected volume), shown in 3D

Figure 28 shows a cyclist model to the nearside (passenger side) of the test vehicle. The cyclist has been moved laterally away from the side of the vehicle until the helmet of the cyclist is at a point where it just fails to intersect with the projected visible volume from the passenger window. This represents the furthest the cyclist could be away from the vehicle and still not be visible. By positioning the VRU in this way the size of any blind spot in direct vision is illustrated. The relative positioning of the pedestrians and cyclist VRUs adjacent to the test vehicles will be shown in 3D as in Figure 28. The positioning will also be shown in 2D as illustrated in Figure 29. The 2D images show the vehicle, the relative positioning of the pedestrians or cyclists and the relevant projections at the appropriate 2D plane height. Colour coding is used to identify the projected areas visible to the driver. Projected areas of direct vision (windows) are coloured blue, projected areas of indirect vision (mirrors) are coloured red. In Figure 29 the blue areas represent the space visible to the driver at a height of 1738mm above the ground. Conversely, the white areas at the same height cannot be seen. Thus the top of the head (helmet) of the cyclist is located at a point just outside of the blue visible area, and is therefore completely obscured from the driver's direct vision. It may be noted that the left shoulder / upper arm of the cyclist is within the blue area. This suggests that part of the cyclist would be visible but this is not the case and is a limitation of the 2D area projections. The blue areas are only visible at the 1738mm height. The shoulder and upper arm of the cyclist are below this height as so may or may not be visible, this is a similar issue as shown in Figure 19 and is discussed further in Section 3.4.6.

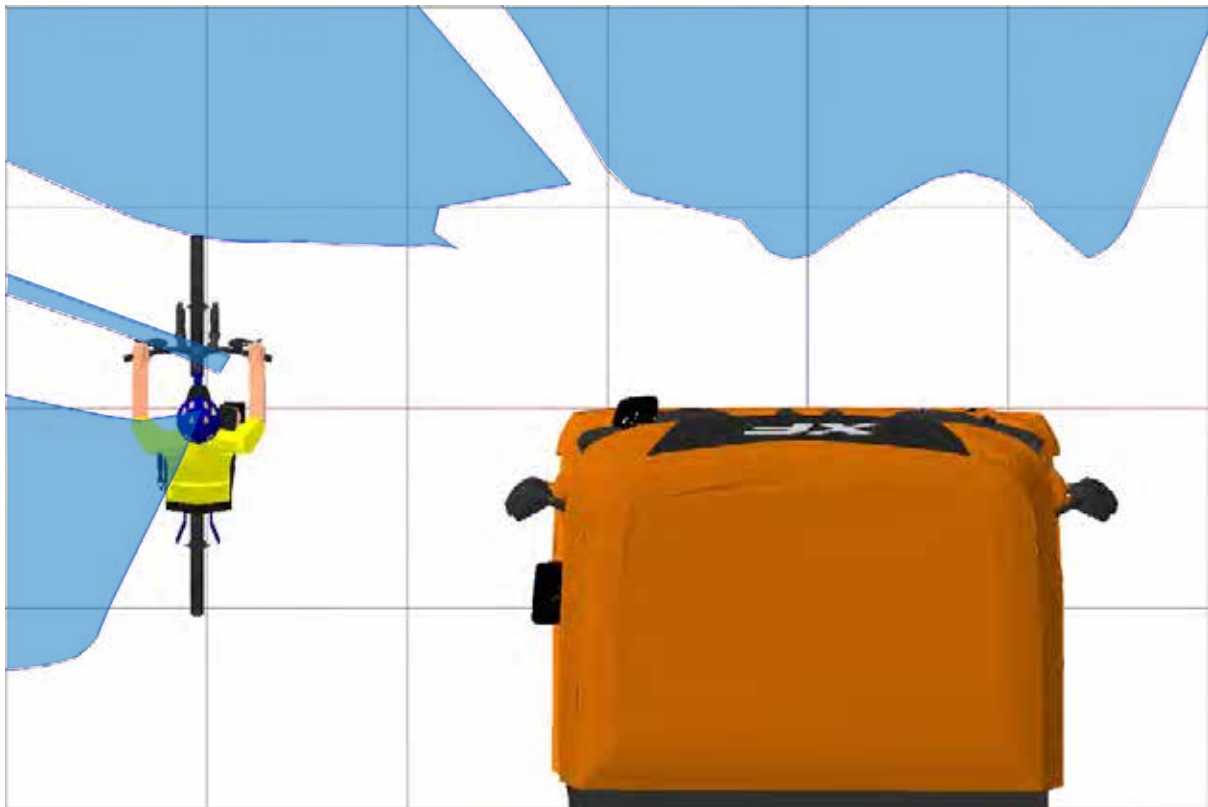


Figure 29. Positioning of cyclist model at a point where they are just not visible, shown in 2D as a top-down view.

To aid in understanding the scale of any blind spots around the vehicle all of the analysis images contain a 1m squared grid on the floor. For example it can be seen in Figure 29 that the right arm of the cyclist is approximately 1.5m from the side of the vehicle. In addition where VRUs are not visible to the driver, the shortest distance between the VRU and the test vehicle is directly measured (Figure 30). This provides objective measures for the comparison of direct vision between test vehicles.



Figure 30. Measurement of shortest distance of a non-visible VRU to the test vehicle

For VRUs that are always visible regardless of positioning, illustrations will still be used to provide an understanding of the degree of visibility. Figure 31 shows how the volumetric projections can be used to determine if a VRU would be visible to the driver due to the intersection of the projection and the cyclist model. This is also supported by images taken from the driver's eye point giving an indication of what the driver would actually be able to see.

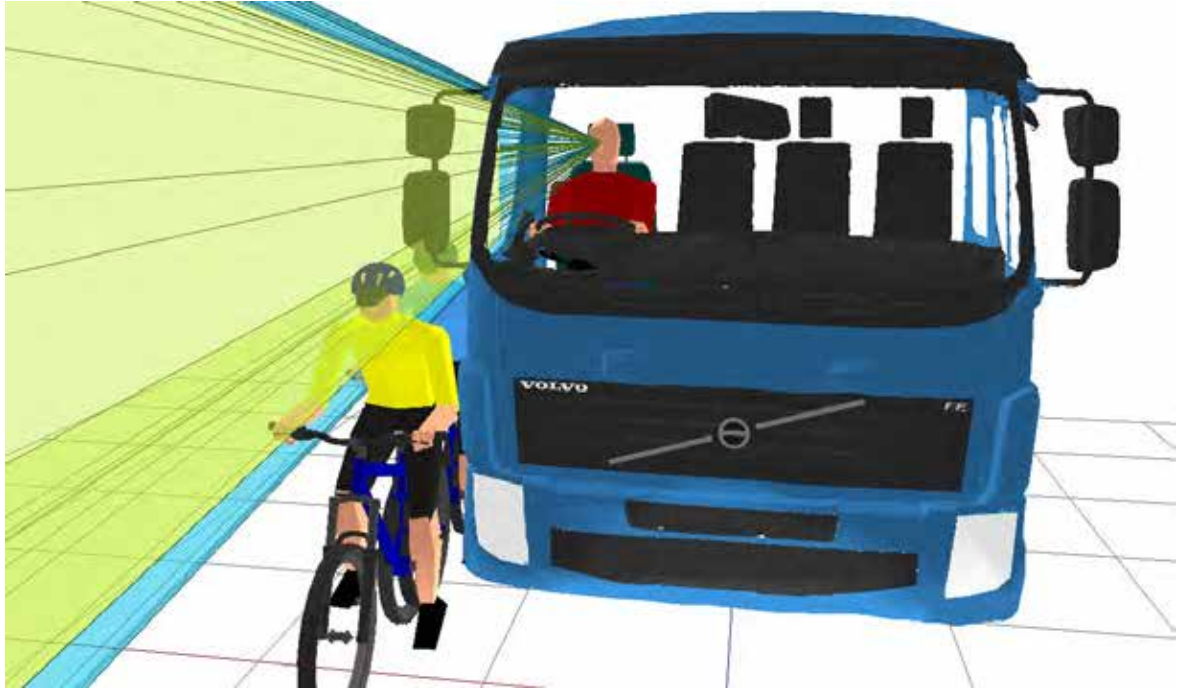


Figure 31. Intersection of the 3D volumetric projection and the VRUs provides an indication that they would be visible to the driver.

Figure 32 shows a driver's eye view of the two cyclists to the offside of the vehicle highlighting how visible they are, even when positioned up against the side of the vehicle.

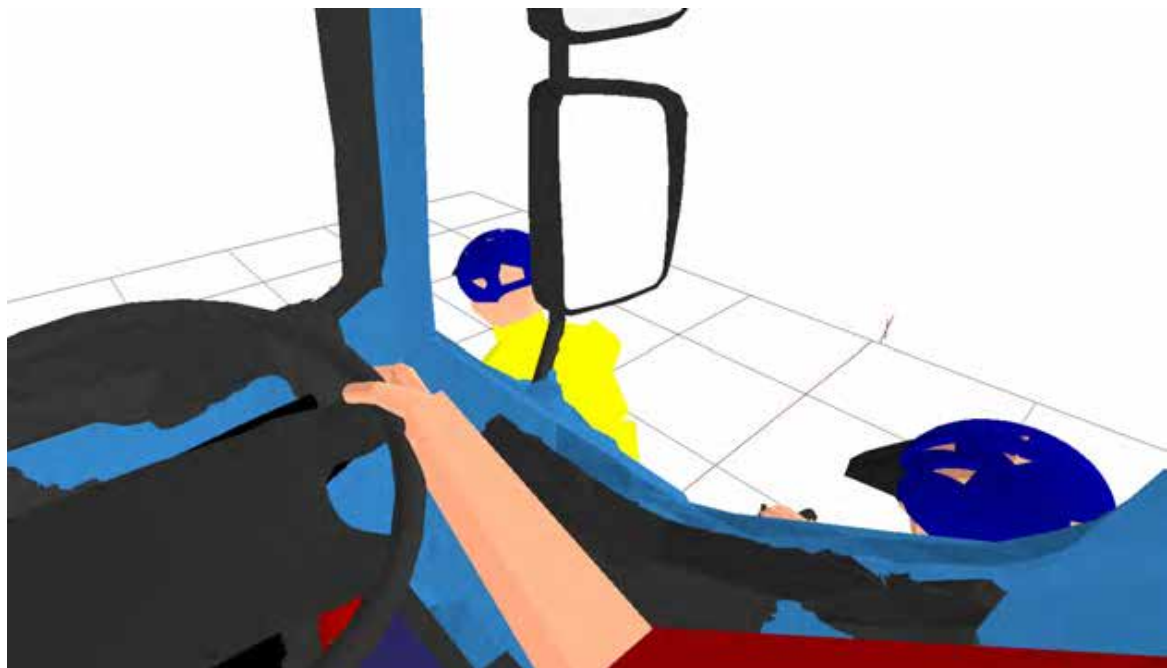


Figure 32. Driver's view of the VRUs adjacent to the vehicle confirming that the VRUs are visible.

3.4.6 VRU MODEL POSITIONING AND LIMITATIONS

For the volumetric analyses, the positioning of the VRU models is an important issue. The use of pedestrian and cyclist models provides both representative and accessible evaluative objects, however in limited numbers, they do not fully provide an exploration of the magnitude of the blind spots around each vehicle. If a VRU is shown to not be visible in one location, as illustrated in Figure 29 this does not provide a full understanding of whether they would be visible or not if the location was changed. In general, it is likely that moving the VRU closer to the vehicle would result in the VRU remaining obscured, moving them further away would result in them becoming visible. The experimental setup of the VRU models aims to partially address this positioning issue through the use of multiple locations across each side of the vehicle in critical areas as described in Sections 3.4.1, 3.4.2 and 3.4.3.

The use of 2D projections in these analyses also raises a number of associated issues. In general a VRU positioned in a white area is likely to result in them being obscured, whilst a VRU positioned in a blue (or red) area is likely to result in them being visible. However, the 2D projections, as discussed previously, are only a snapshot of visibility at the specific height of the 2D plane. Figure 27 highlights this limitation, the right hand image suggests that only the middle (green) pedestrian is visible in the Class VI mirror. However, the left hand image shows that all three pedestrians are visible in the Class VI mirror to differing degrees. Furthermore Figure 29 shows a cyclist positioned at a location where they are not visible to the driver. The image also shows that the left shoulder / upper arm of the cyclist is within the blue area suggesting that part of the cyclist would be visible. As the left shoulder / upper arm of the cyclist is below the plane (+1738mm) at which the 2D areas are projected it is not possible to infer visibility or not of the cyclist (or part of the cyclist) at this height. The conclusion is that it is not straightforward to predict what would happen if a VRU model were moved from the assessed locations and to draw more general conclusions about visibility of VRUs around the vehicle anywhere other than in the assessed locations or at the 2D projection heights.

These issues highlight the need to take multiple approaches to assess and communicate the field of view afforded the driver of any of the test vehicles. In addition the results of these assessments should not be simplified or taken out of context to the extent that they lose the richness resulting from the multidimensional approach employed in this research. It is only together that an understanding of what is, or is not, visible can be obtained.

In combination the methods utilised provide a standardised means to compare the FOV across a range of vehicles. For the specific locations selected the visibility of VRUs adjacent to the vehicles can also be objectively evaluated. To explore the visibility of VRUs more thoroughly, accounting for A-pillar obscuration, the impact of mirror body obscuration and the influence of road layout and accident scenario testing more comprehensively, further research would need to be performed that is beyond the scope of this report. However, to further address these limitations, both in the use of a fixed set of VRU models and the distortion inherent in the 2D projections, when attempting to provide an overall understanding of the FOV of a specific vehicle configuration, an additional projection technique has been used. The aim was to develop a method for the objective evaluation of FOV that would allow metrics to be obtained that represented a greater understanding of the view afforded to the driver in key locations around the vehicle for all test vehicles.

3.5 SPHERICAL PROJECTIONS OF FIELD OF VIEW

In addition to the VRU analysis a 360 degree FOV Area analysis has been employed. The approach utilises a spherical projection technique based on previous work conducted by the Loughborough team as part of investigations into supporting Primary NCAP vision assessments. As previously described the technique employs projections from the eye point of the driver through apertures (windows), and via mirrors. In both instances the ray is extended until it intersects with the surface of a sphere (see Figure 33). The sphere is centred on the driver's eye point and has a radius of 10m⁸. The intersection of the rays and the sphere surface defines a projected aperture (or mirror) area. One of the limitations in using the 2D planar projections discussed previously is distortion and the potential to provide an easy mis-interpretation of what is visible to the driver (see Figure 19). Much of this distortion is due to the 2D plane not being perpendicular to the direction of view (from the eye or from the surface of the mirror) and hence why they should only be used in conjunction with the 3D projections. To address this, the FOV area projections utilise a projection surface that is always perpendicular to the direction of view for direct vision and thus minimise any distortion effects. Furthermore the projections are independent of the issues surrounding the vehicle height allowing cab design to be compared independently of mounting height.

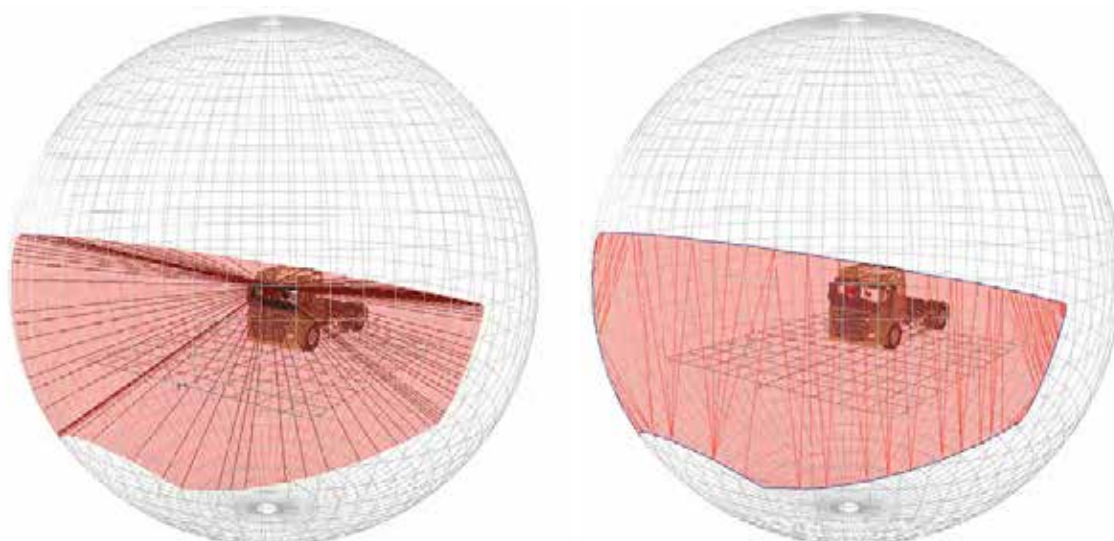


Figure 33. Field of view projection of a windscreen. The left image shows the rays extending form the eye point to the sphere. The right images shows the resulting polygon projection on the surface of the sphere and its tessellation.

The projected areas can also have their size calculated to provide an objective metric for the magnitude of the field of view afforded the driver. As the areas are mapped onto the surface of a sphere, area calculation must be based on the resultant spherical polygon. The projected polygons may be convex or concave and so the polygons are tessellated and the resulting spherical triangles have their area calculated and summed to provide the area of the spherical polygon. The area of a spherical triangle is calculated using the following formula:

$$\text{Area } (\Delta) = r^2 [(A+B+C) - \pi]$$

Where A, B and C are the internal angles of the triangle and r is the radius of the sphere.

⁸ 10m was selected for illustration purposes providing a useful distance in reporting.

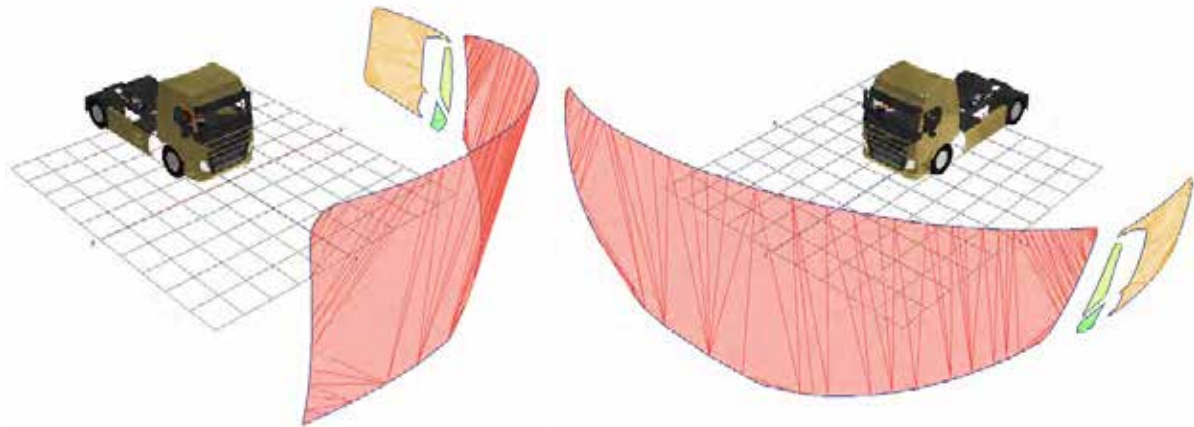


Figure 34. FOV area projection of a number of vehicle window apertures

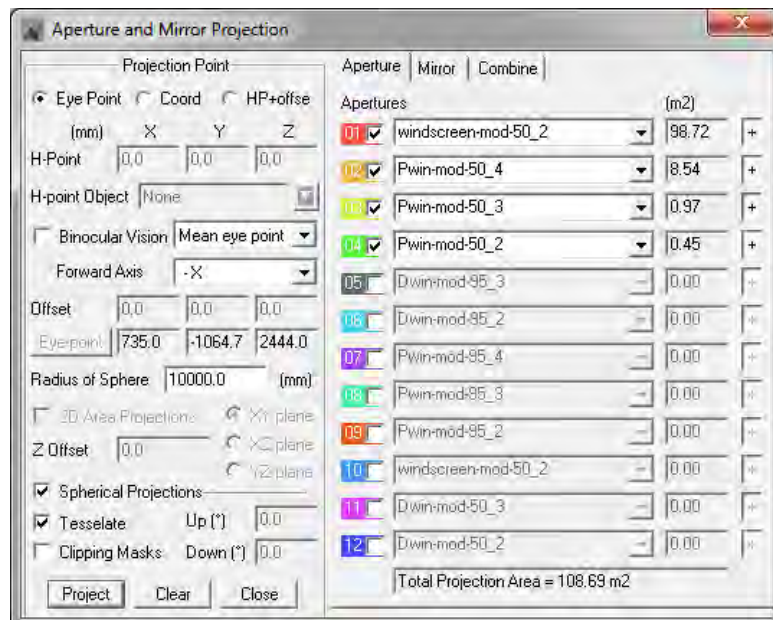


Figure 35. An example of the area calculations for the four apertures shown in Figure 34.

As the radius of the sphere is part of the area calculation it can be seen that the selection of a 10m radius sphere will affect the area values produced but equally that they are proportional to the square of the radius and so if a smaller sphere was used the values would be smaller, but between apertures, or between vehicles, area size would remain in the same relative order. Thus if the nearside window of the vehicle in Figure 34 had a projected FOV area of one quarter the projected area of the windscreen, this ratio would be constant whether the sphere radius was 1m, 10m or 100m.

3.5.1 COMBINING FOV AREA PROJECTIONS

The basic FOV area projection methodology has also been extended to account for two observations from the evaluation of field of view that combines direct and indirect vision. Direct vision aperture projections always result in a series of discrete areas, as shown in Figure 34. However, indirect vision projections often result in overlapping areas (see Figure 36).

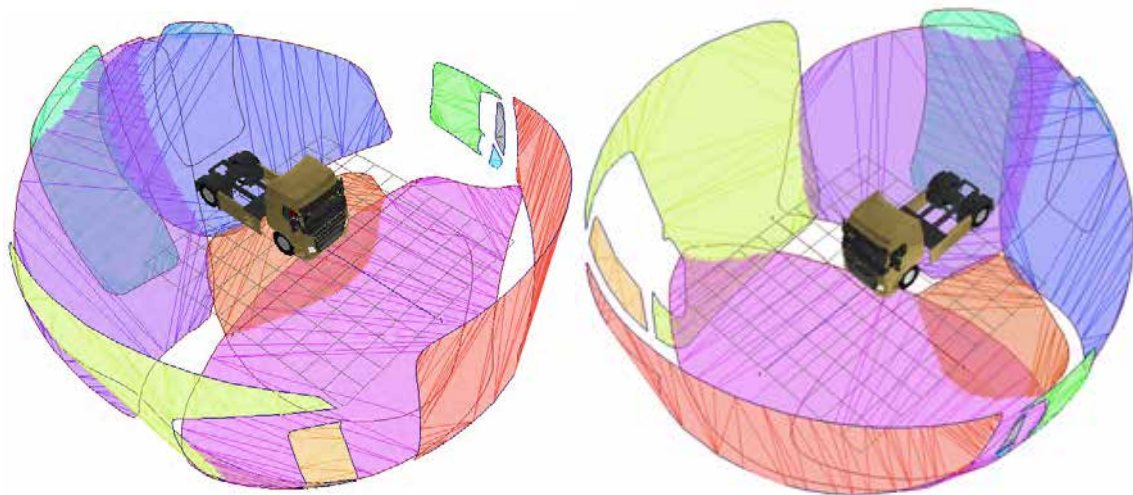


Figure 38. Full FOV area projection including both direct and indirect vision, highlight the extent of the overlapping field of view

Thus the methodology was extended to combine projections to remove any overlap. Figure 39 shows the result of a combined FOV area projection. The projected area is shown as 96.46m² in contrast to the uncombined, overlapping projections shown in Figure 37 with an area of 117.71m².

The process of combination is not intended to make any judgement about the effectiveness and use of any particular window or mirror. Even though the field of view afforded by the Class II mirror is often largely subsumed by the FOV of the Class IV mirror, this should not be used to infer that the Class II mirror is redundant. Whilst the Class IV mirror should afford a view of the same area of the driving environment, it is also often a smaller mirror with a greater radius of curvature and thus more distortion. This makes a case for both mirrors to be useful to the driver in gaining an understanding of the driving environment. For all FOV area projections both the combined and uncombined values will be shown and any area that has been affected by the combining process will be highlighted.

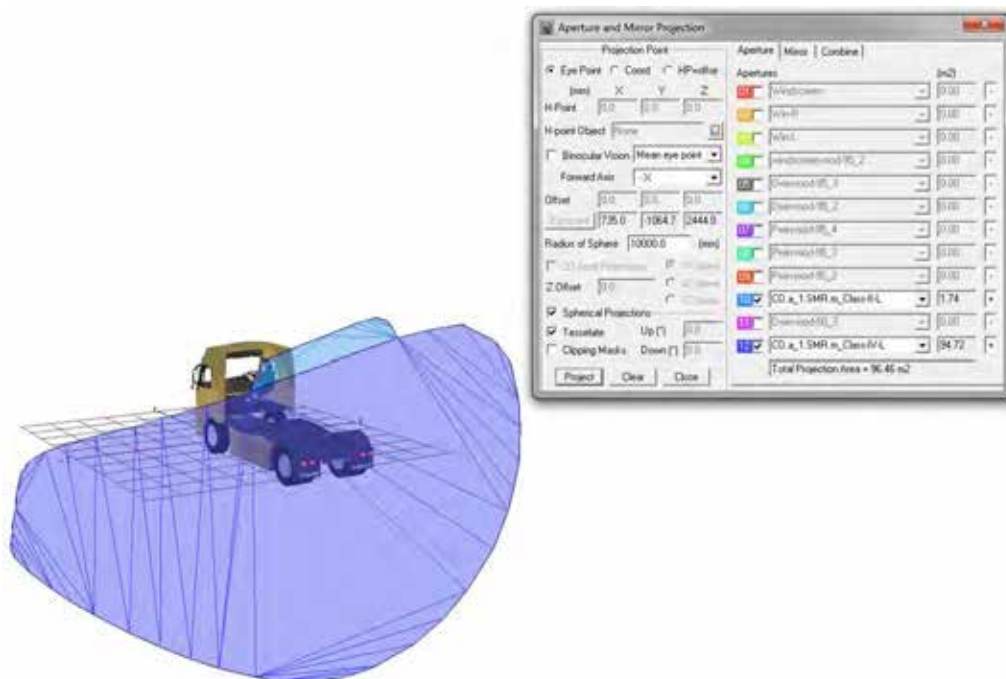


Figure 39. Combined FOV area projection of Class IV and Class II mirror with the overlap removed

3.5.2 CLIPPING FOV AREA PROJECTIONS

The second observation concerns the potential for distortion of the objective FOV metrics through projections that cover areas not of direct relevance for this work. For example, a vehicle may offer a high level window aperture that affords the driver a view of high level elements in the driving environment e.g. traffic signals. This work is predominantly focused on the visibility of VRUs that are primarily at a relatively low level around the vehicle. Thus the methodology was further extended to clip the direct vision projections to an angle up from the horizontal plane through the driver's eye point. The angle selected was +7 degrees in line with UNECE Regulation 125⁹ that concerns approval of motor vehicles with regard to the forward field of vision of the motor vehicle driver and is shown in Figure 40.

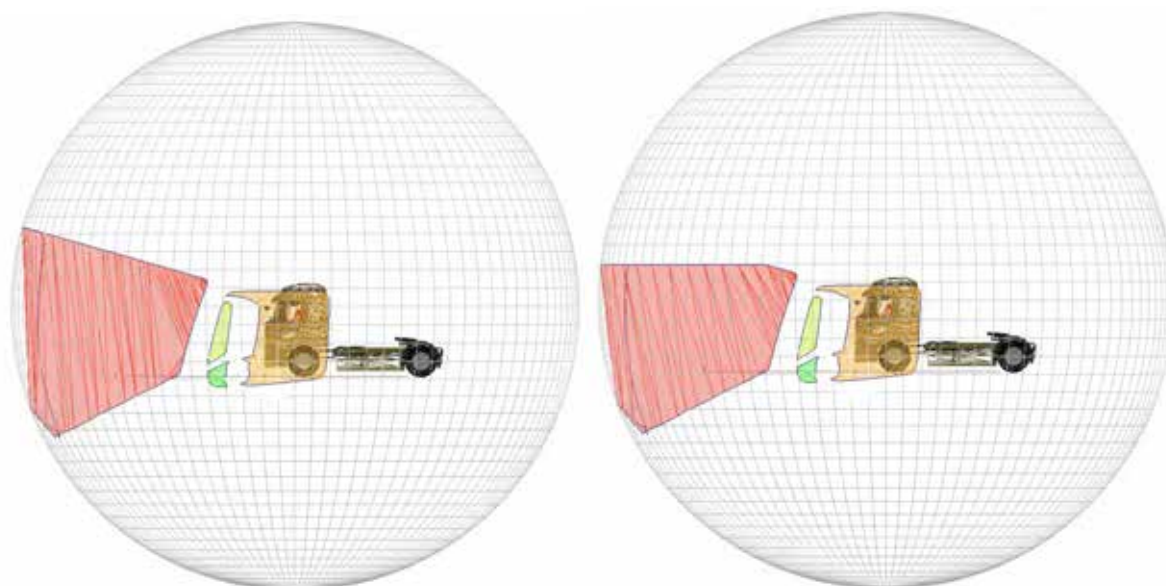


Figure 40. Clipping of the FOV area projections to a plane +7deg above the eye point, removing the influence of fields of view well above the eye point and less relevant to the identification of VRUs adjacent to the vehicle

Figure 41 shows the result on the reported areas from a clipped projection where the top of the windscreen has been clipped to the plane defined by the 7 degree angle. The clipped area of 80.54m² can be compared to the unclipped area shown in Figure 35 for the same aperture of 98.72m². Note that the other three apertures shown are below the clipping angle and thus are unclipped.

⁹ UNECE Addendum 124: Regulation 125. Uniform provisions concerning the approval of motor vehicles with regard to the forward field of vision of the motor vehicle driver. Revision 2. 2013.

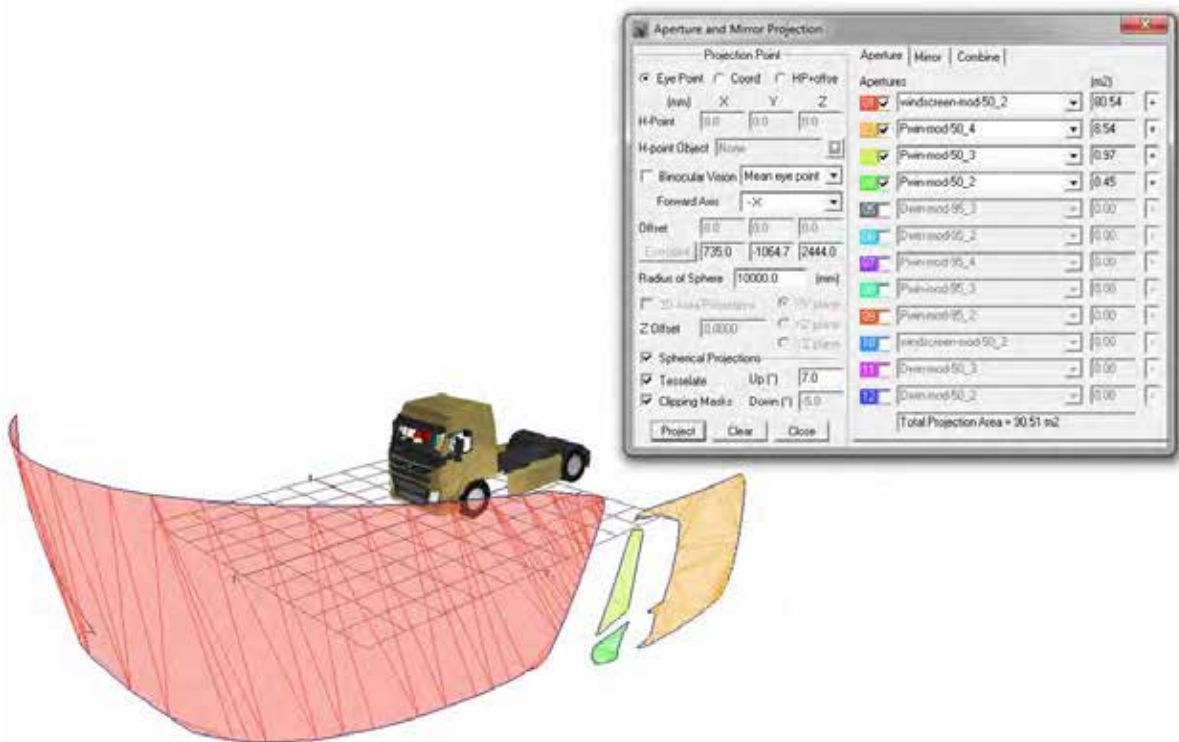


Figure 41. Clipped FOV area projection of a number of vehicle window apertures and their area calculations

3.6 THE ADDITION OF OBSCURATION OBJECTS TO THE FOV AREA PROJECTIONS

The ability to see out of the windows of a vehicle is hindered by the obscuration provided by the structure that holds the mirrors on each side of the vehicle, and elements of the dashboard structure which block the view through the bottom of the viewable area of the windscreen. In order to account for this a method was devised where paths were created to allow the subtraction of the elements that obscure vision from the FOV area projection calculations. This method involved looking through the eyes of the human model to allow the shape of the obscuring object from the eye point of the driver to be traced. This resulted in the production of a path which is then subtracted from the overall FOV area projection total. An example can be seen in Figure 42 where the same mirror mounting structure is being viewed by the three drivers with varying eye points. The left hand image shows the 5thile driver's view of the mirror, which matches the green obscuration path. The middle image shows the 50thile driver's view which matches the red obscuration path. The right hand image shows the 95thile view which matches the yellow obscuration path. Figure 43 shows how these contours look when taking an exterior view into the vehicle window, showing that the contours are aligned to the window glass, and how the shape of the obscuration paths vary due to the different eye points of the drivers. Obscuration paths were created for the windscreen, driver window and passenger window of each vehicle to ensure that obscuration by the mirror mounting structure, the steering wheel and dash board structure were subtracted from the overall totals for the FOV area projections.

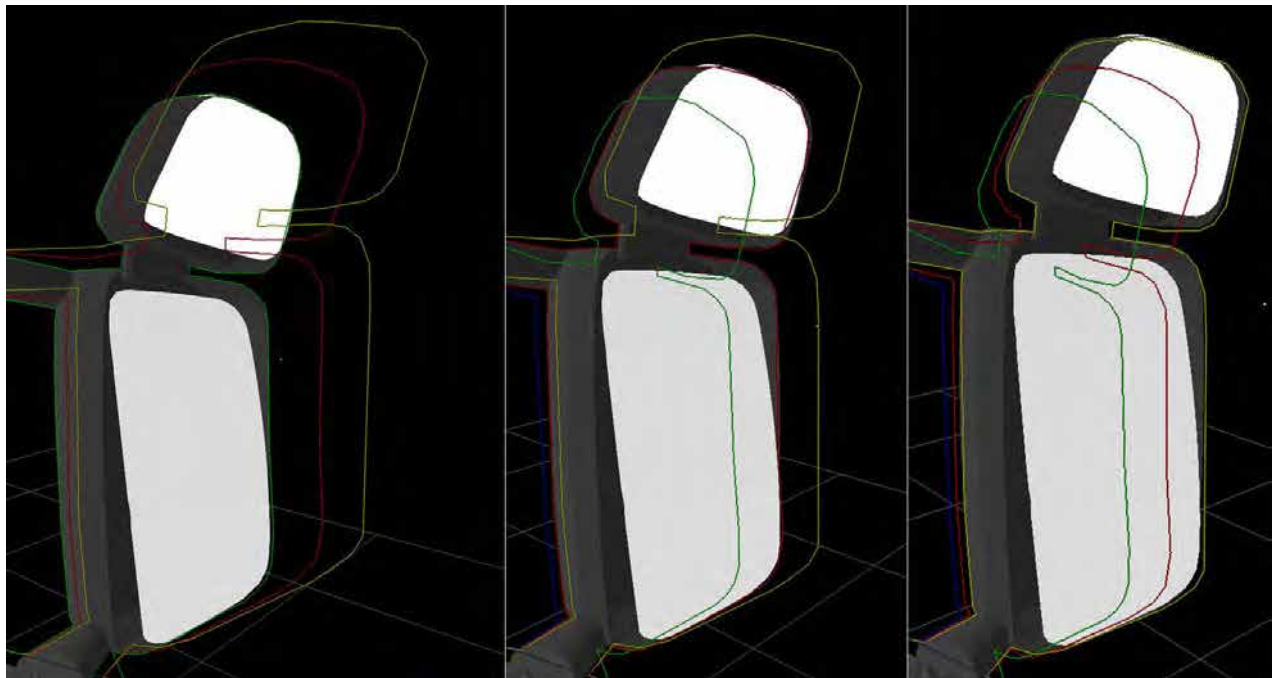


Figure 42. The view of the mirror mounting structure through the eyes of the 5thile driver (left), 50th %ile Driver (middle) and the 95thile driver (right)

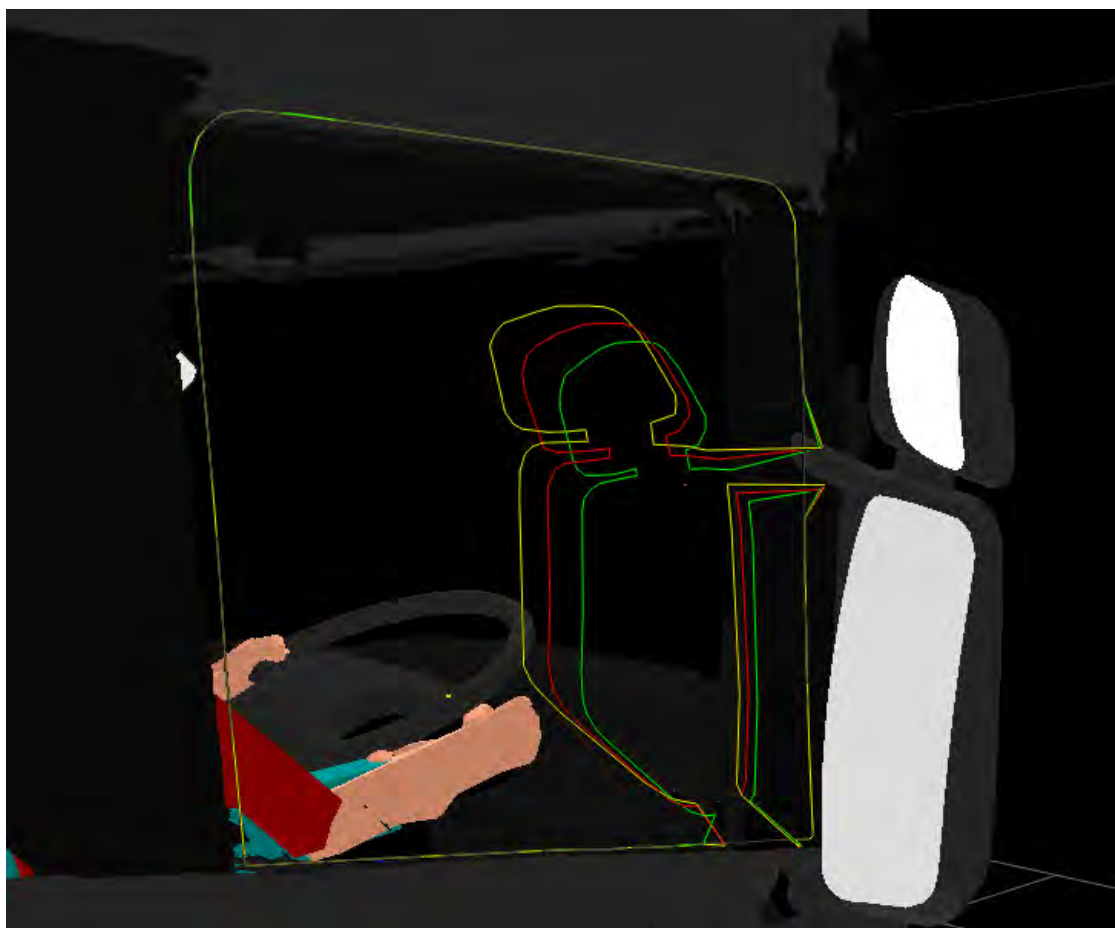


Figure 43. The view of the three obscuration paths in the window frame of the SCANIA LEC vehicle

4 RESULTS

4.1 FIELD OF VIEW – VRU VISIBILITY

The following sections present the results of the VRU analyses for all 19 of the assessed vehicles shown in Section 3.1.

4.1.1 DAF CF N3 DISTRIBUTION - 50TH %ILE MALE DRIVER



Figure 44. Evaluation model of DAF CF N3 Distribution variant vehicle

4.1.1.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 45 shows a top-down view of all of the window projections for the DAF CF N3 cab with a 50th %ile UK Male Driver. The image on the right of Figure 45 shows the areas of these projections that intersect with the ground. Figure 46 shows the same for the the mirror projections and Figure 47 shows the two combined. In this case the projections have been clipped to a radius of twenty metres. Any area outside of the coloured projections, within that twenty metre radius, is effectively a blind spot at the ground plane.

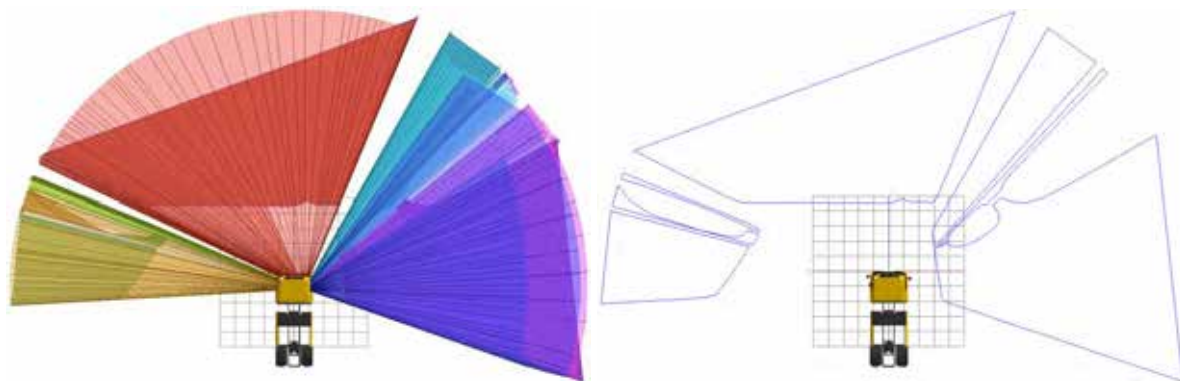


Figure 45. The projection of the windscreen and window apertures at the ground plane for the DAF CF N3

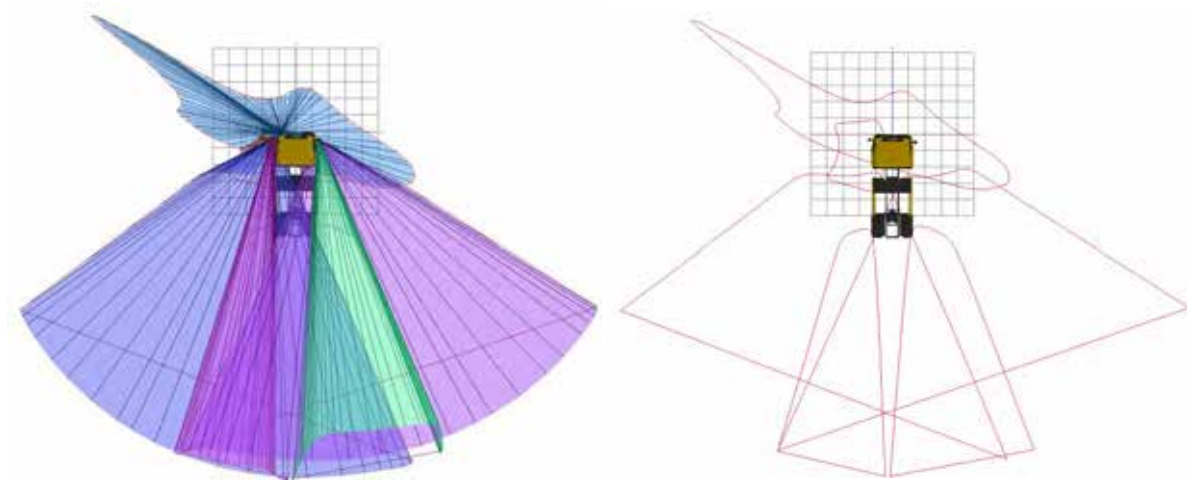


Figure 46. The projection of the mirrors at the ground plane for the DAF CF N3

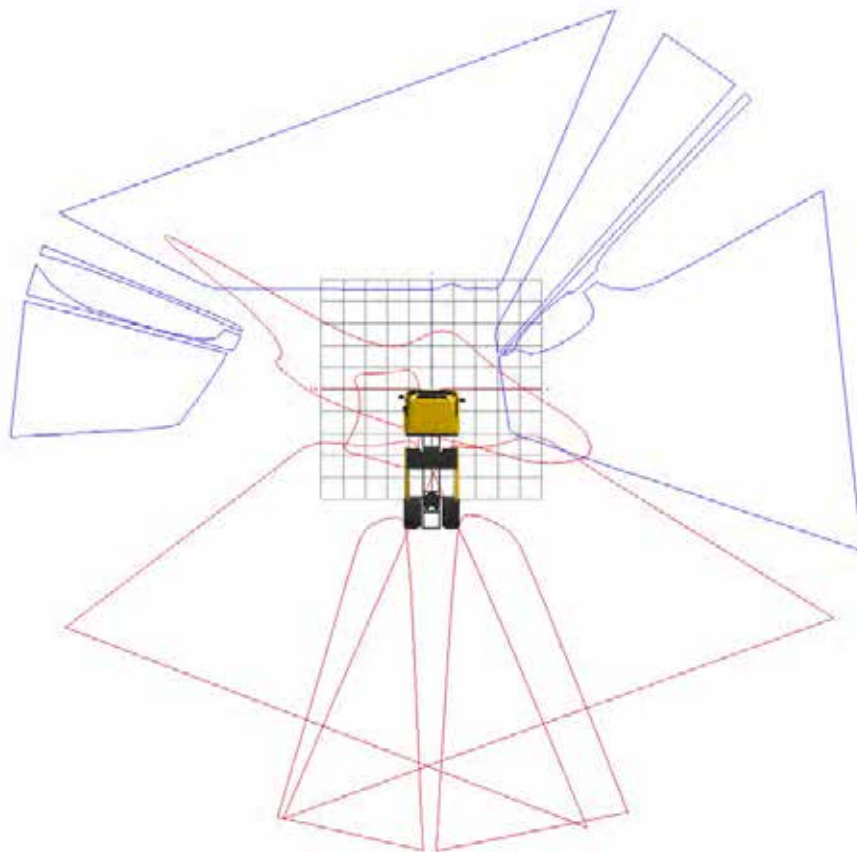


Figure 47. The combined direct and indirect vision projections at the ground plane for the DAF CF N3

Figure 48 through Figure 52 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 53 and Figure 54 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

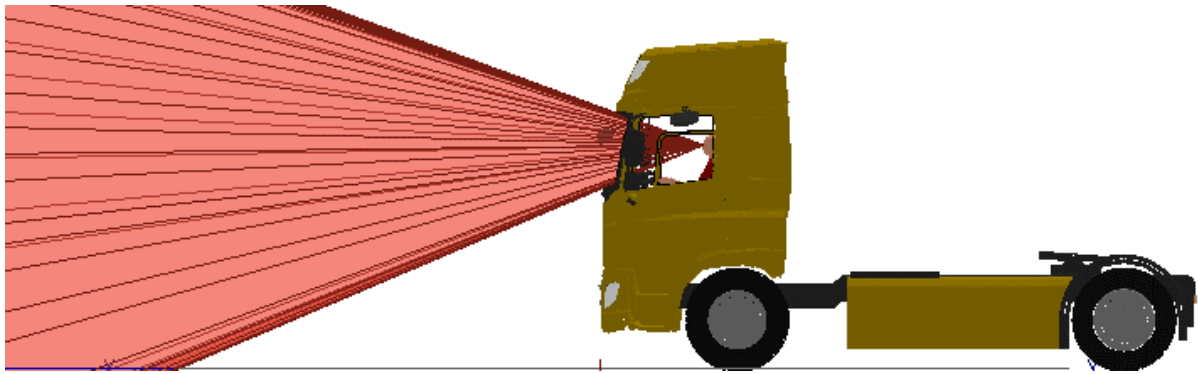


Figure 48. A side view of the windscreen aperture projection for the DAF CF N3



Figure 49. Frontal views of the off side and near side door window projections for the DAF CF N3

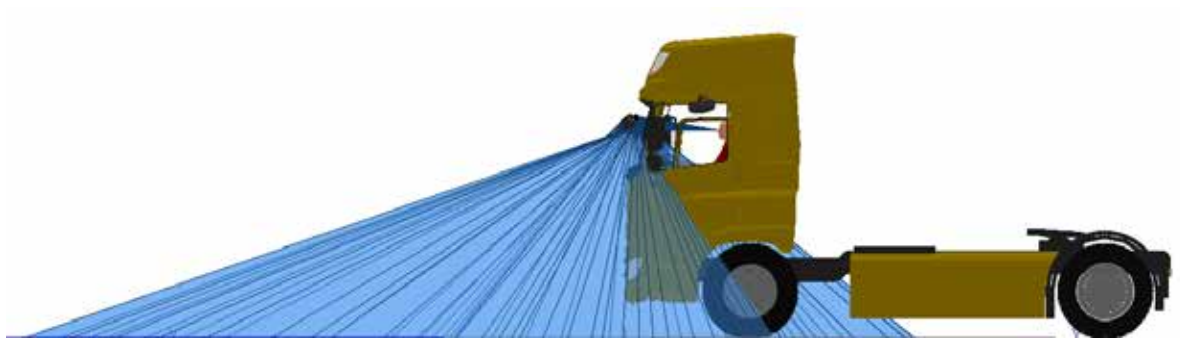


Figure 50. A side view of the Class VI mirror projection for the DAF CF N3



Figure 51. A front view of the Class V mirror projection for the DAF CF N3

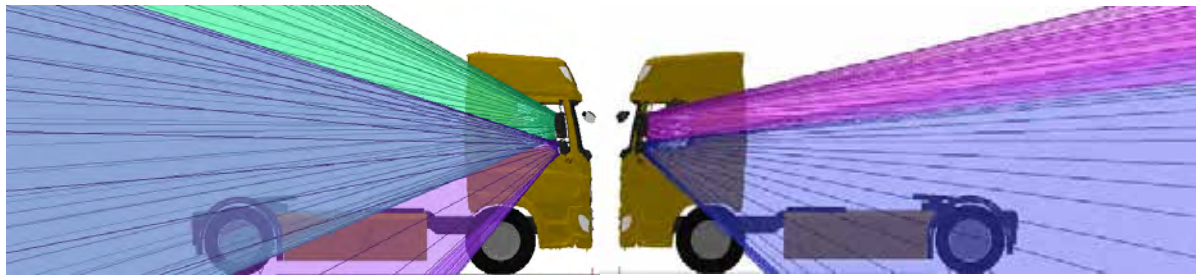


Figure 52. Side views of the combined Class II and Class IV mirror projections for the DAF CF N3

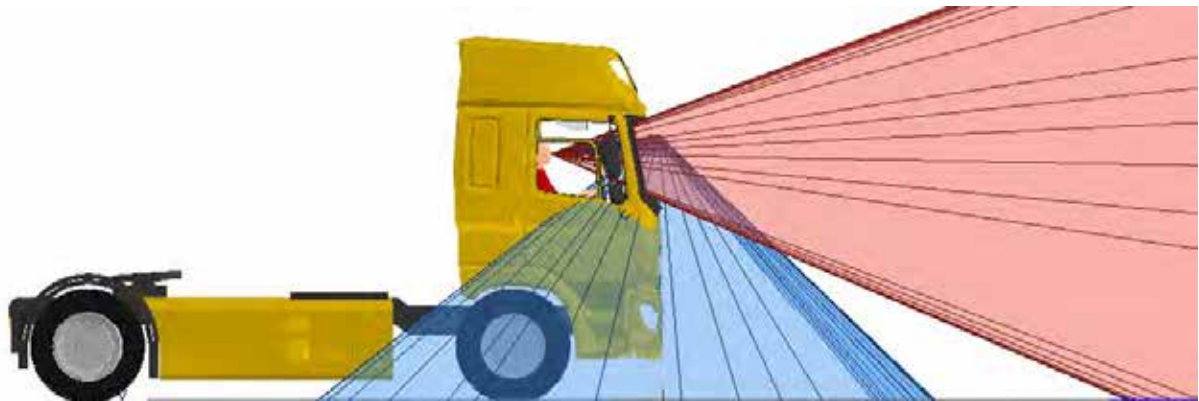


Figure 53. Combined projection of the windscreen and Class VI mirror to the front of the DAF CF N3

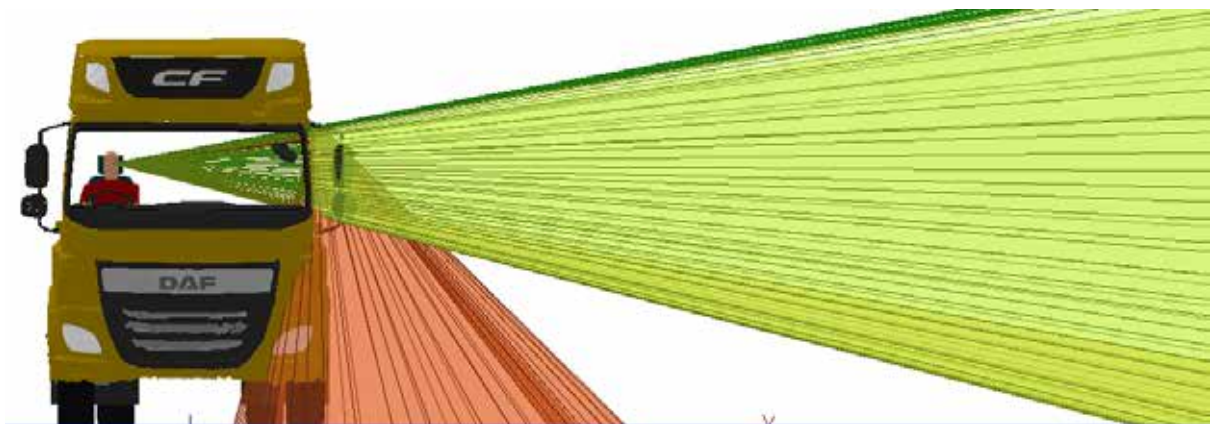


Figure 54. Combined projection of the near side windows and Class V mirror to the side of the DAF CF N3

4.1.1.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 55 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

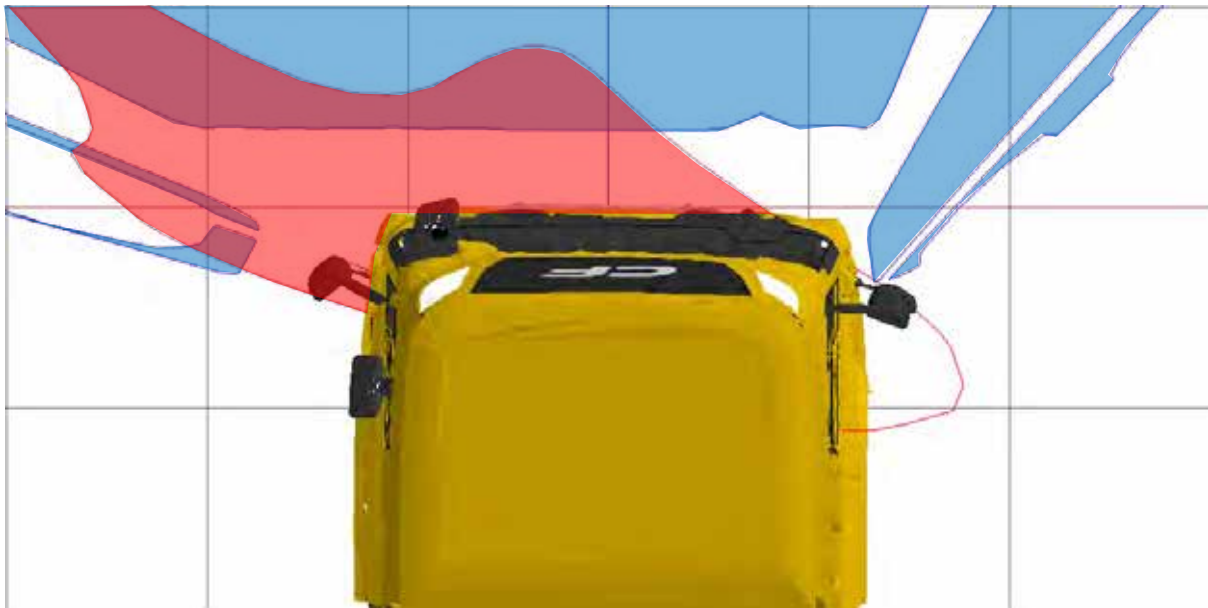


Figure 55. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 47. However Figure 56 and Figure 57 show that there is a clear space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.

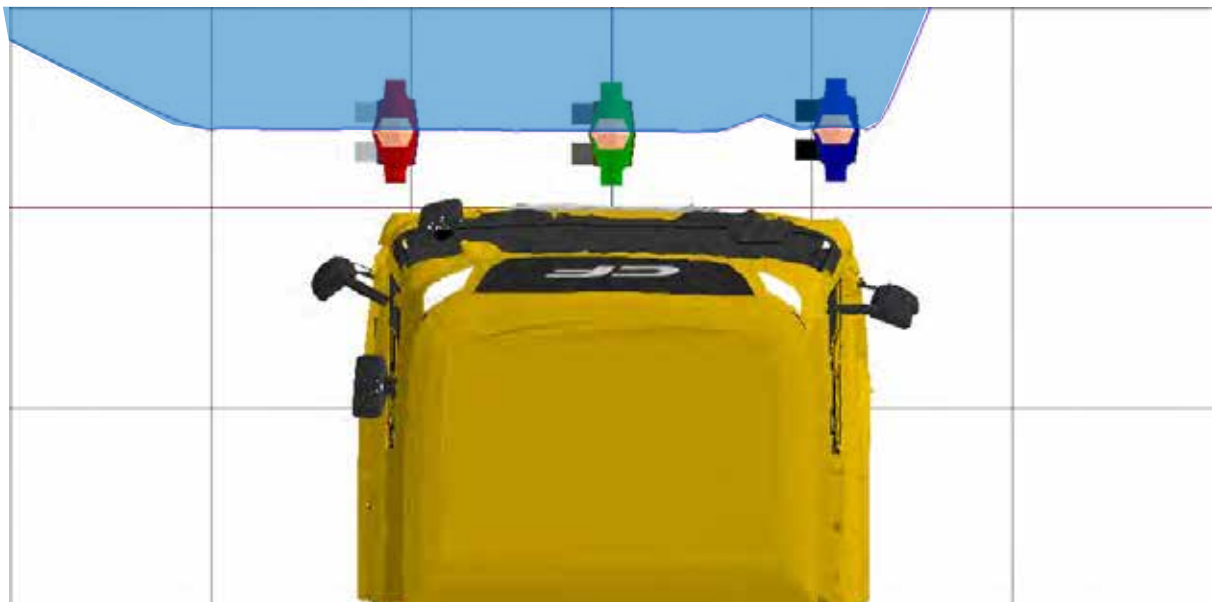


Figure 56. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

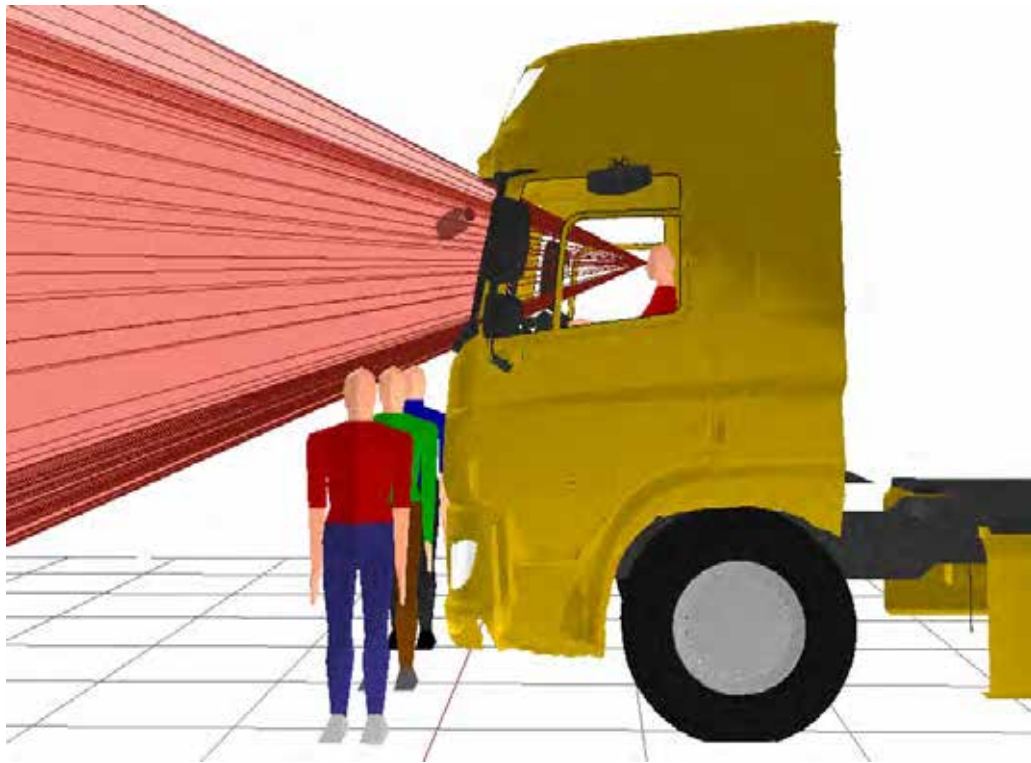


Figure 57. 3D view showing that the three human models can stand 163mm (blue), 144mm (green) and 154mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 58. The view from the driver's eyes clearly shows the three pedestrians are hidden from view.

For forwards visibility of the pedestrians all three can be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 163mm from the front of the vehicle, the left (red) pedestrian is positioned at 154mm from the front of the vehicle and the central (green) pedestrian is positioned at 144mm from the front of the vehicle. The projections show that it is possible for a pedestrian of 50th %ile UK male height or shorter to be hidden from direct vision in these locations.

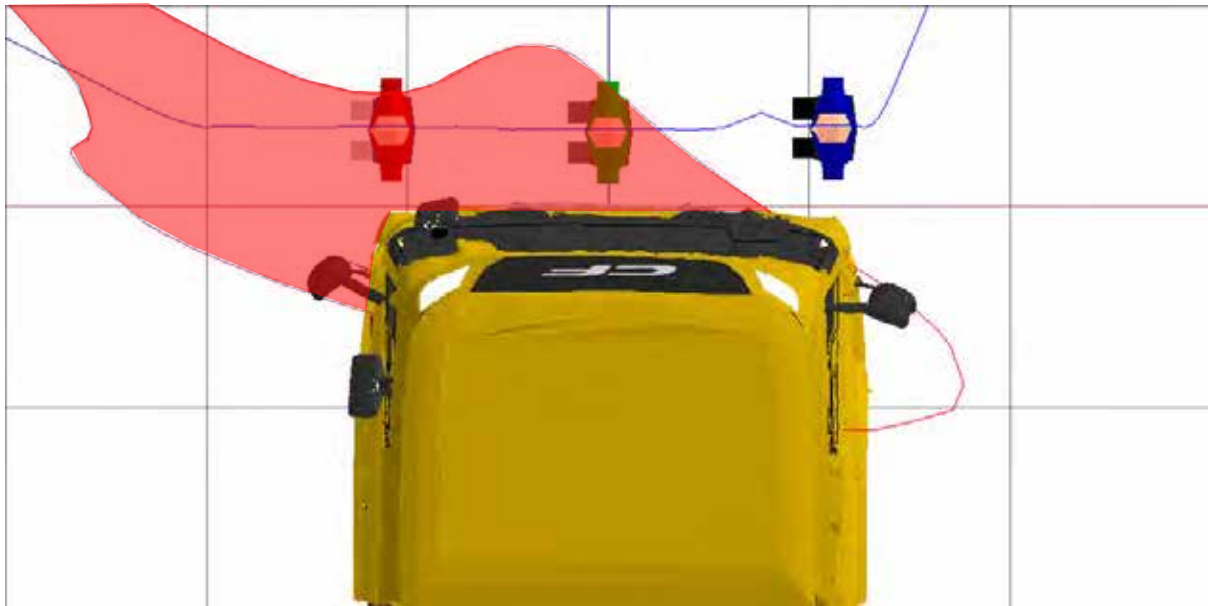


Figure 59. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

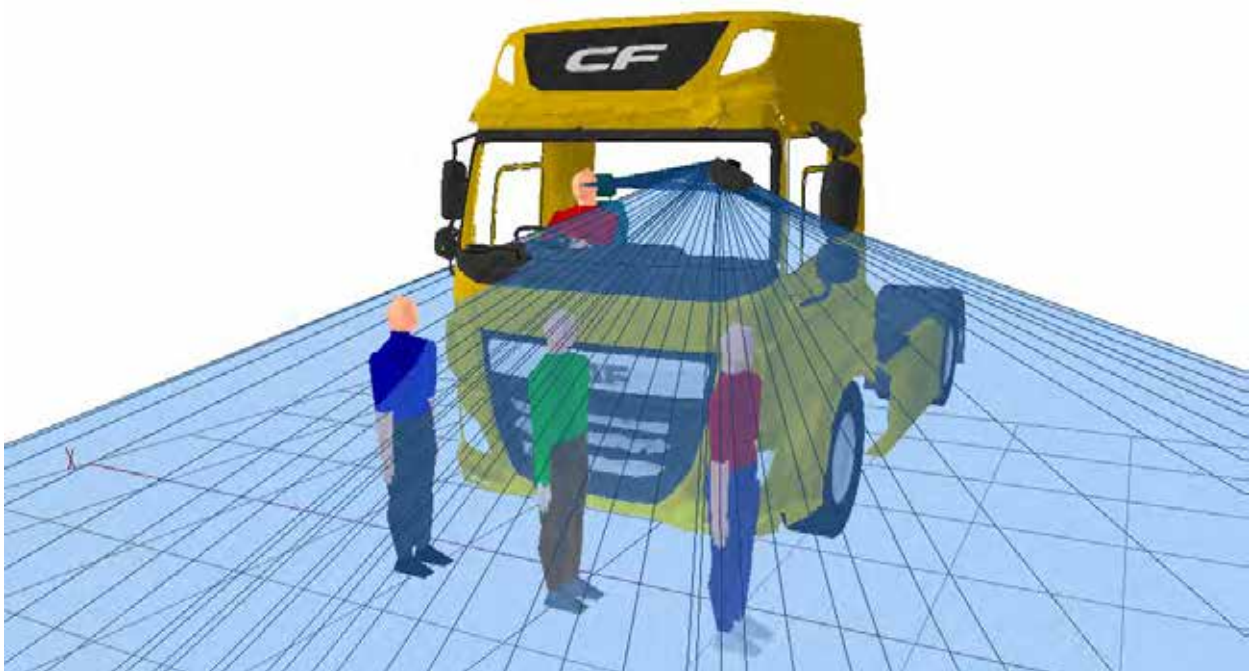


Figure 60. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 60 shows that the pedestrian to the left (red) and centre (green) would be completely visible and the pedestrian to the right (blue) would be visible from the left shoulder down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide the pedestrian models that have been tested to the front of the DAF CF N3.

4.1.1.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

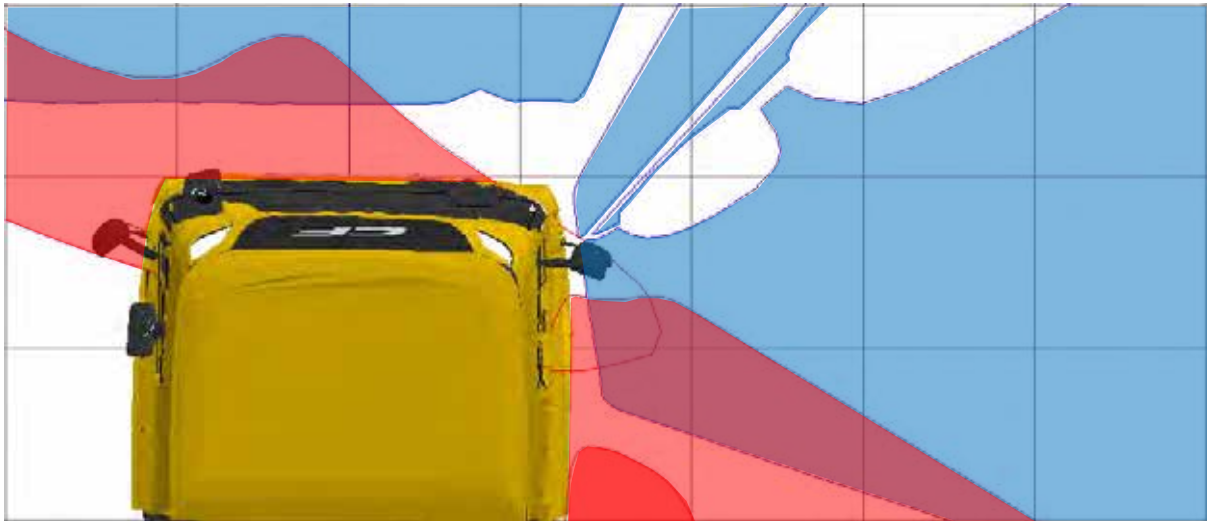


Figure 61. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

From Figure 61 it is clear that the visible areas at a height representative of a cyclist are closer to the vehicle than those taken at ground level shown in Figure 47. Figure 62, Figure 63 and Figure 64 show that whilst there is a small gap between the offside of the vehicle and the near edges of the visible areas, there is insufficient space in which a cyclist could be hidden from direct view.

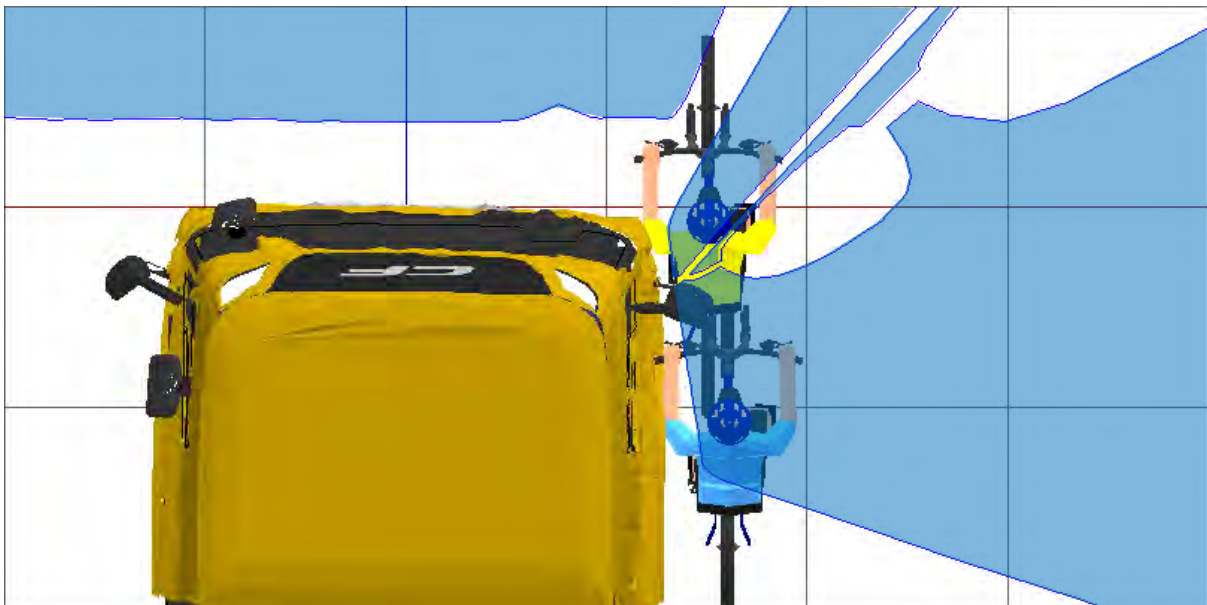


Figure 62. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist



Figure 63. 3D view showing that both cyclists cannot be hidden from direct vision to the offside of the DAF CF N3

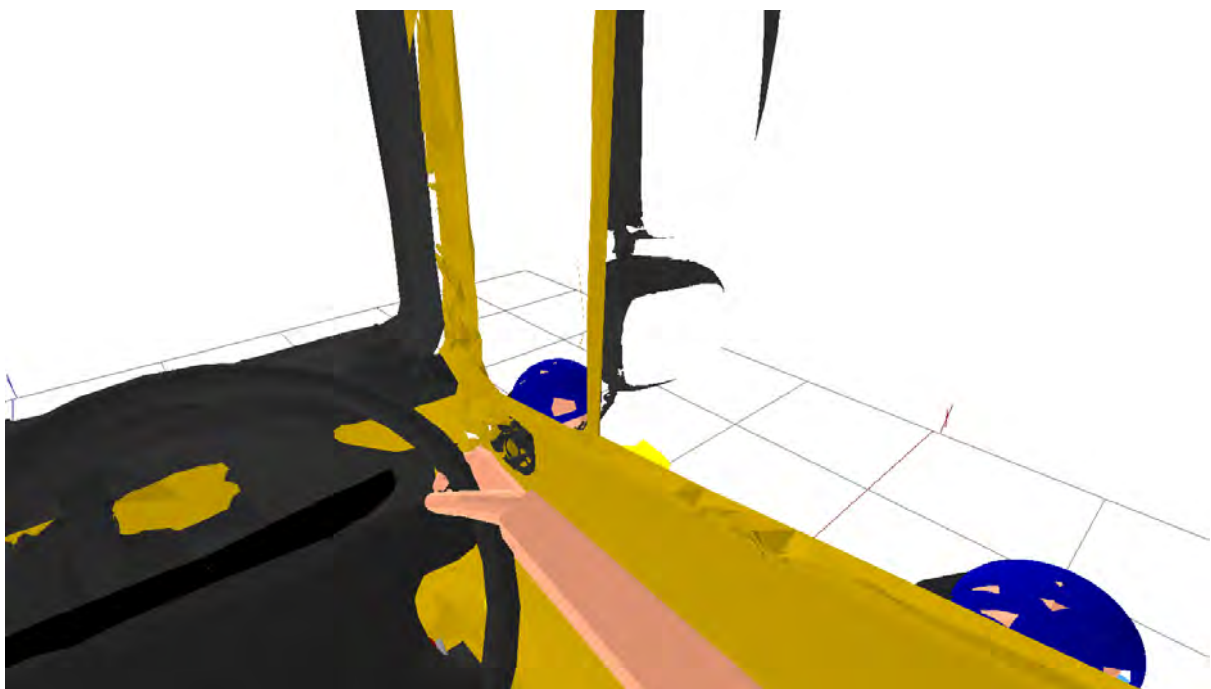


Figure 64. The view from the driver's eyes clearly shows the two cyclists are visible, even when positioned against the side of the vehicle.

For offside visibility of the cyclists there is no blind spot that could obscure a cyclist. Figure 64 shows that even with the cyclists touching the side of the cab they would still be visible to the driver.

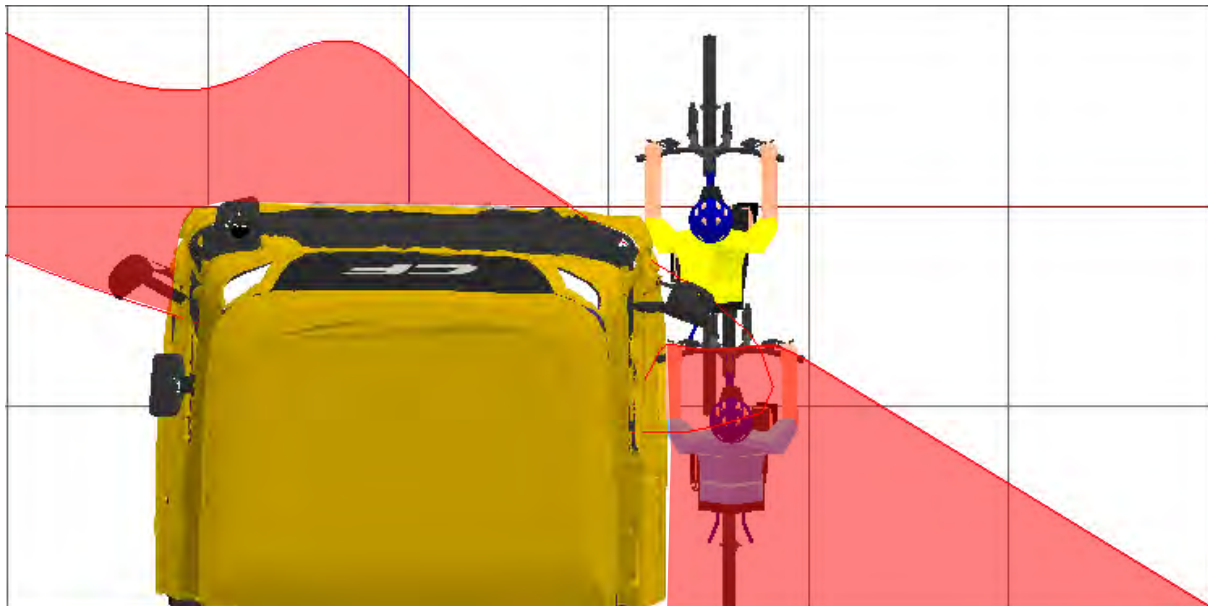


Figure 65. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist



Figure 66. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

In addition to being visible in direct vision the cyclists are also visible in the mirrors. Figure 66 shows that theoretically both cyclists are visible in the Class VI mirror. However, due to limitations of the projection technique, the rear cyclist (blue) would actually be hidden from view by the cab of the vehicle. However, part of the front (yellow) cyclist would be visible in the Class VI mirror including their arms and the front of the bicycle.

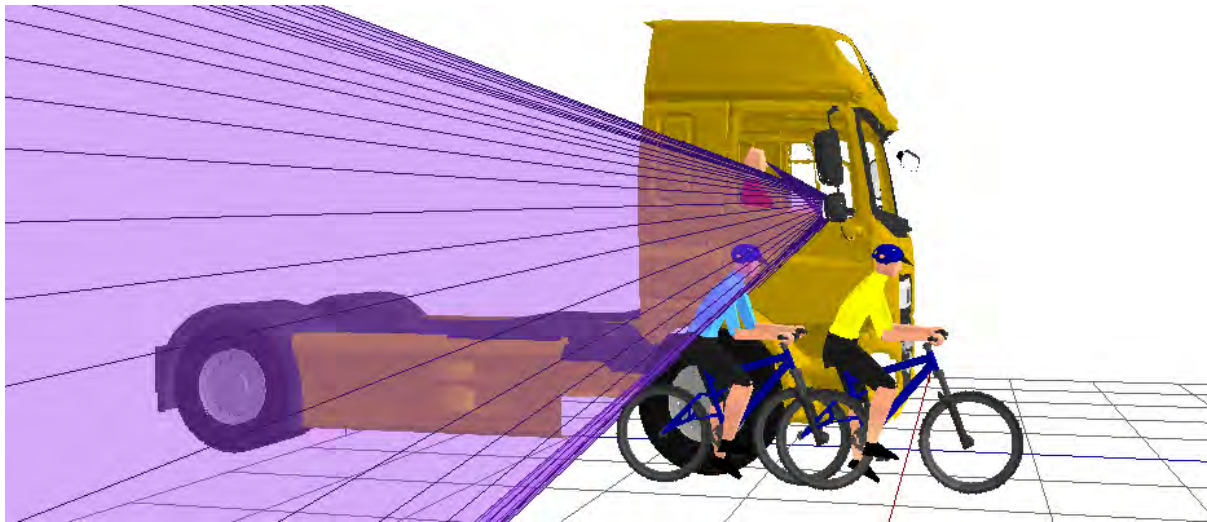


Figure 67. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 67 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and upper body. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the offside of the DAF CF N3.

4.1.1.4 NEAR SIDE (PASSENGER SIDE) VISIBILITY – CYCLIST



Figure 68. The areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 69 and Figure 70 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

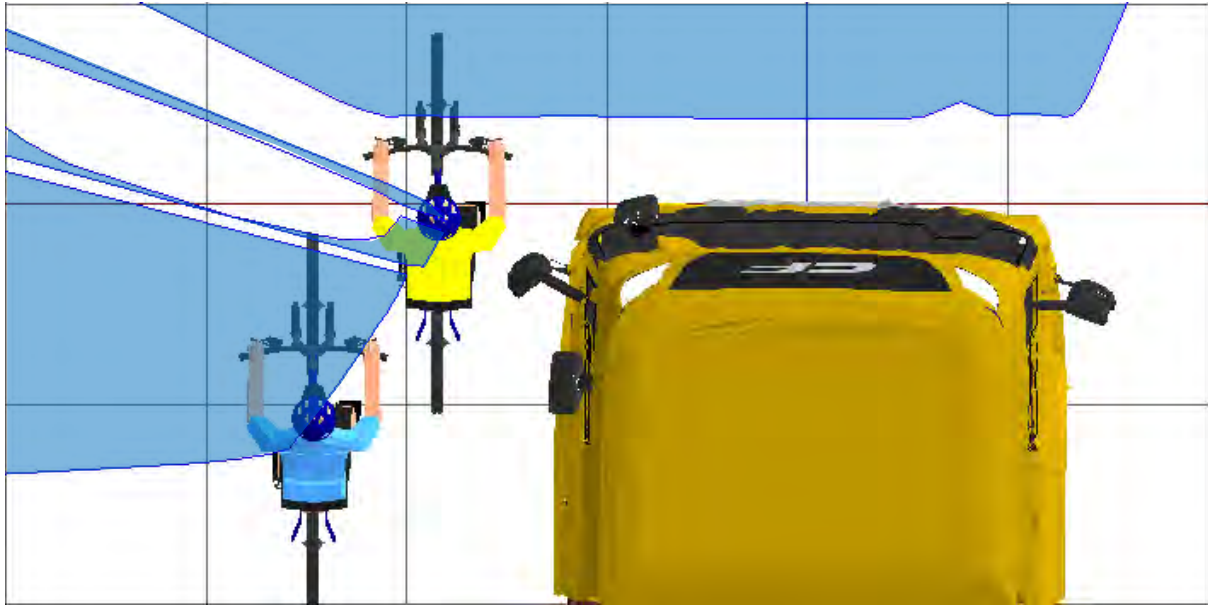


Figure 69. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist



Figure 70. 3D view showing that the two human models can be positioned 230mm (yellow) and 848mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 71. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 230mm from the side of the vehicle, the rear (blue) cyclist is positioned at 848mm from the side of the vehicle.



Figure 72. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

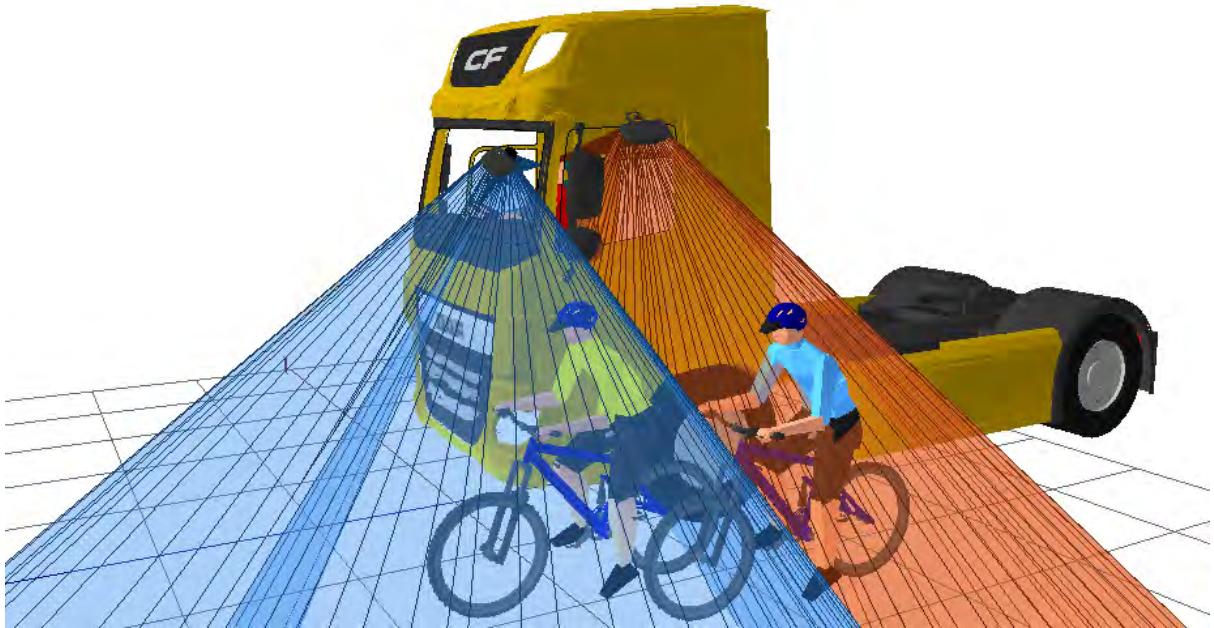


Figure 73. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 73 shows that both are visible in the Class V and Class VI mirrors. The front (yellow) cyclist is completely visible in the Class VI mirror and all bar their head in the Class V mirror. The rear (blue) cyclist's front wheel is visible in the Class VI and from their right shoulder down in the Class V mirror.



Figure 74. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is visible in the projection of the Class IV mirror

Figure 74 shows that the rear of the two cyclists (blue) is also visible in the projection of the nearside Class IV mirror. The cyclist would only be partially visible including the torso of the rider and the rear wheel of the cycle. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the nearside of the DAF CF N3.

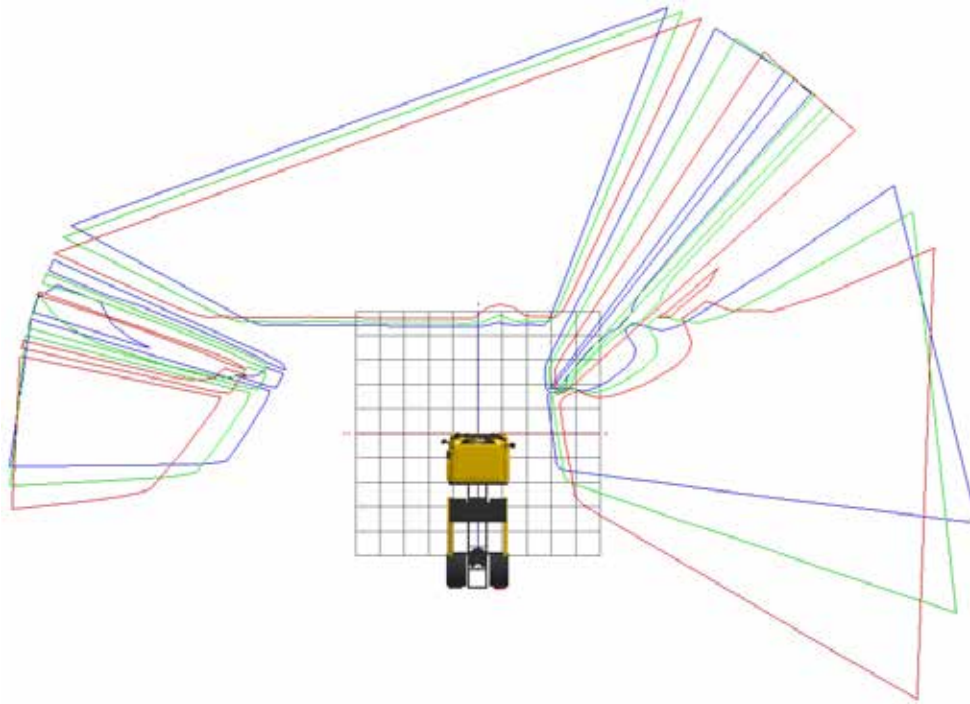
4.1.1.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

Figure 75. A plan view of the projection of the windscreen and side windows onto the ground plane for the DAF CF N3 for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.1.2 DAF CF N3G CONSTRUCTION - 50TH %ILE MALE DRIVER



Figure 76. Evaluation model of DAF CF N3G Construction variant vehicle

4.1.2.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 77 shows a top-down view of all of the window projections for the DAF CF N3G cab with a 50th %ile UK Male Driver. The image on the right of Figure 77 shows the areas of these projections that intersect with the ground. Figure 78 shows the same for the the mirror projections and Figure 79 shows the two combined. In this case the projections have been clipped to a radius of twenty metres. Any area outside of the coloured projections, within that twenty metre radius, is effectively a blind spot at the ground plane.

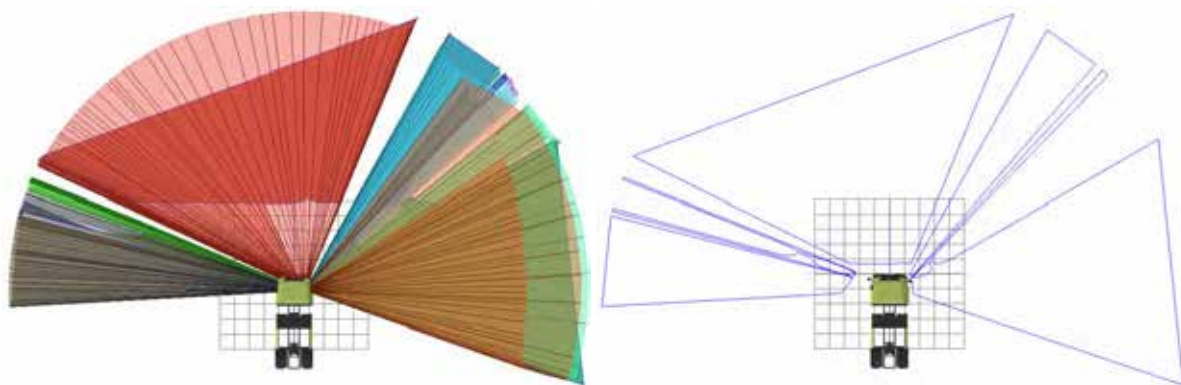


Figure 77. The projection of the windscreen and window apertures at the ground plane for the DAF CF N3G

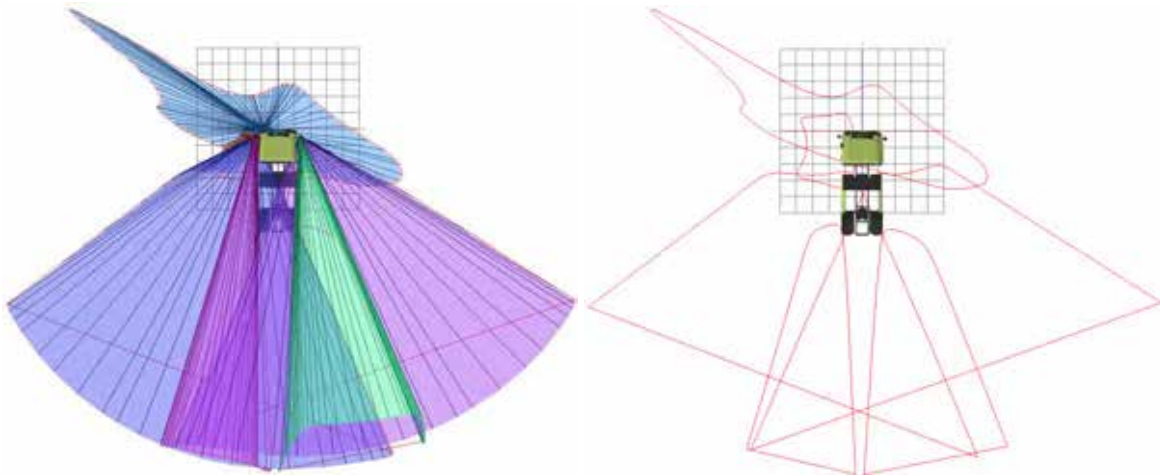


Figure 78. The projection of the mirrors at the ground plane for the DAF CF N3G

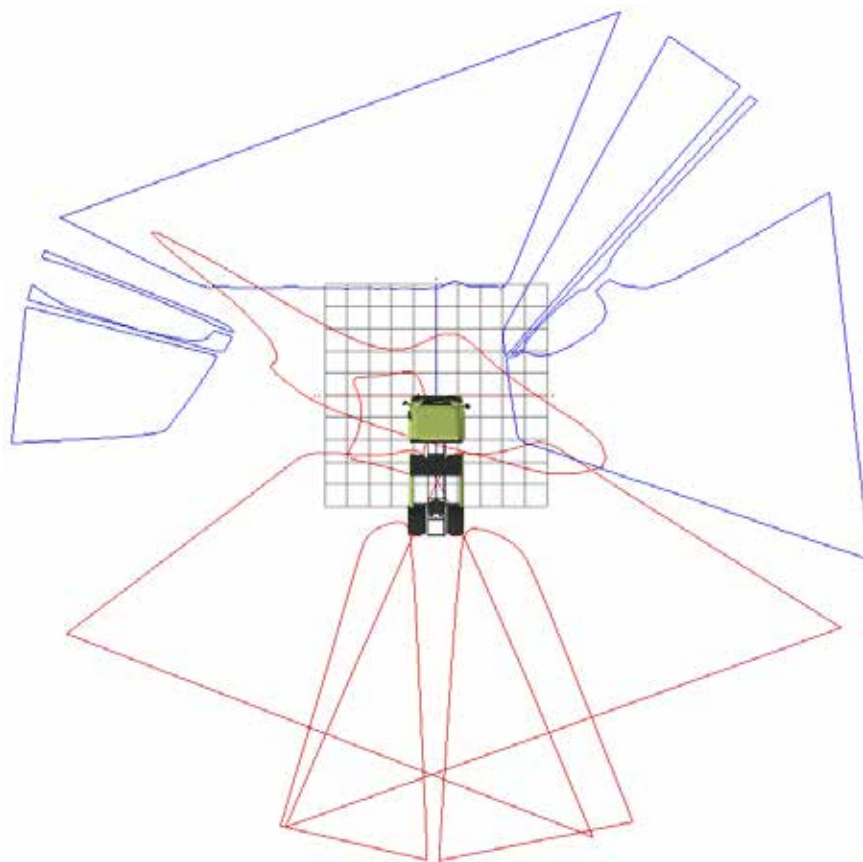


Figure 79. The combined direct and indirect vision projections at the ground plane for the DAF CF N3G

Figure 80 through Figure 84 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 85 and Figure 86 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

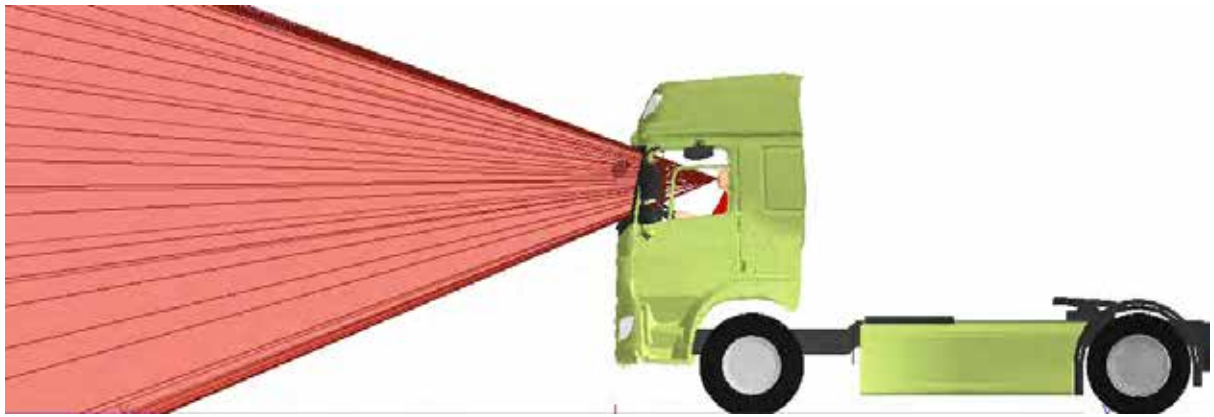


Figure 80. A side view of the windscreen aperture projection for the DAF CF N3G



Figure 81. Frontal views of the off side and near side door window projections for the DAF CF N3G



Figure 82. A side view of the Class VI mirror projection for the DAF CF N3G



Figure 83. A front view of the Class V mirror projection for the DAF CF N3G



Figure 84. Side views of the combined Class II and Class IV mirror projections for the DAF CF N3G

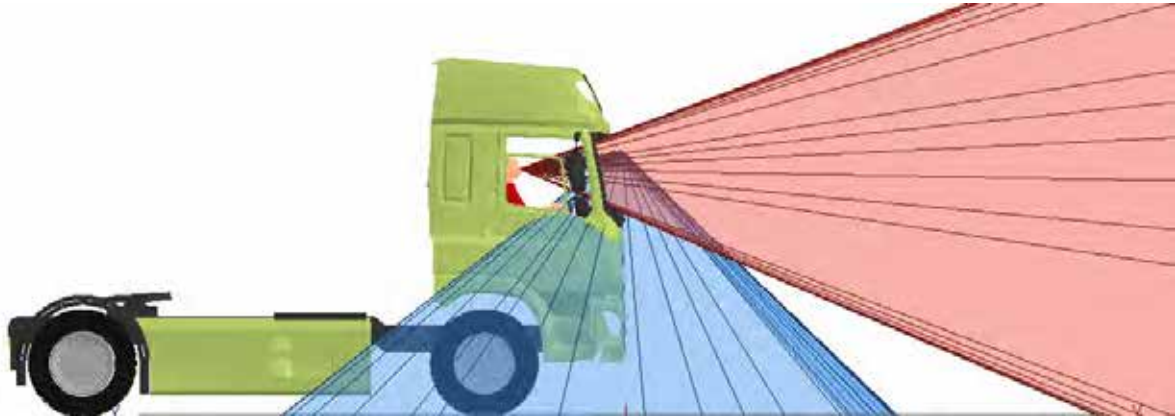


Figure 85. Combined projection of the windscreen and Class VI mirror to the front of the DAF CF N3G

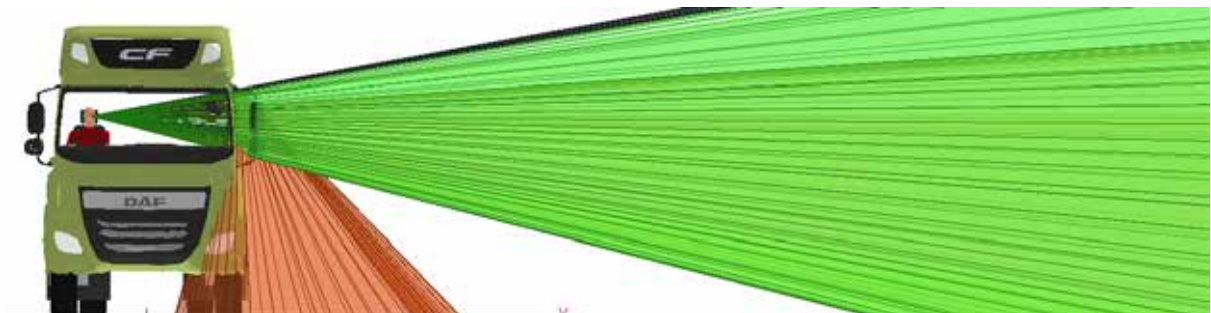


Figure 86. Combined projection of the near side windows and Class V mirror to the side of the DAF CF N3G

4.1.2.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 87 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.



Figure 87. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 79. However Figure 88 and Figure 89 show that there is a clear space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.



Figure 88. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

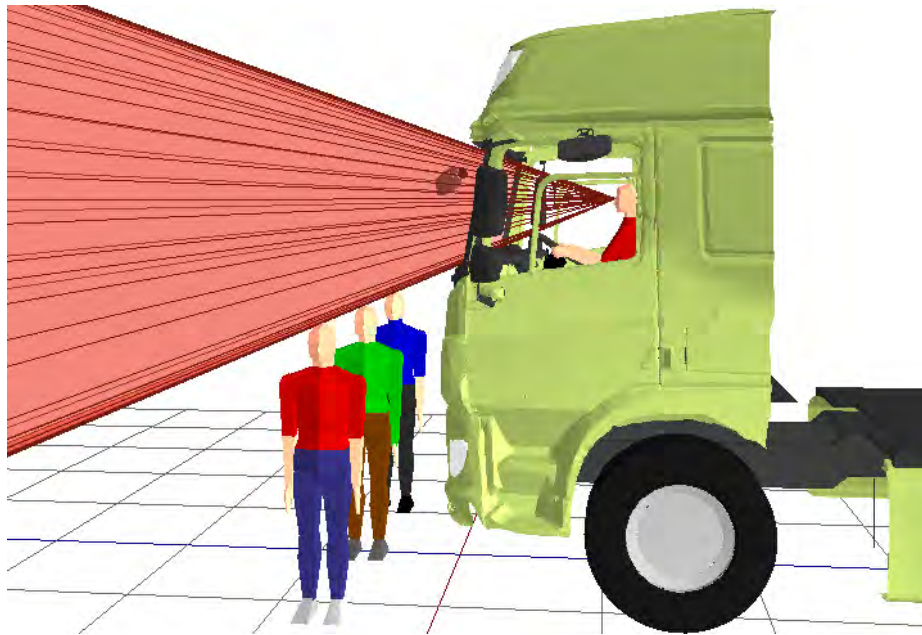


Figure 89. 3D view showing that the three human models can stand 453mm (blue), 429mm (green) and 463mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 90. The view from the driver's eyes clearly shows the three pedestrians are hidden from view.

For forwards visibility of the pedestrians all three can be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 453mm from the front of the vehicle, the left (red) pedestrian is positioned at 463mm from the front of the vehicle and the central (green) pedestrian is positioned at 429mm from the front of the vehicle. The projections show that it is clearly possible for a pedestrian of 50th %ile UK male height or shorter to be hidden from direct vision in these locations. It is also important to note the increase in the blind spot to direct vision due to the increased height of the cab of the DAF CF N3G over the CF N3. The maximum distance has increased from 163mm (see Figure 56) to 463mm from the front of the cab in which a pedestrian can be hidden.

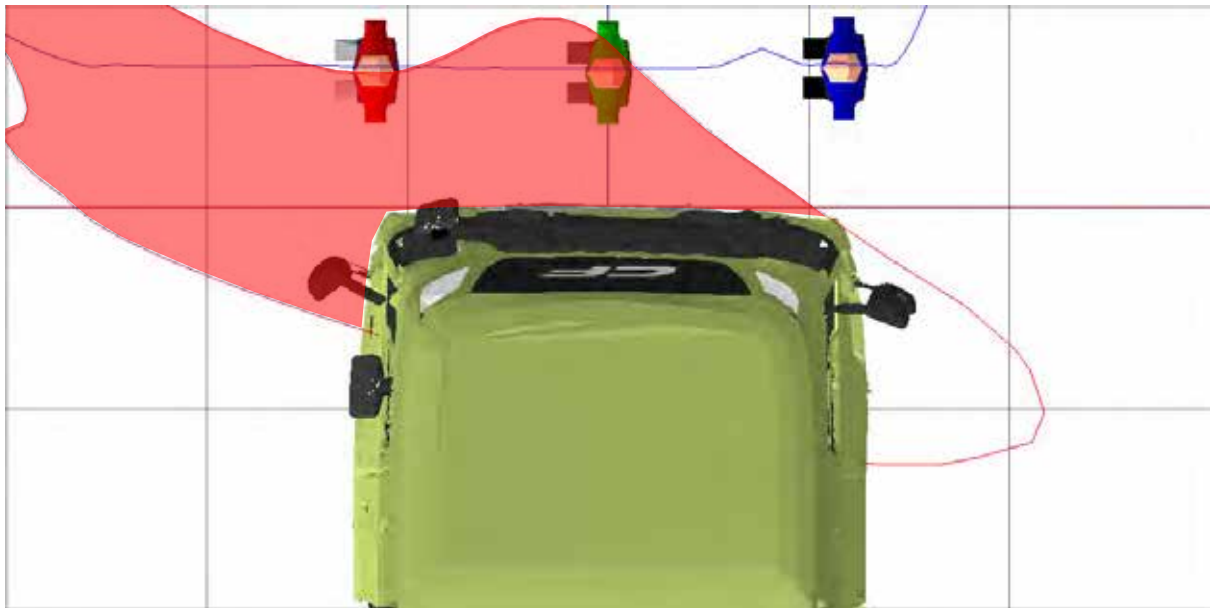


Figure 91. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian



Figure 92. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 92 shows that the pedestrian to the centre (green) would be completely visible, the pedestrian to the left (red) would be completely visible bar the top of their head, and the pedestrian to the right (blue) would be visible from the left shoulder down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide the pedestrian models that have been tested to the front of the DAF CF N3G.

4.1.2.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

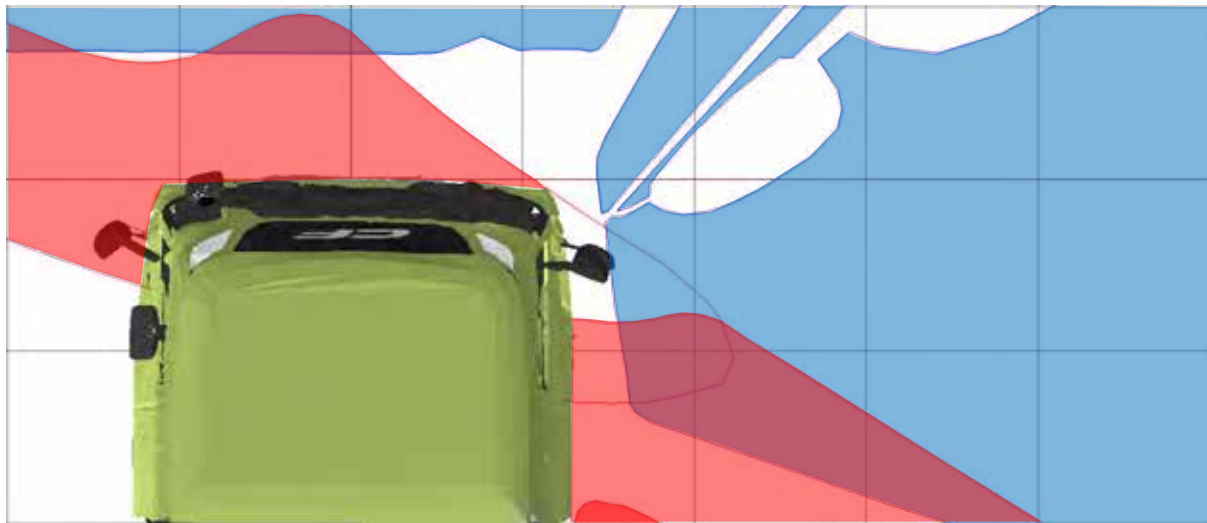


Figure 93. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

From Figure 93 it is clear that the visible areas at a height representative of a cyclist are closer to the vehicle than those taken at ground level shown in Figure 79. Figure 94, Figure 95 and Figure 96 show that whilst there is a small gap between the offside of the vehicle and the near edges of the visible areas, there is insufficient space in which a cyclist could be hidden from direct view.

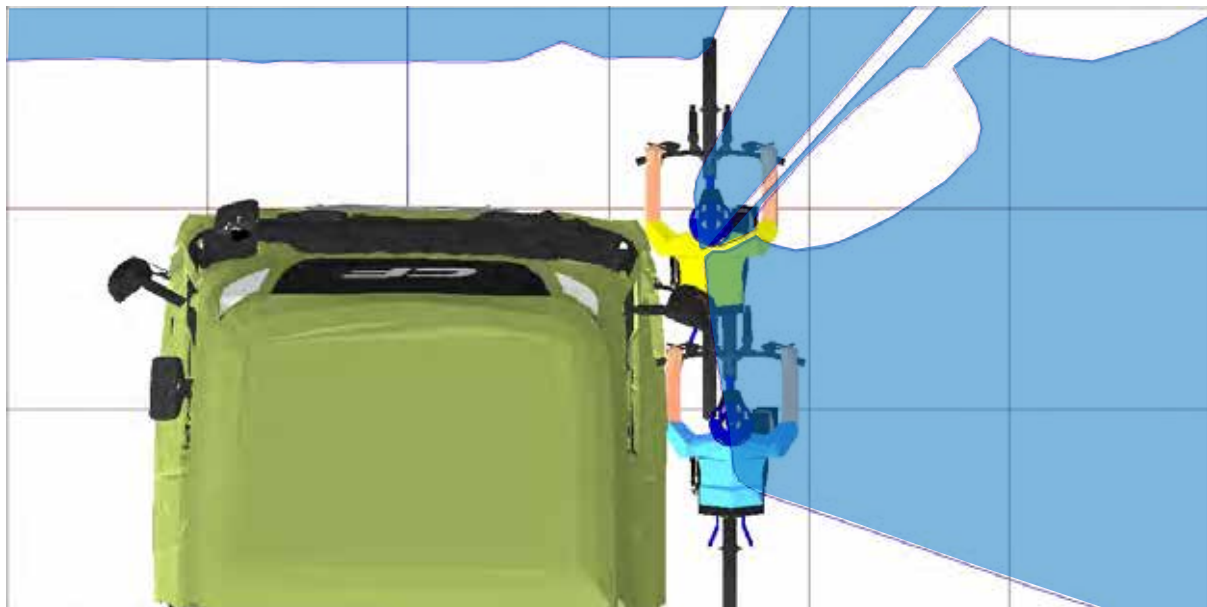


Figure 94. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist



Figure 95. 3D view showing that both cyclists cannot be hidden from direct vision to the offside of the DAF CF N3

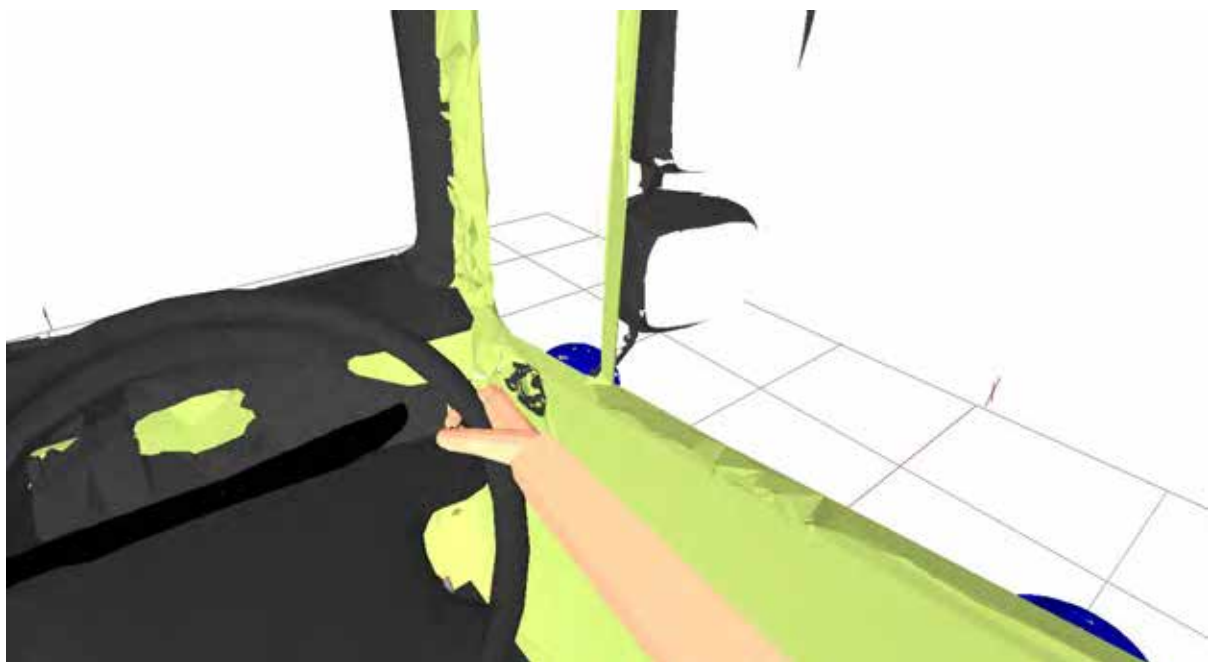


Figure 96. The view from the driver's eyes clearly shows the two cyclists are visible, even when positioned against the side of the vehicle.

For offside visibility of the cyclists there is no blind spot that could obscure a cyclist. Figure 96 shows that even with the cyclists touching the side of the cab they would still be visible to the driver. However, in comparison to the DAF CF N3 the additional cab height of the CF N3G does result in less of the cyclists' helmets being visible (see Figure 64).

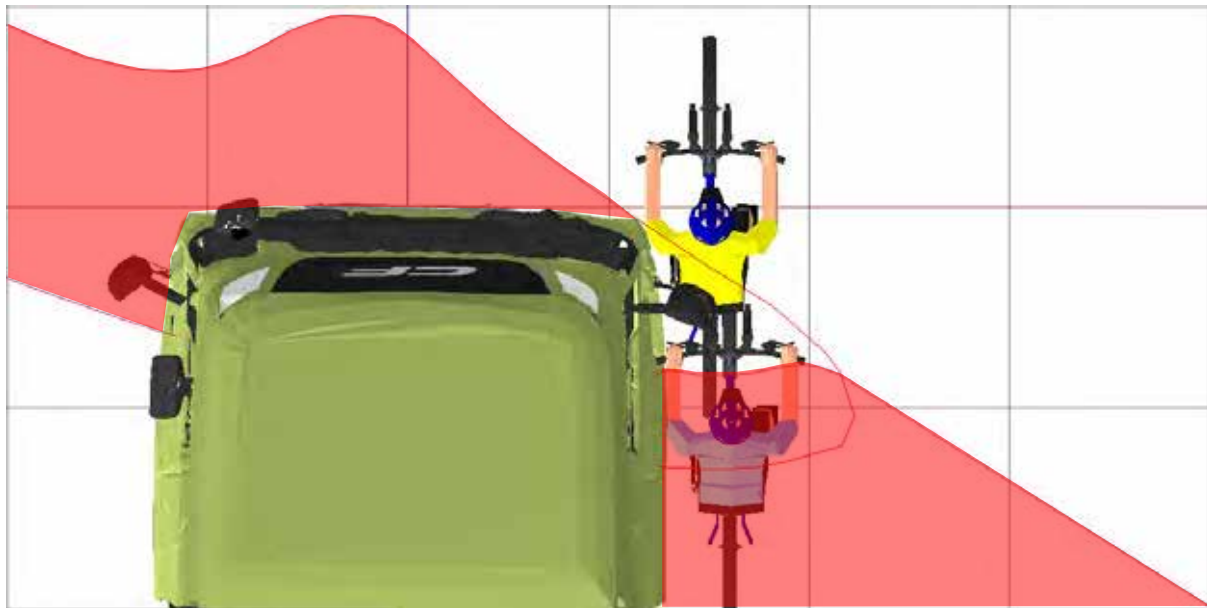


Figure 97. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist



Figure 98. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

In addition to being visible in direct vision the cyclists are also visible in the mirrors. Figure 98 shows that theoretically both cyclists are visible in the Class VI mirror. However, due to limitations of the projection technique, the rear cyclist (blue) would actually be hidden from view by the cab of the vehicle. However, part of the front (yellow) cyclist would be visible in the Class VI mirror including their arms and the front of the bicycle. The positioning of the cyclist within the blue volume in Figure 98 indicates that the portion of the yellow cyclist that is visible would be placed towards the edge of the right hand bottom edge of the Class VI mirror.

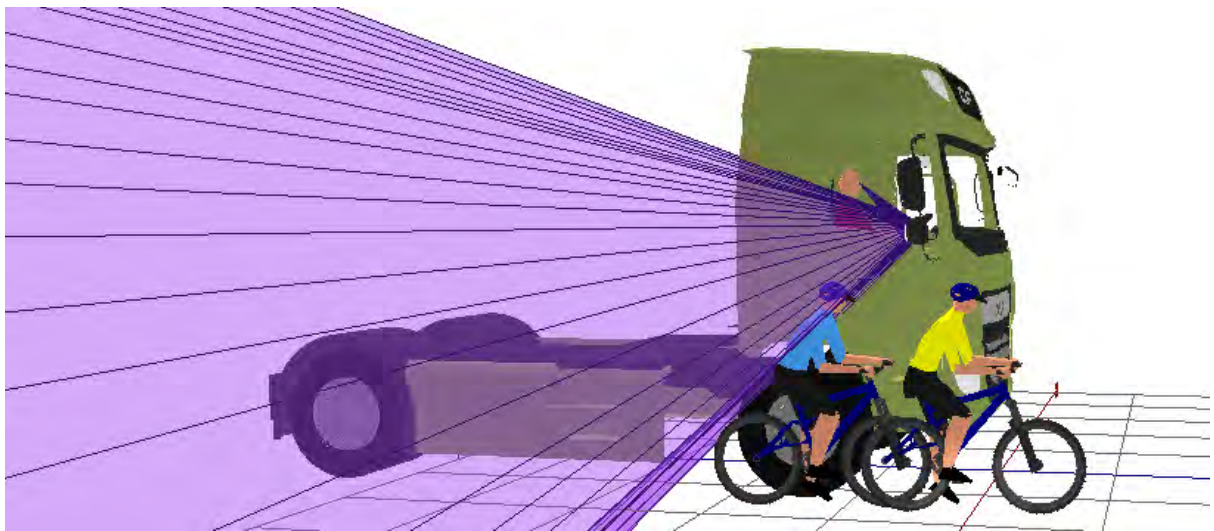


Figure 99. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 99 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and upper body. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the offside of the DAF CF N3G.

4.1.2.4 NEAR SIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

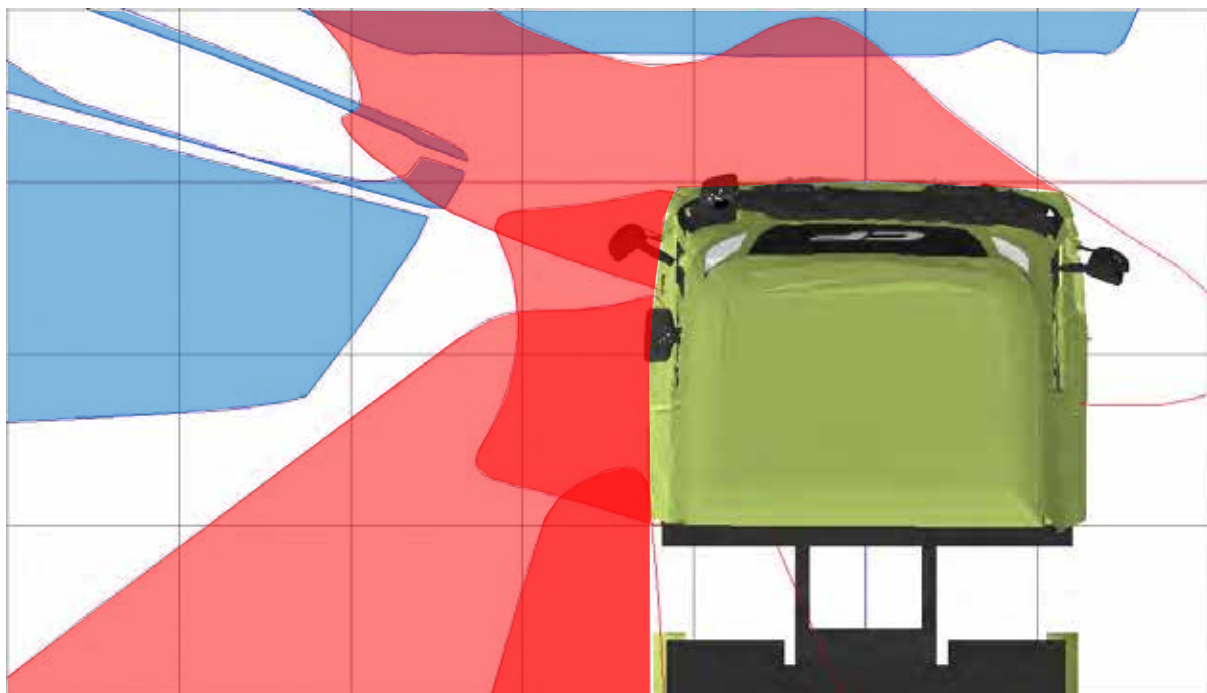


Figure 100. The areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 101 and Figure 102 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

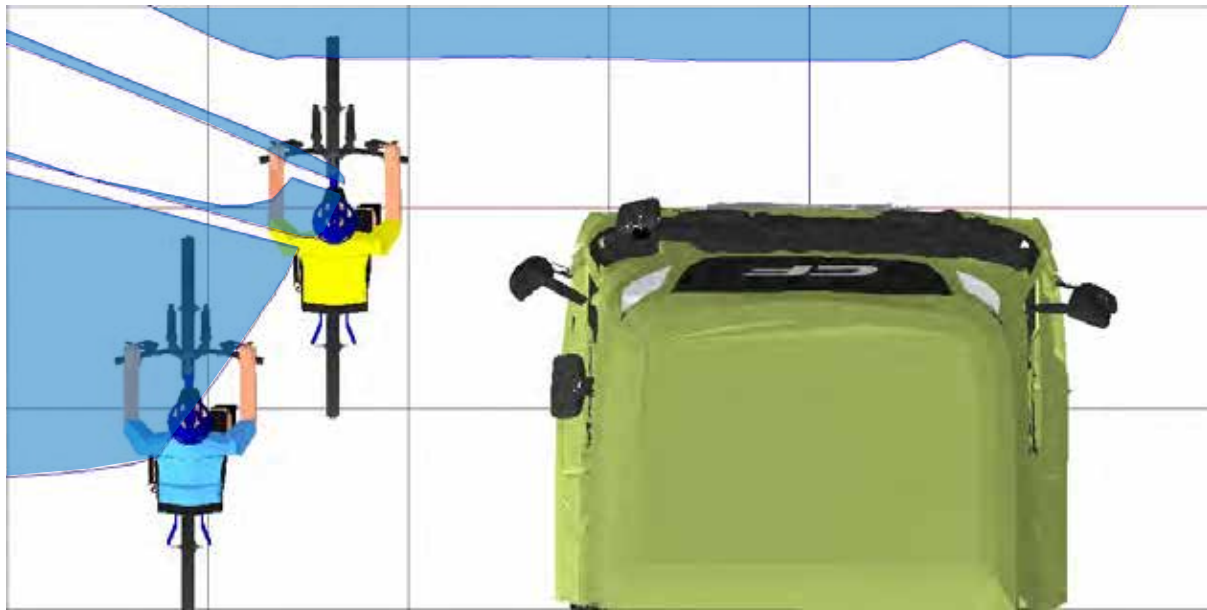


Figure 101. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

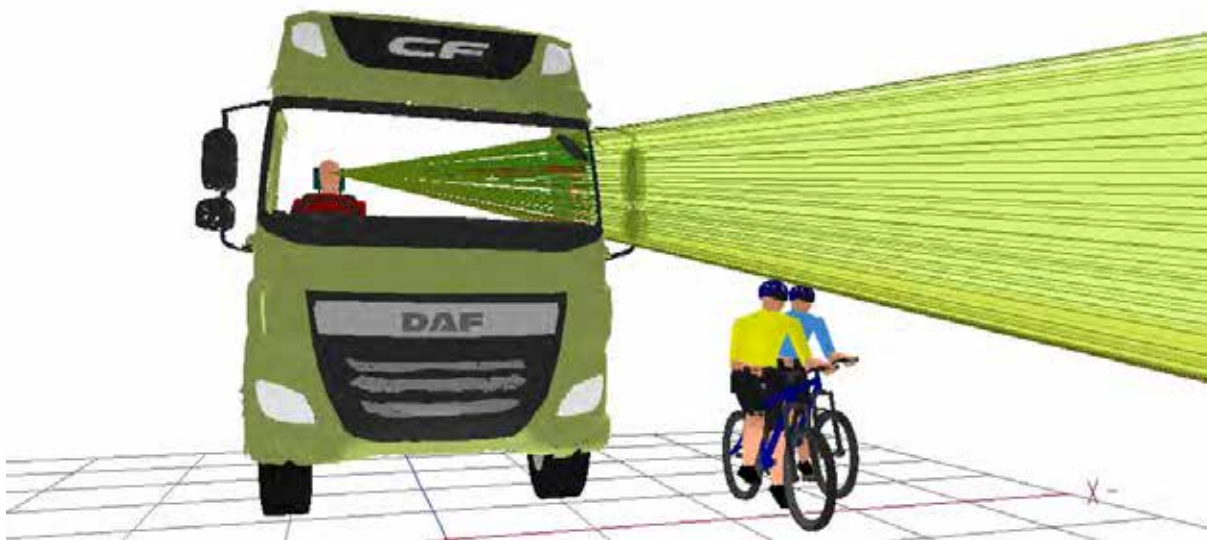


Figure 102. 3D view showing that the two human models can be positioned 744mm (yellow) and 1472mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 103. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 744mm from the side of the vehicle, the rear (blue) cyclist is positioned at 1472mm from the side of the vehicle. As seen in the forward vision assessment there is an increase in the blind spot to direct vision due to the increased height of the cab of the DAF CF N3G over the CF N3. The maximum distance has increased from 848mm (see Figure 69) to 1472mm from the side of the cab in which a cyclist can be hidden.

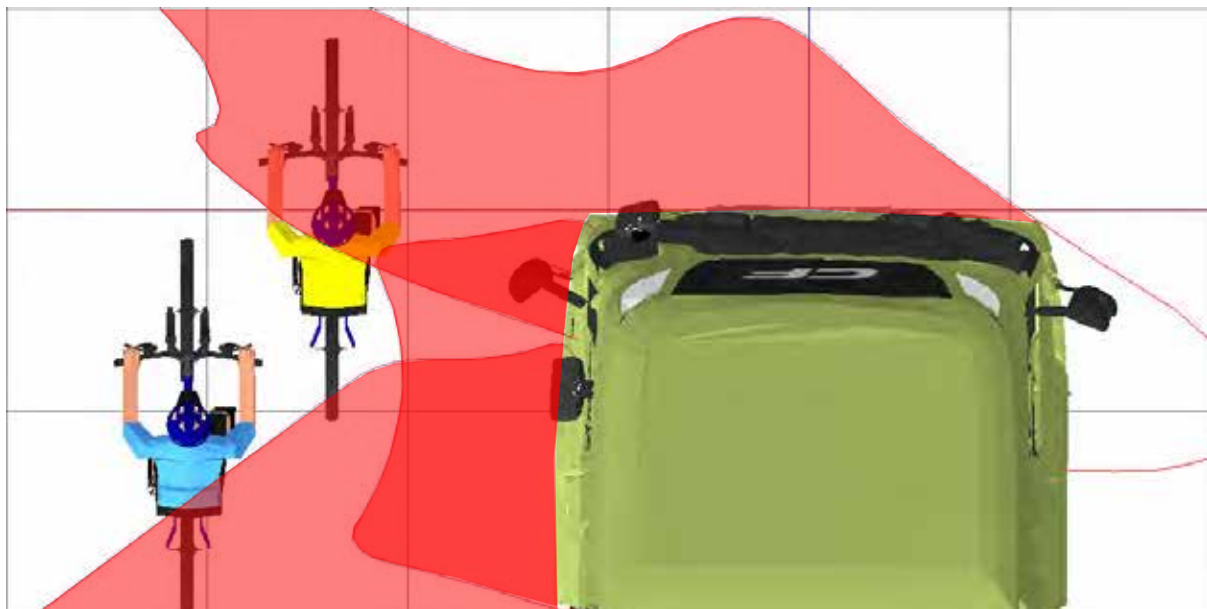


Figure 104. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist



Figure 105. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 106 shows that both are visible in the Class V and Class VI mirrors. The front (yellow) cyclist is completely visible in the Class VI mirror and all bar their head and left shoulder in the Class V mirror. The rear (blue) cyclist is only barely visible in either mirror, the front wheel of the bicycle would be visible in the Class VI mirror and the lower halves of the wheels, as well as the cyclist’s right foot would be visible in the Class V.



Figure 106. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is barely visible in the projection of the Class IV mirror

Figure 106 shows that a small portion of the back of the rear of the two cyclists (blue) is also visible in the projection of the nearside Class IV mirror. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the nearside of the DAF CF

N3. However, the visibility of the rear (blue) cyclist is very low and would only present as small parts of the cyclist / bicycle in the Class IV, Class V and Class VI mirrors. In a real-world setting the visibility of a cyclist in this position could not be relied upon.

4.1.2.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

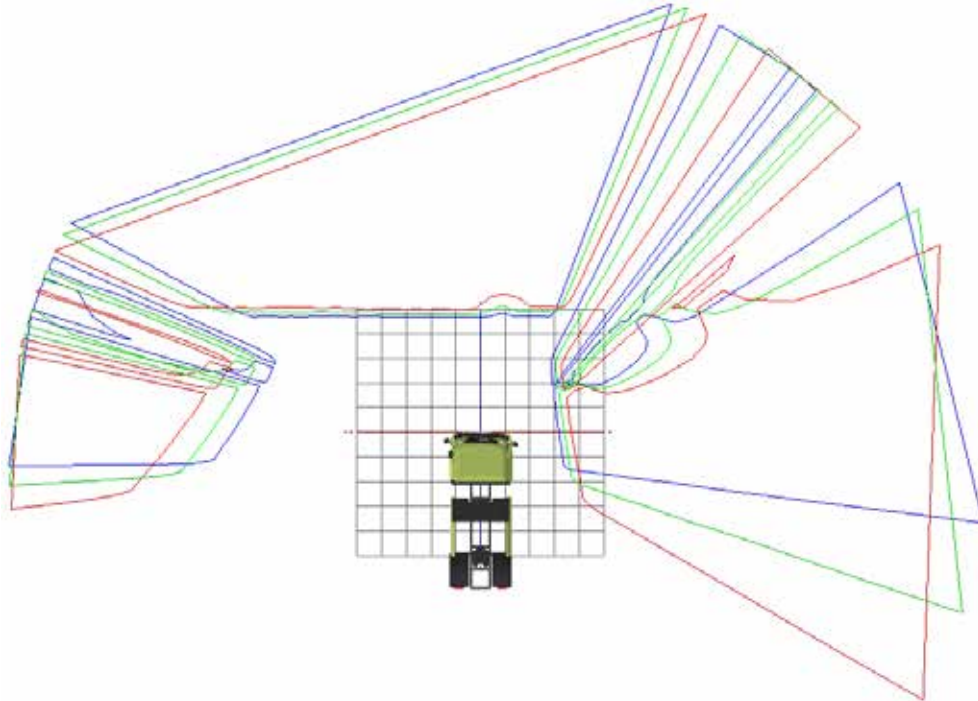


Figure 107. A plan view of the projection of the windscreen and side windows onto the ground plane for the DAF CF N3G for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.1.3 DAF XF N3 DISTRIBUTION - 50TH %ILE MALE DRIVER



Figure 108. Evaluation model of DAF XF N3 Distribution variant vehicle

4.1.3.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 109 shows a top-down view of all of the window projections for the DAF XF N3 cab with a 50th %ile UK Male Driver. The image on the right of Figure 109 shows the areas of these projections that intersect with the ground. Figure 110 shows the same for the the mirror projections and Figure 111 shows the two combined. In this case the projections have been clipped to a radius of twenty metres. Any area outside of the coloured projections, within that twenty metre radius, is effectively a blind spot at the ground plane.

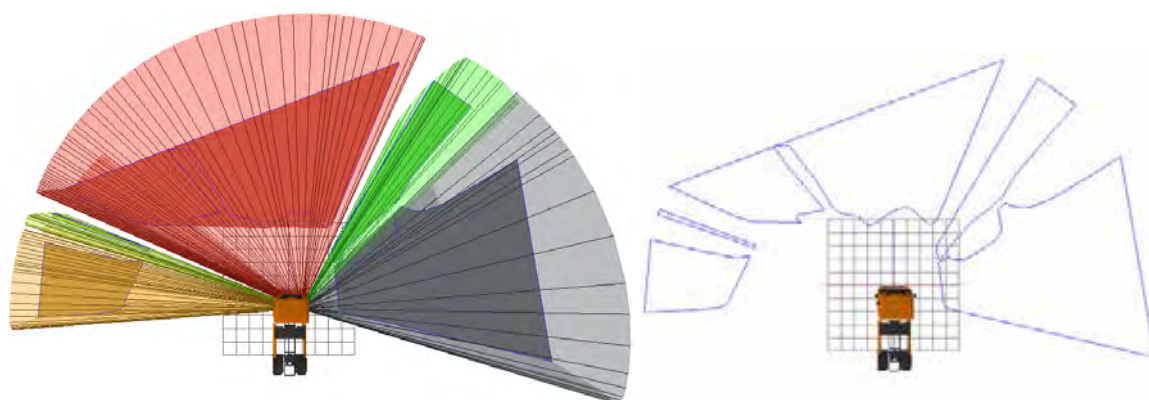


Figure 109. The projection of the windscreen and window apertures at the ground plane for the DAF XF N3

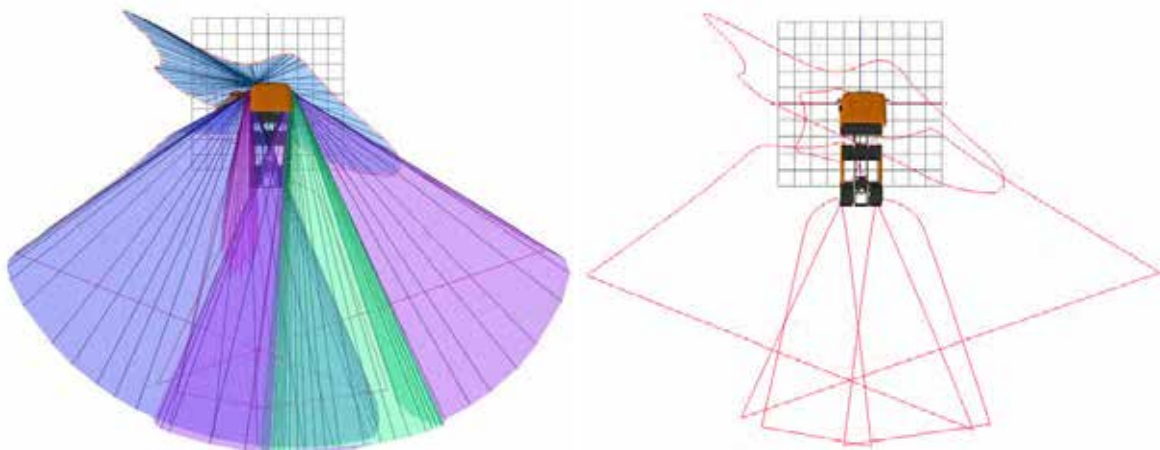


Figure 110. The projection of the mirrors at the ground plane for the DAF XF N3

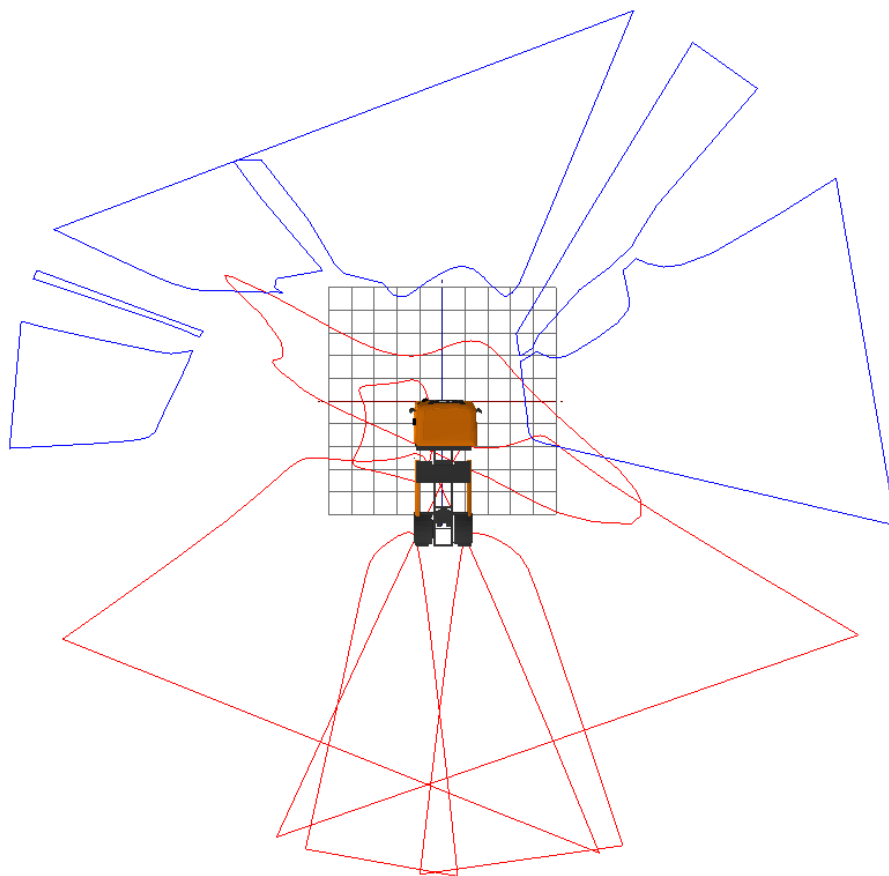


Figure 111. The combined direct and indirect vision projections at the ground plane for the DAF XF N3

Figure 112 through Figure 116 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 117 and Figure 118 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

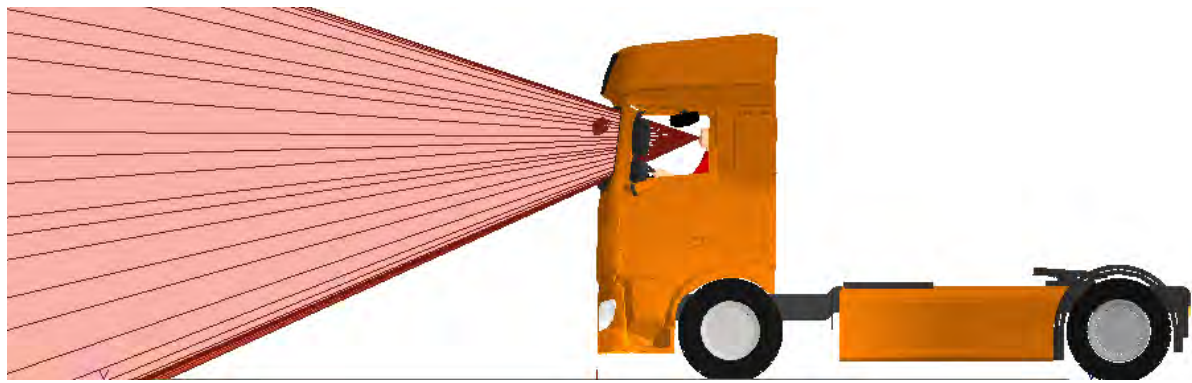


Figure 112. A side view of the windscreen aperture projection for the DAF XF N3



Figure 113. Frontal views of the off side and near side door window projections for the DAF XF N3

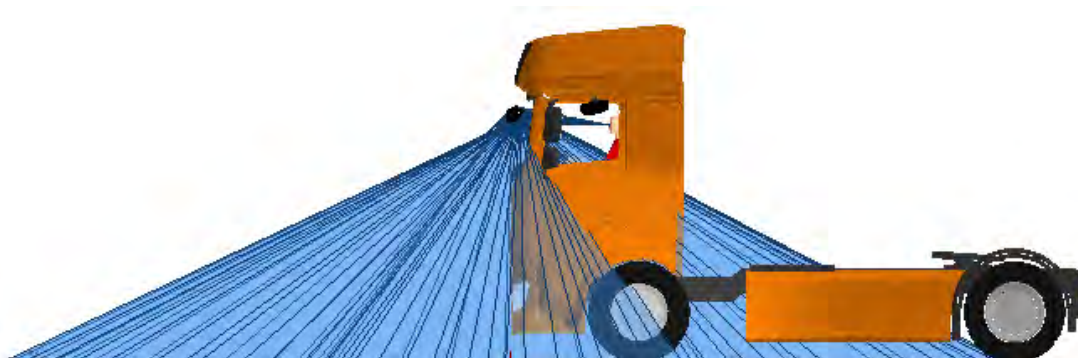


Figure 114. A side view of the Class VI mirror projection for the DAF XF N3



Figure 115. A front view of the Class V mirror projection for the DAF XF N3

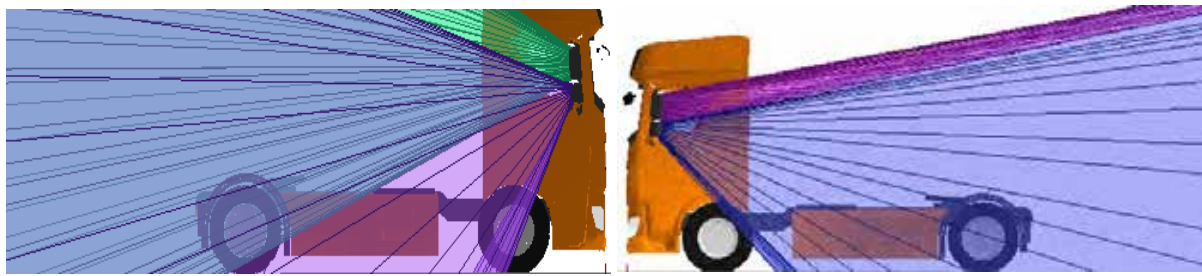


Figure 116. Side views of the combined Class II and Class IV mirror projections for the DAF XF N3

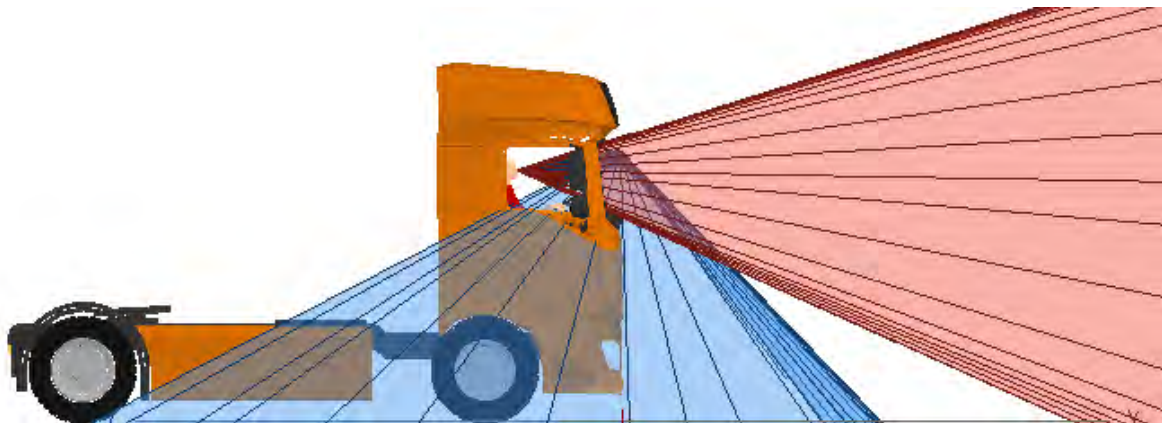


Figure 117. Combined projection of the windscreen and Class VI mirror to the front of the DAF XF N3

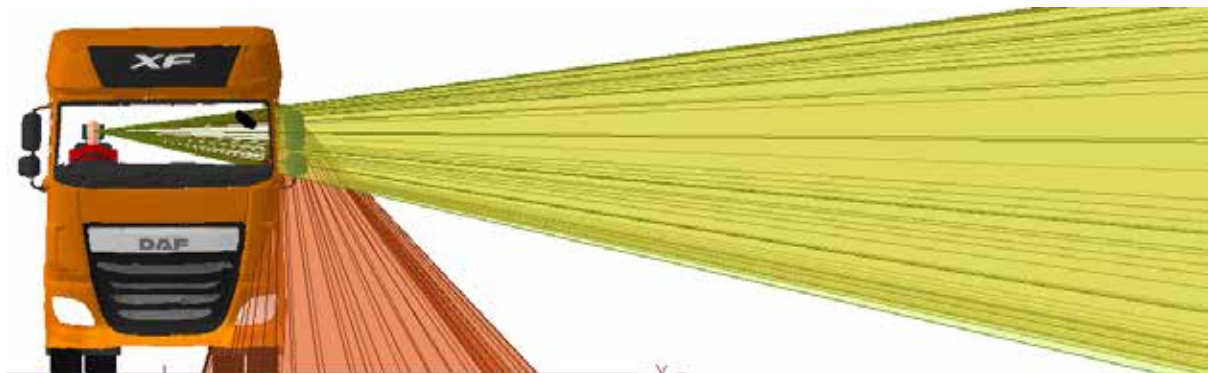


Figure 118. Combined projection of the near side windows and Class V mirror to the side of the DAF XF N3

4.1.3.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 119 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.



Figure 119. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 111. However Figure 120 and Figure 121 show that there is a clear space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.

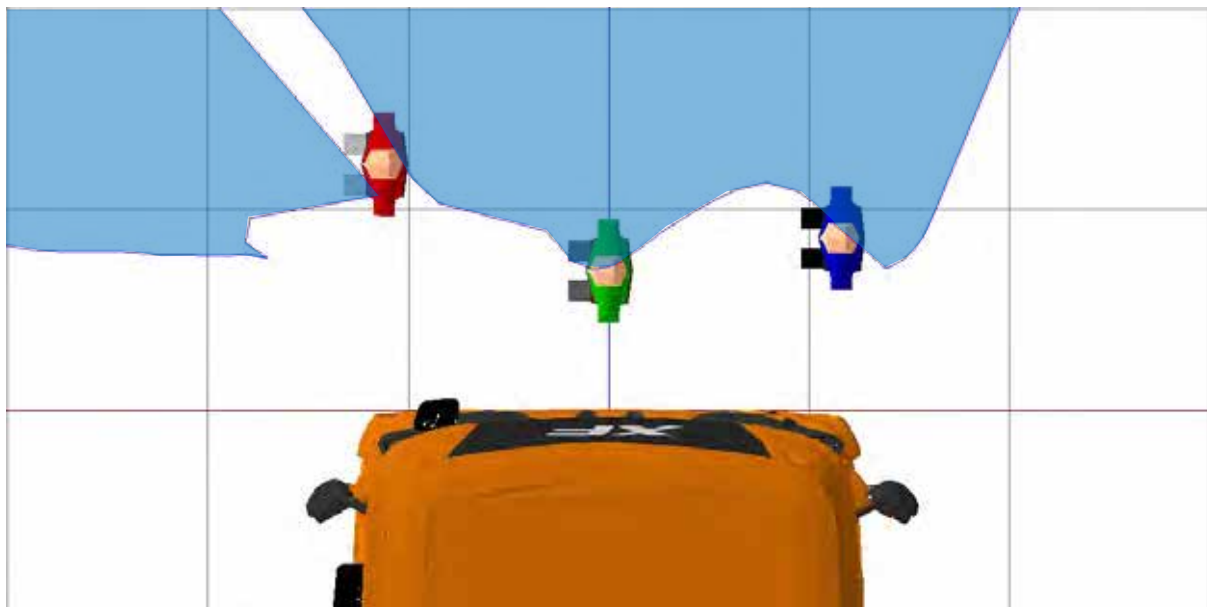


Figure 120. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

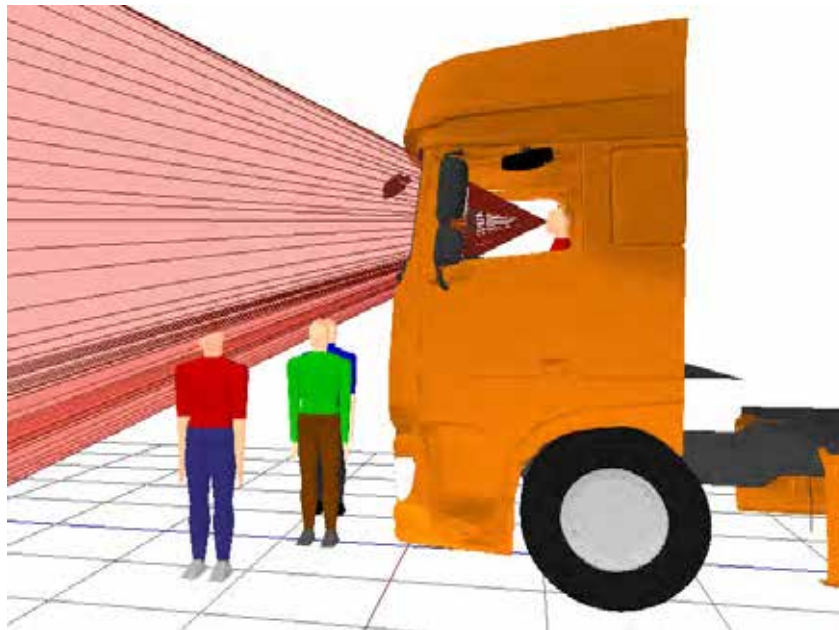


Figure 121. 3D view showing that the three human models can stand 622mm (blue), 432mm (green) and 962mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 122. The view from the driver's eyes clearly shows the three pedestrians are hidden from view.

For forwards visibility of the pedestrians all three can be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 622mm from the front of the vehicle, the left (red) pedestrian is positioned at 962mm from the front of the vehicle and the central (green) pedestrian is positioned at 432mm from the front of the vehicle. The projections show that it is clearly possible for a pedestrian of 50th %ile UK male height or shorter to be hidden from direct vision in these locations.

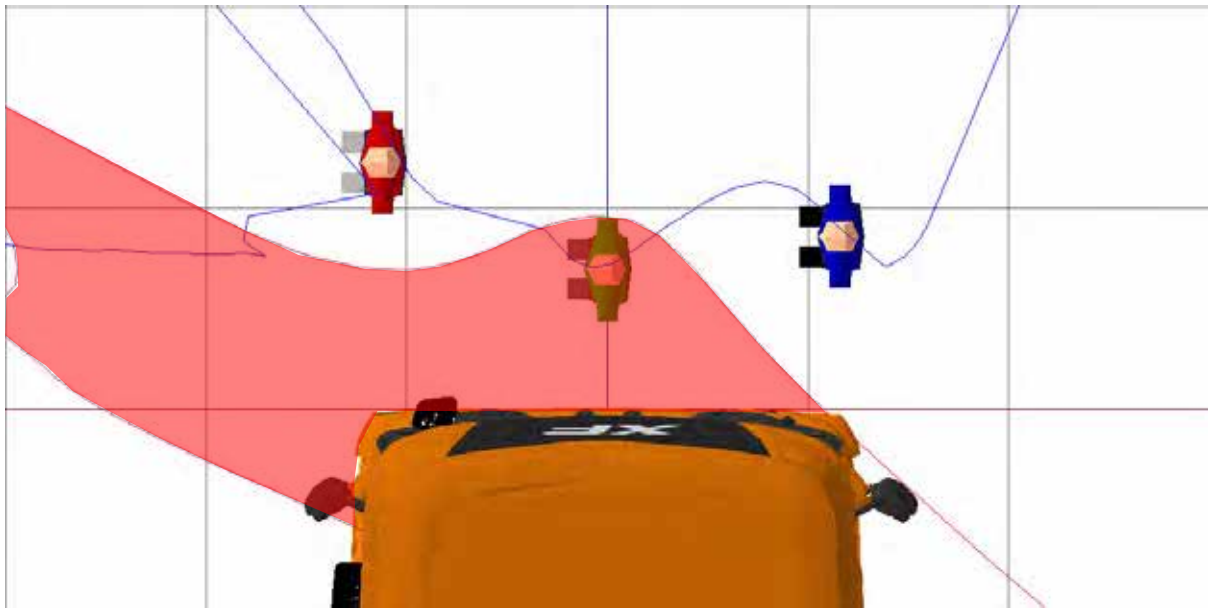


Figure 123. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

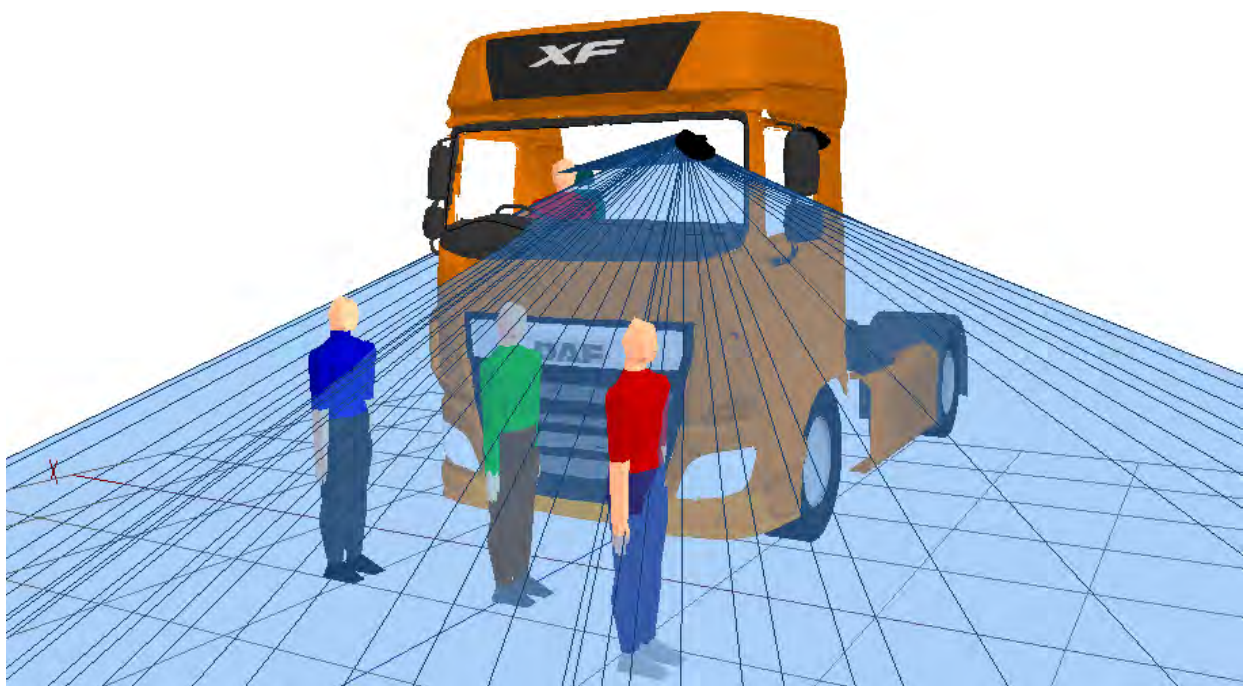


Figure 124. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 124 shows that the pedestrian to the centre (green) would be completely visible, and the pedestrians to the right (blue) and to the left (red) would be visible from the left shoulder down. Though it is apparent that due to the angle of cutoff of the projection much less of the left (red) pedestrian is visible. The driver would be able to see only the left arm and legs of a pedestrian in this position. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide the pedestrian models that have been tested to the front of the DAF XF N3.

4.1.3.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

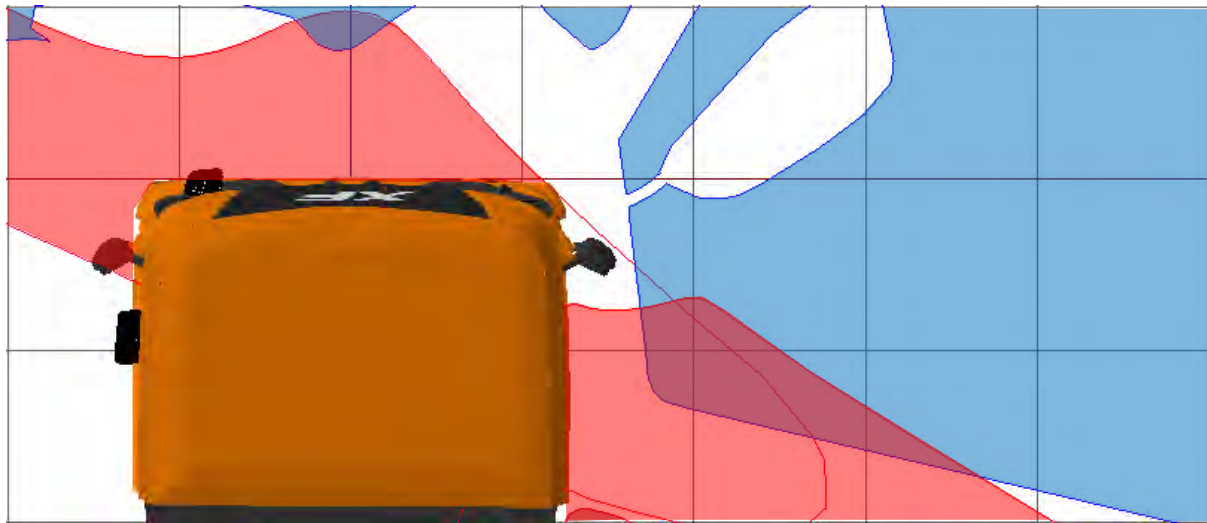


Figure 125. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

From Figure 125 it is clear that the visible areas at a height representative of a cyclist are closer to the vehicle than those taken at ground level shown in Figure 111. Figure 126, Figure 127 and Figure 128 show that it is just possible to hide a cyclist from direct vision.

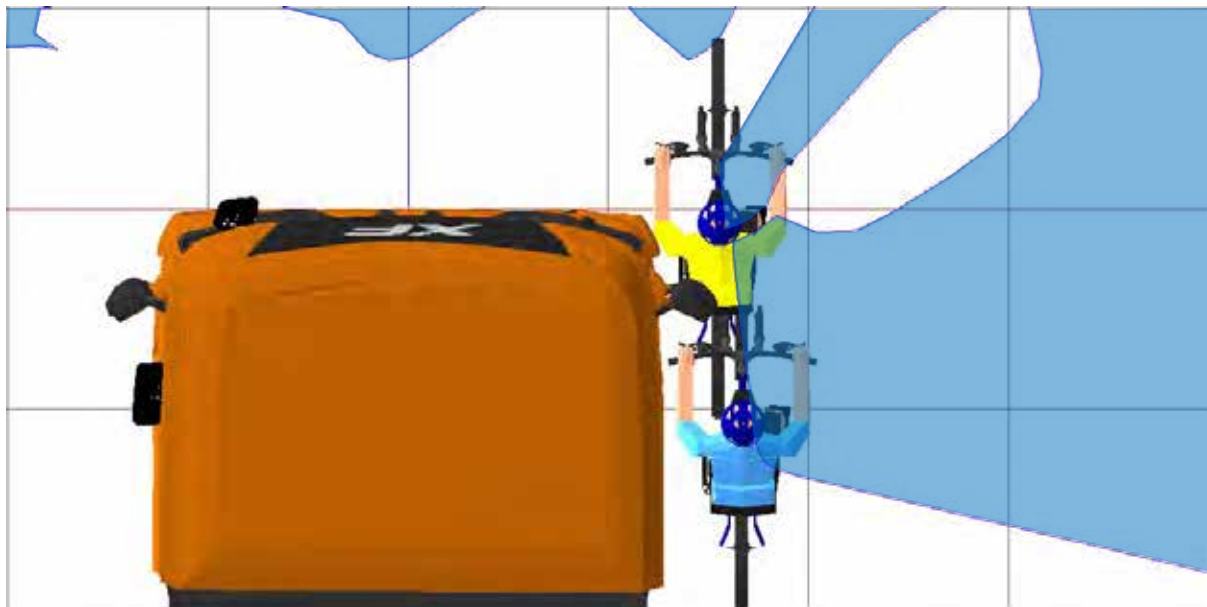


Figure 126. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist



Figure 127. 3D view showing that the two human models can be positioned 0mm (yellow) and 53mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 128. The view from the driver's eyes shows the two cyclists are hidden from view.

For offside visibility of the cyclists both can be hidden from the driver's direct vision. However, the front (yellow) cyclist must be positioned against the side of the vehicle, and the rear (blue) cyclist can only be positioned up to 53mm from the side of the vehicle.

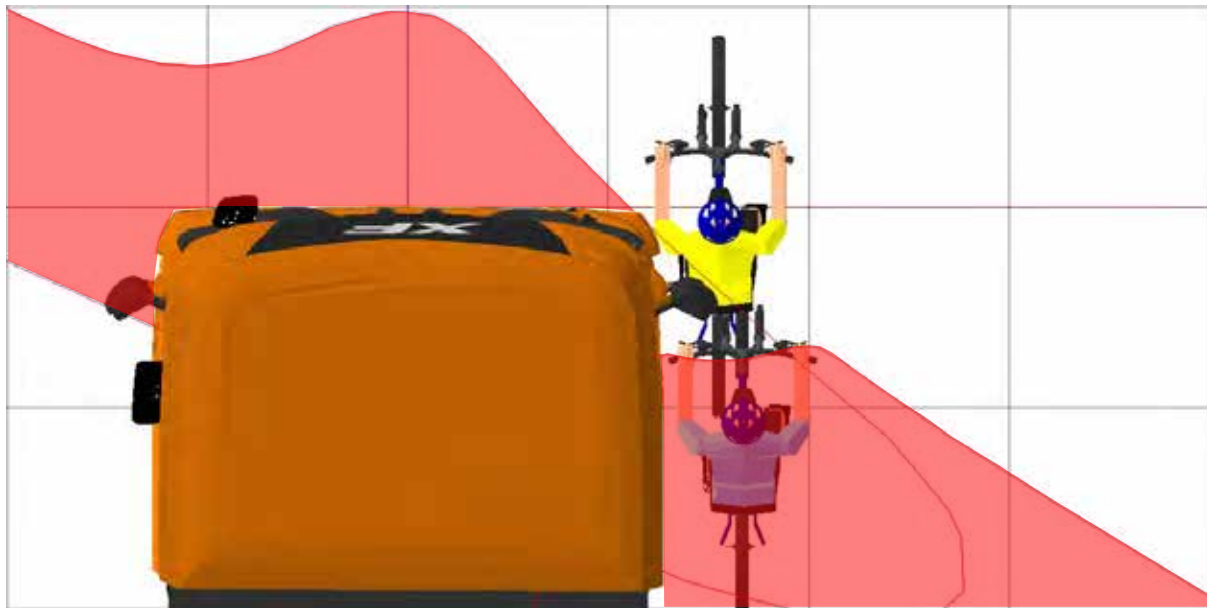


Figure 129. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist



Figure 130. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

Though the two cyclists can be hidden from direct view to the offside of the vehicle both are visible in the Class IV and Class VI mirrors. Figure 130 shows that theoretically both cyclists are visible in the Class VI mirror. However, due to limitations of the projection technique, the rear cyclist (blue) would actually be hidden from view by the cab of the vehicle. However, part of the front (yellow) cyclist would be visible in the Class VI mirror including their arms and the front of the bicycle.

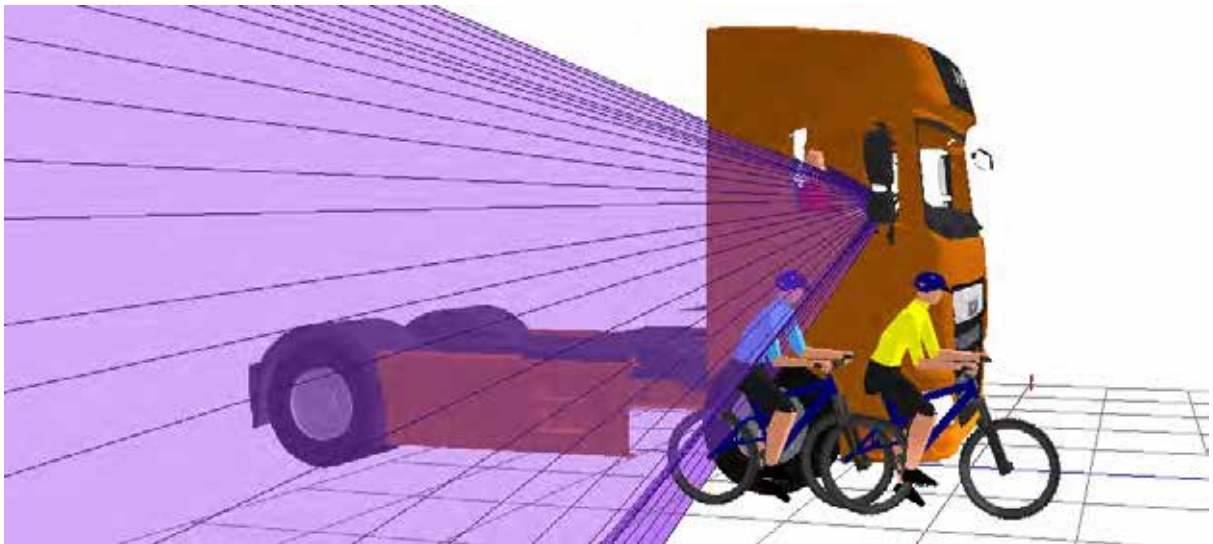


Figure 131. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 131 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and upper body. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the offside of the DAF XF N3.

4.1.3.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

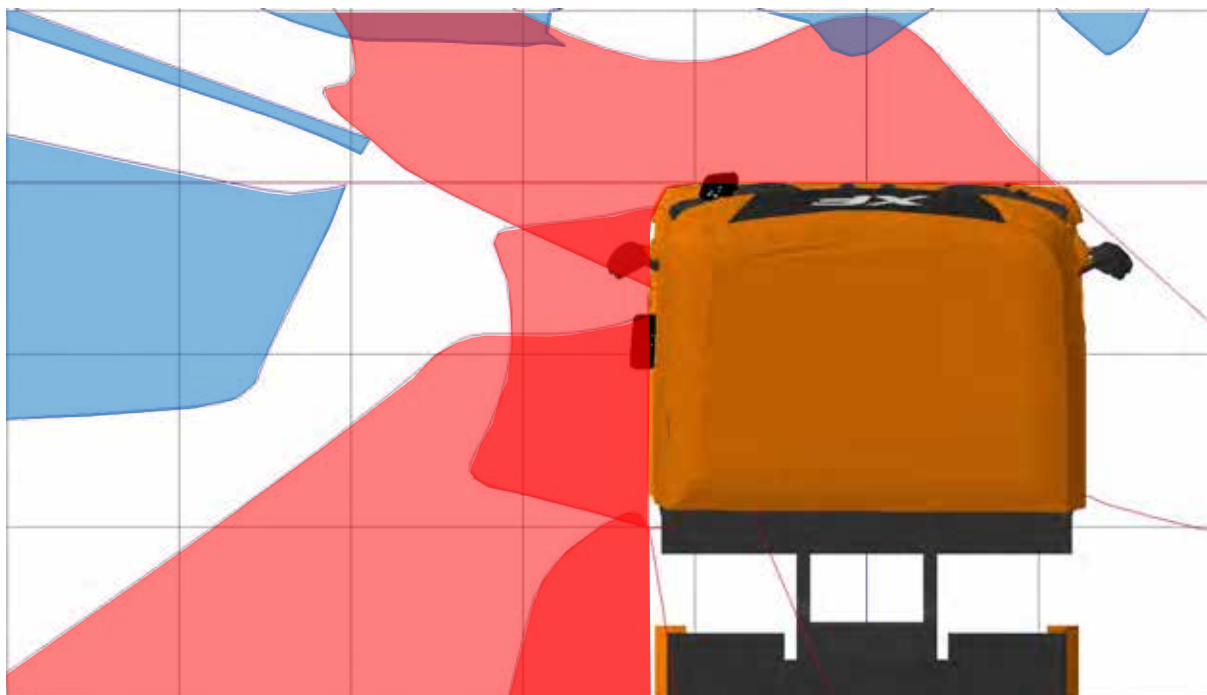


Figure 132. The areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 133 and Figure 134 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

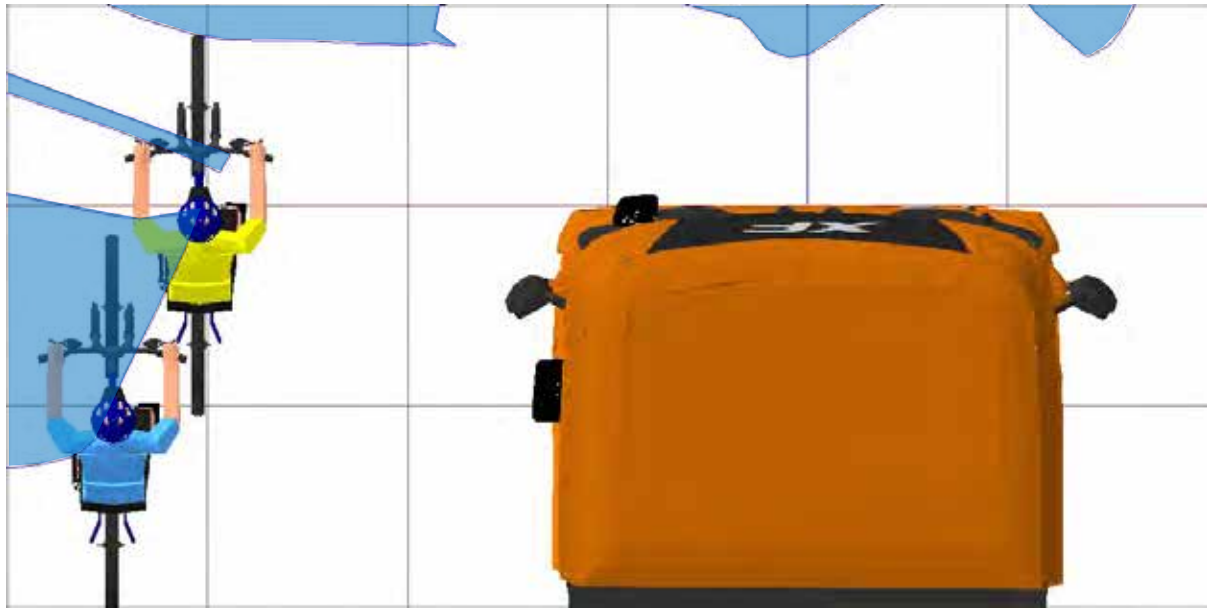


Figure 133. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

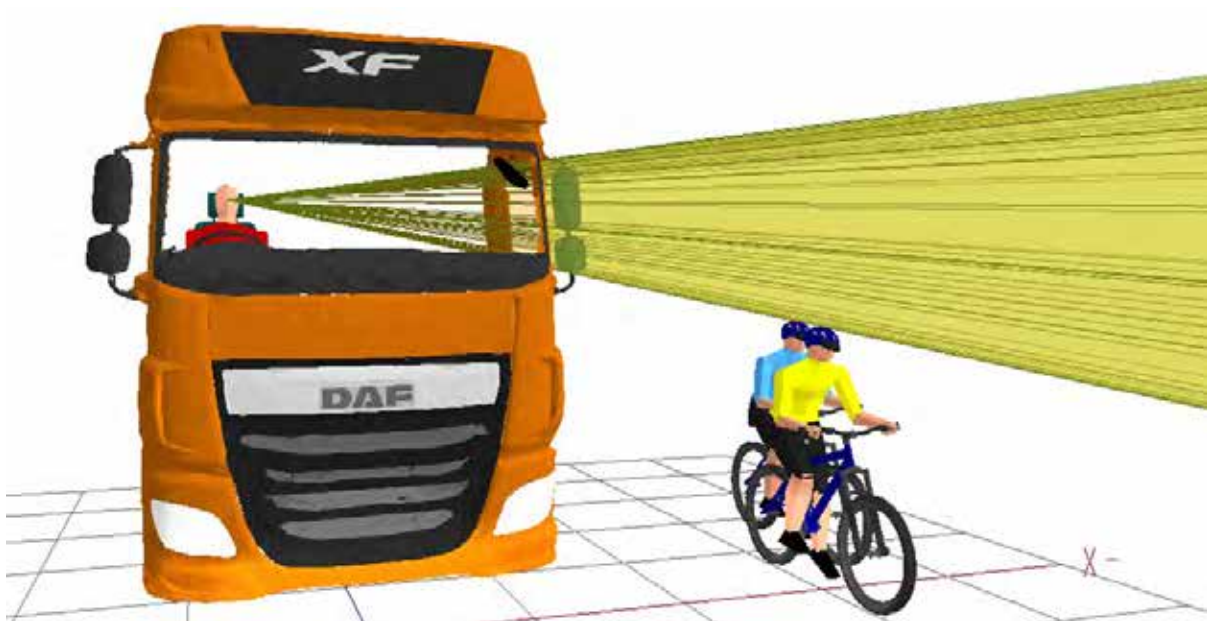


Figure 134. 3D view showing that the two human models can be positioned 1452mm (yellow) and 1827mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 135. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 1452mm from the side of the vehicle, the rear (blue) cyclist is positioned at 1827mm from the side of the vehicle. The additional height of the cab makes the blind spot in direct vision significantly greater than that seen for the DAF CF.



Figure 136. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

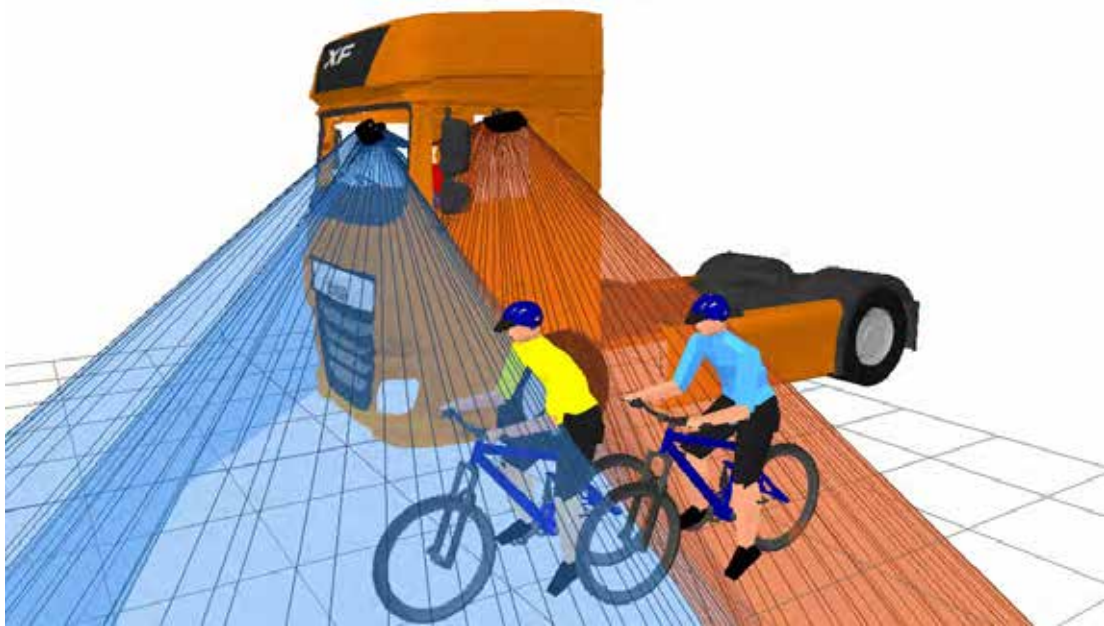


Figure 137. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 137 shows that both are visible in the Class V and Class VI mirrors. The front (yellow) cyclist is visible in the Class VI mirror though only their arms and the front of the bicycle would be visible. The front (yellow) cyclist’s legs and the lower part of the bicycle would also be visible in the Class V mirror. The rear (blue) cyclist is only barely visible in either mirror, part of the front wheel of the bicycle would be visible in the Class VI mirror and a very small part of the rear wheel would be visible in the Class V.

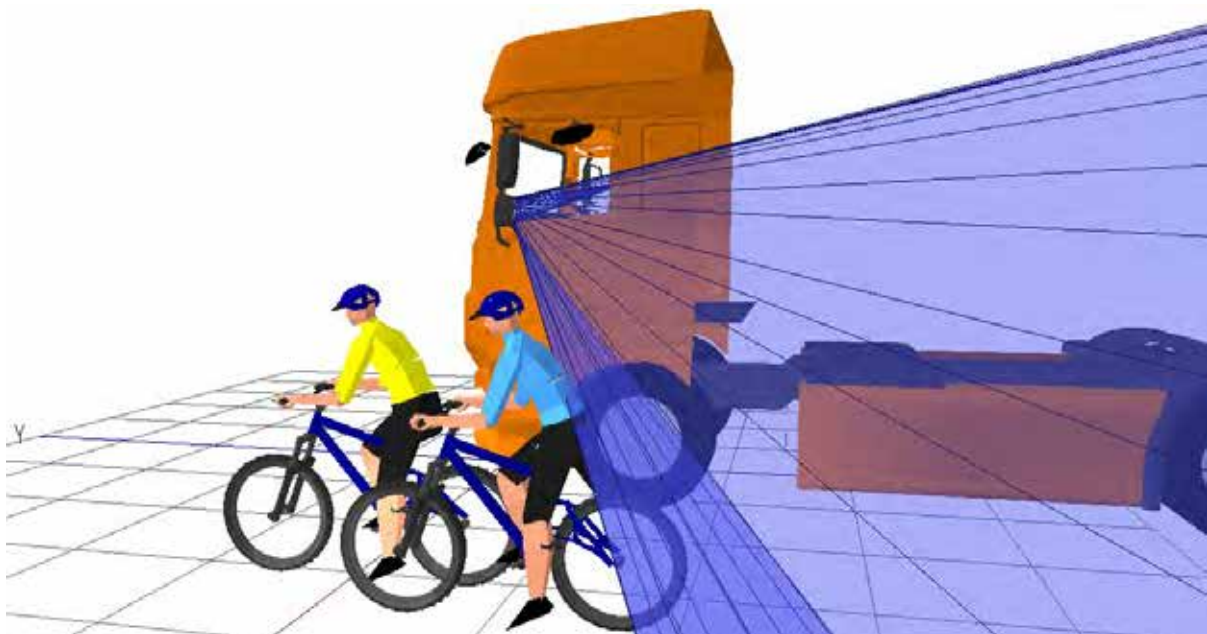


Figure 138. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is barely visible in the projection of the Class IV mirror

Figure 138 shows that a small portion of the back of the rear of the two cyclists (blue) is also visible in the projection of the nearside Class IV mirror. Whilst small parts of the rear (blue) cyclist are visible in the

combination of the Class IV, V and VI mirrors, the projections show that it is possible, even for a driver using both direct vision and their mirrors, to effectively hide a cyclist to the nearside of the DAF XF N3.

4.1.3.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

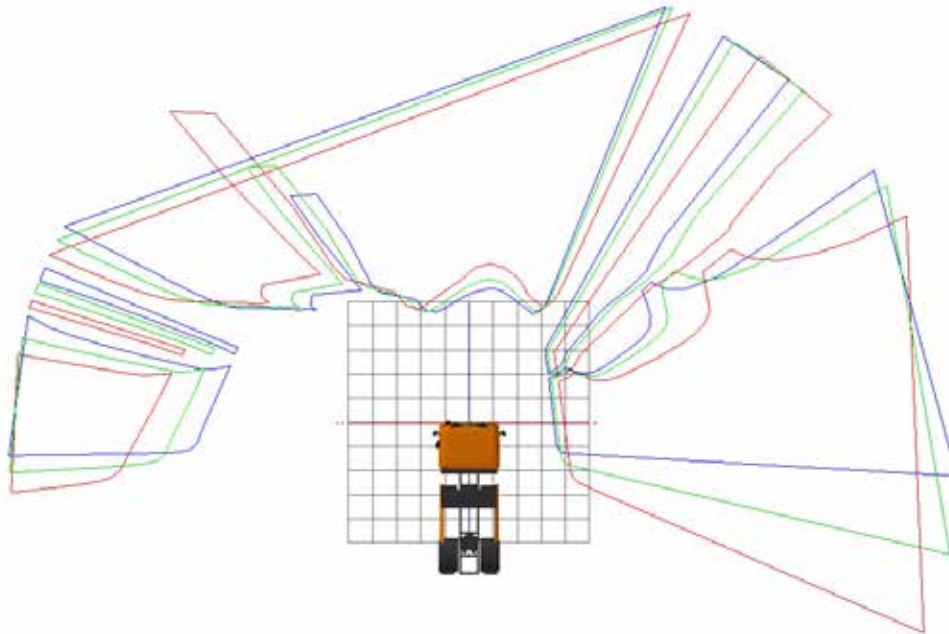


Figure 139. A plan view of the projection of the windscreen and side windows onto the ground plane for the DAF XF N3 for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.1.4 DENNIS EAGLE ELITE 6 LOW ENTRY CAB - 50TH %ILE MALE DRIVER

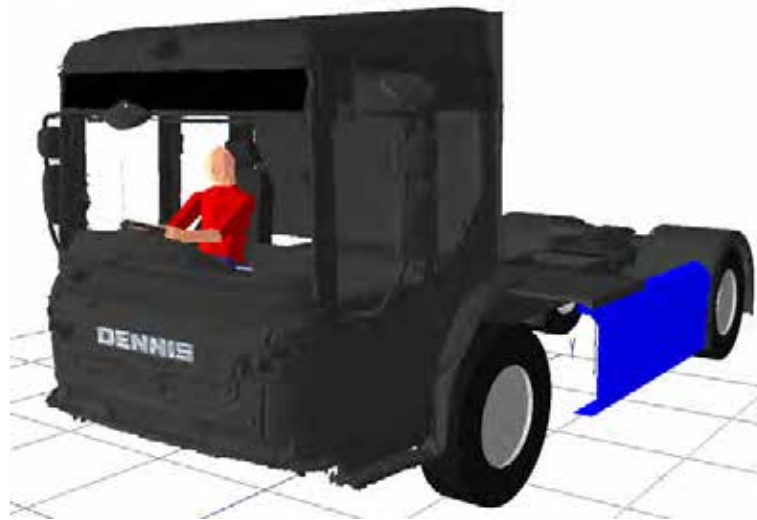


Figure 140. Evaluation model of Dennis Eagle Elite 6 LEC vehicle

4.1.4.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 141 shows a top-down view of all of the window projections for the Dennis Eagle Elite 6 cab with a 50th %ile UK Male Driver. The image on the right of Figure 141 shows the areas of these projections that intersect with the ground. Figure 142 shows the same for the the mirror projections and Figure 143 shows the two combined. In this case the projections have been clipped to a radius of twenty metres. Any area outside of the coloured projections, within that twenty meter radius, is effectively a blind spot at the ground plane.

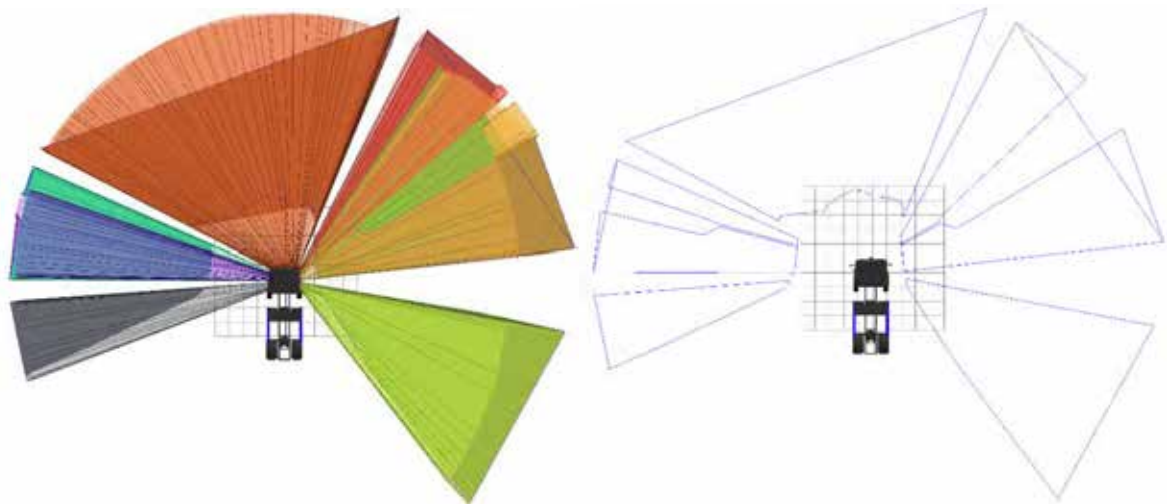


Figure 141. The projection of the windscreen and window apertures at the ground plane for the Dennis Eagle Elite 6 LEC

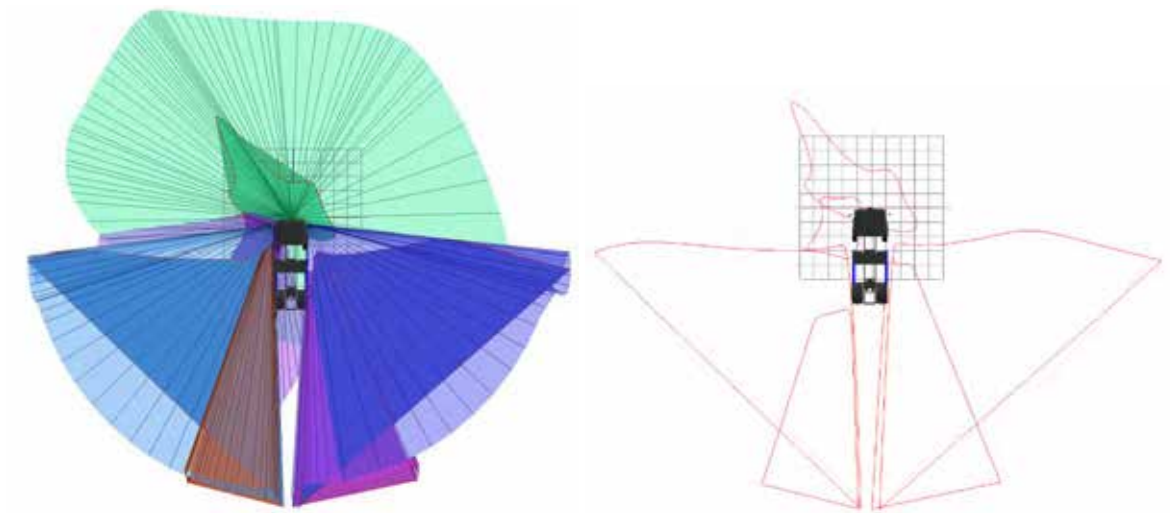


Figure 142. The projection of the mirrors at the ground plane for the Dennis Eagle Elite 6 LEC

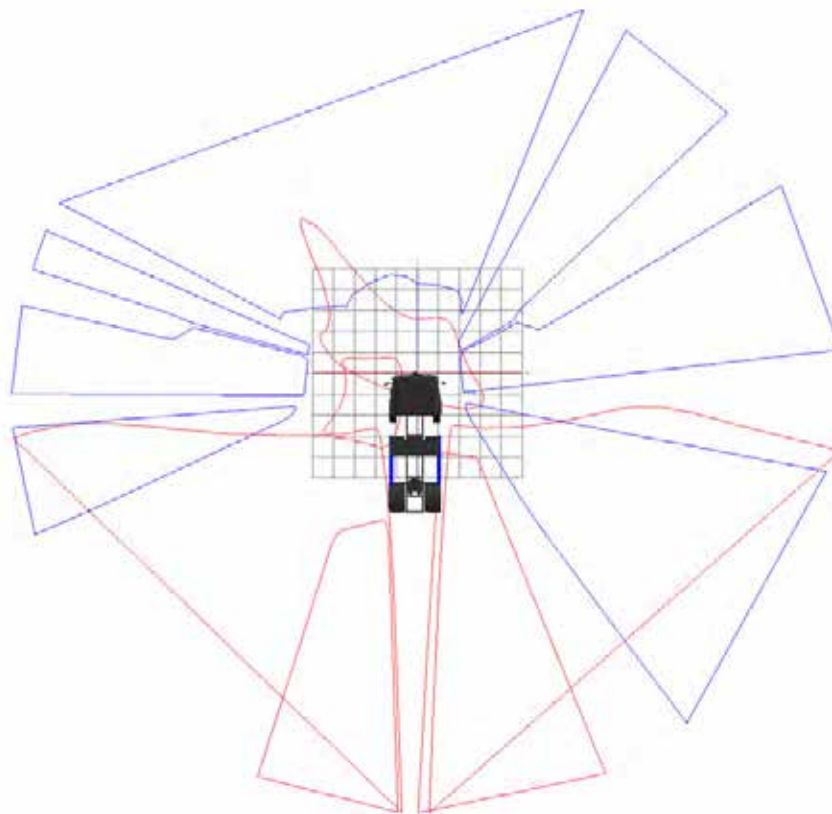


Figure 143. The combined direct and indirect vision projections at the ground plane for the Dennis Eagle Elite 6 LEC

Figure 144 through Figure 148 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 149 and Figure 150 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

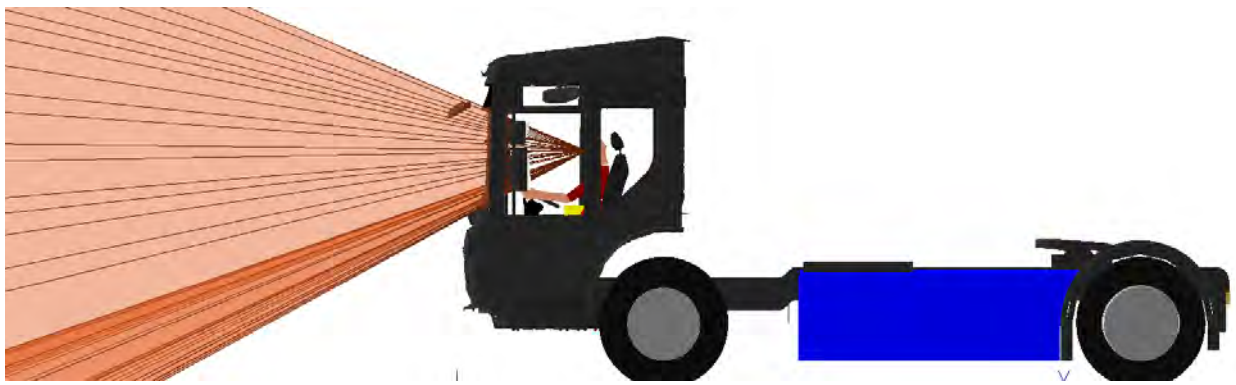


Figure 144. A side view of the windscreen aperture projection for the Dennis Eagle Elite 6 LEC

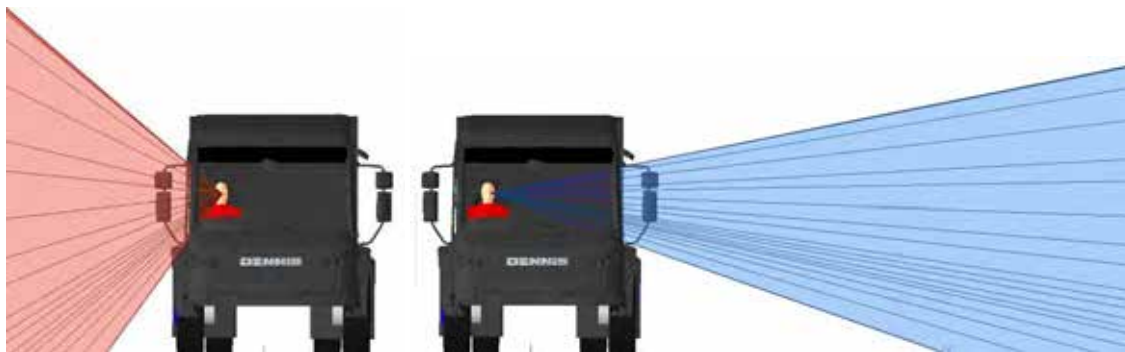


Figure 145. Frontal views of the off side and near side door window projections for the Dennis Eagle Elite 6 LEC

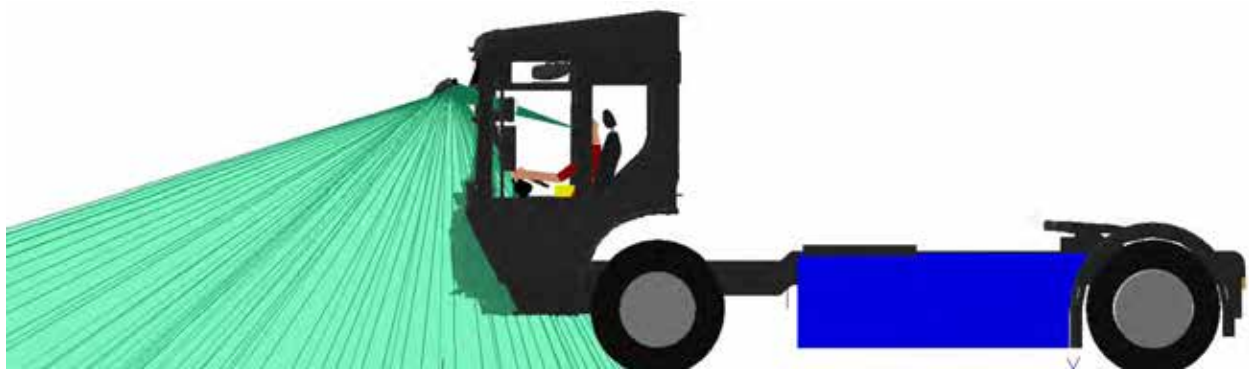


Figure 146. A side view of the Class VI mirror projection for the Dennis Eagle Elite 6 LEC



Figure 147. A front view of the Class V mirror projection for the Dennis Eagle Elite 6 LEC

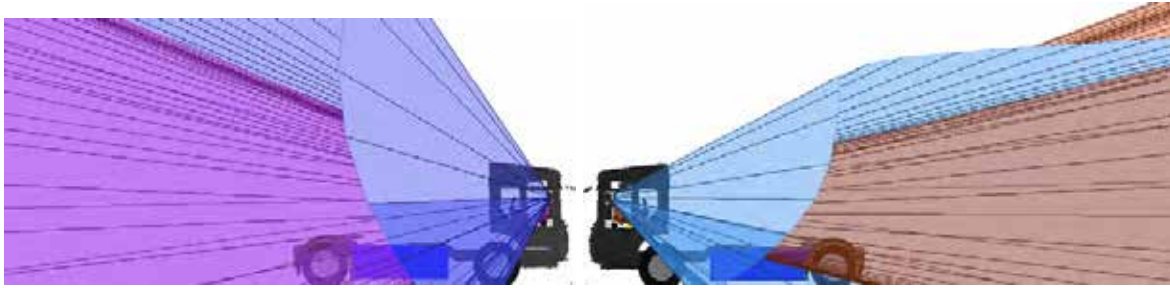


Figure 148. Side views of the combined Class II and Class IV mirror projections for the Dennis Eagle Elite 6 LEC

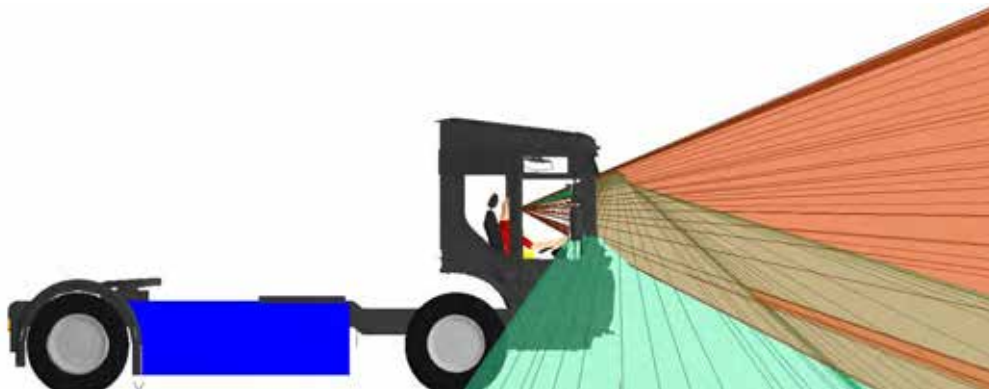


Figure 149. Combined projection of the windscreen and Class VI mirror to the front of the Dennis Eagle Elite 6 LEC

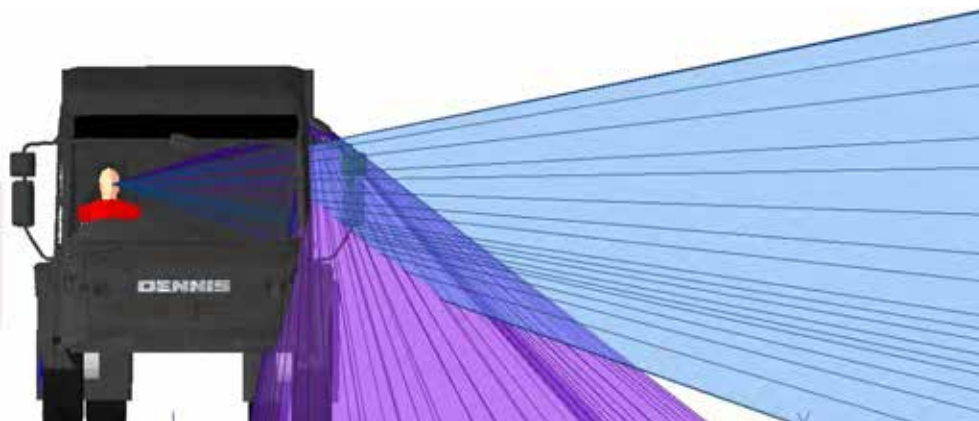


Figure 150. Combined projection of the near side windows and Class V mirror to the side of the Dennis Eagle Elite 6 LEC

4.1.4.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 151 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

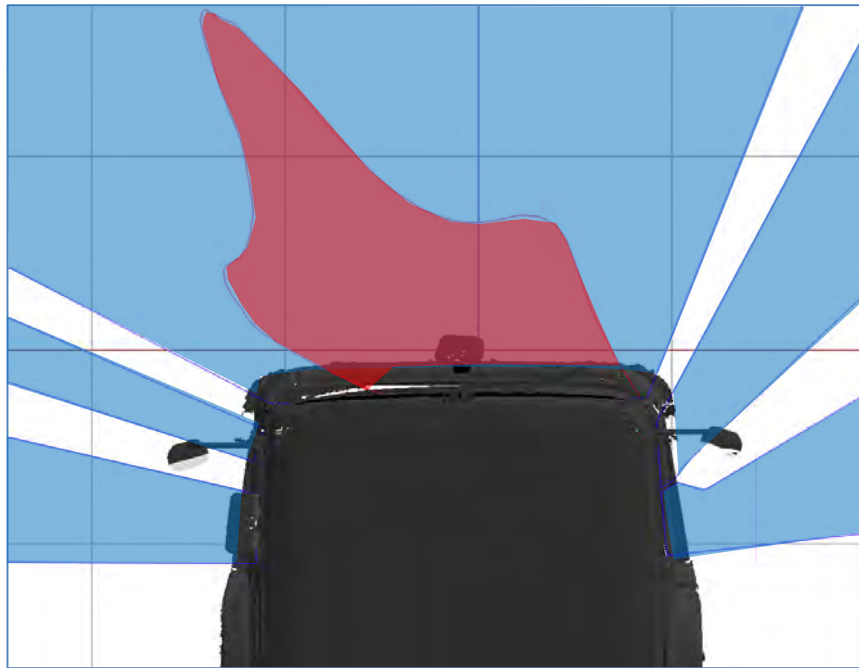


Figure 151. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From Figure 152 it is clear that the visible areas at a height representative of a pedestrian are adjacent to the vehicle side, i.e. there is no gap in which a pedestrian human model with a stature that represents an average UK male can be hidden from the driver's view.

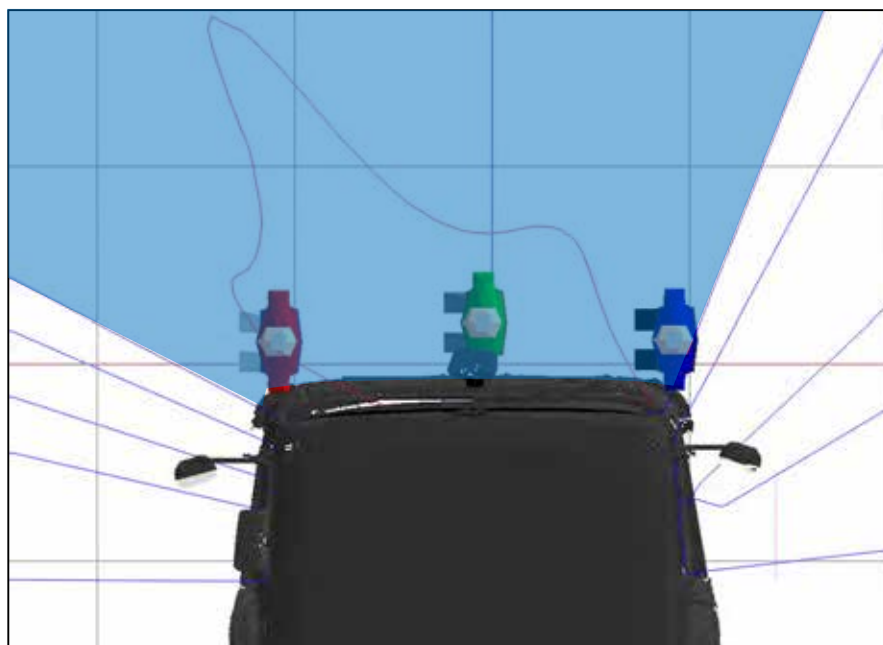


Figure 152. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

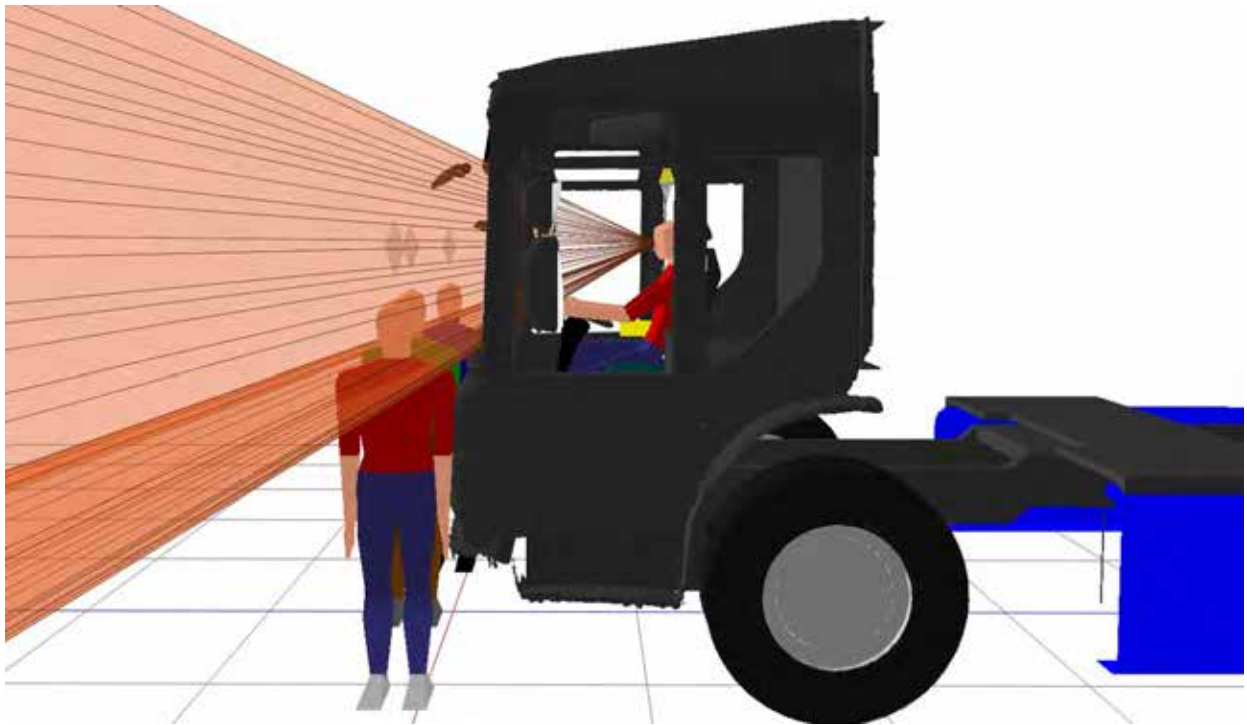


Figure 153. 3D view showing that none of the pedestrians cannot be hidden from the drivers view

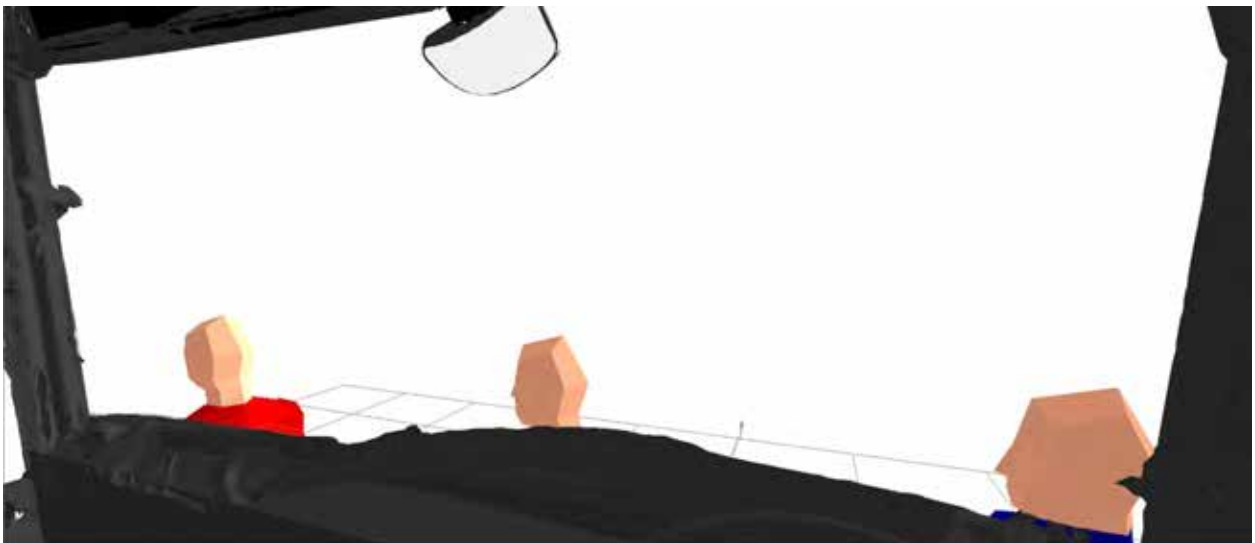


Figure 154. The view from the driver's eyes shows that none of the pedestrians can be hidden from the drivers view

For forwards visibility of the pedestrians it is not possible to hide the three human models from the direct vision of the driver of the Dennis Eagle Elite 6 cab as demonstrated in Figure 153 and Figure 154. This is a feature of the low mounting height of the cab design for the Dennis Eagle Elite 6 cab.

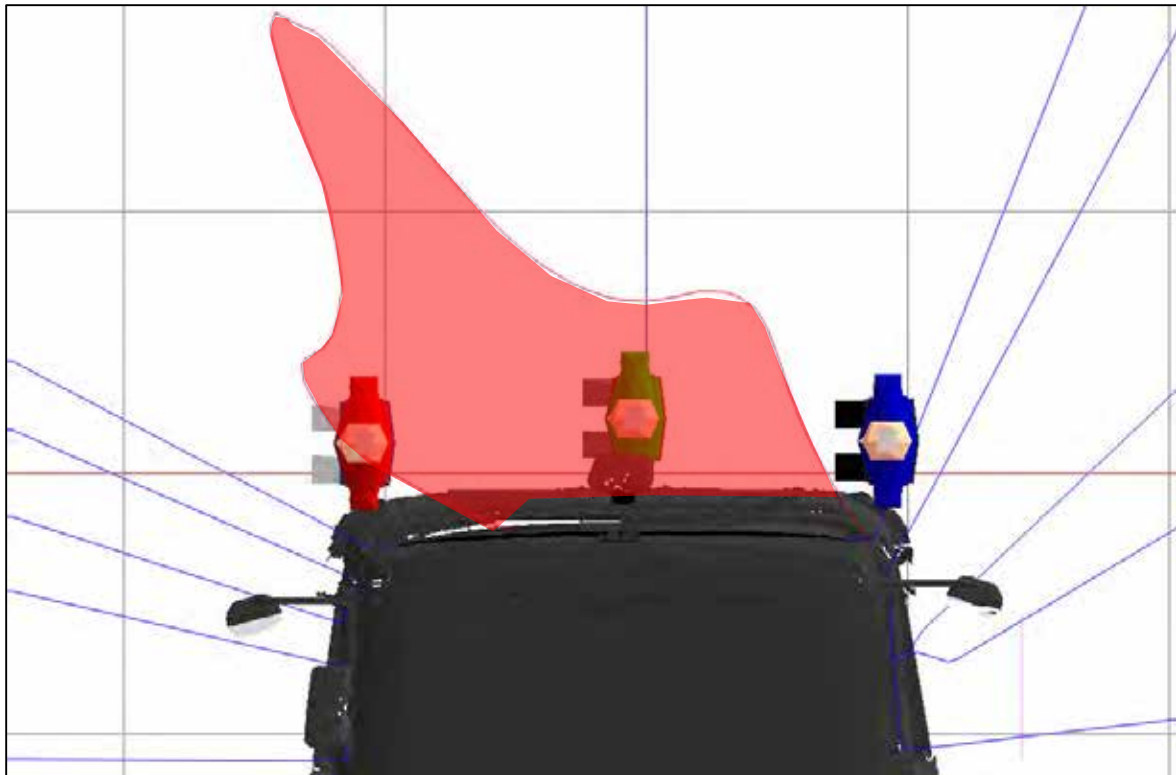


Figure 155. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

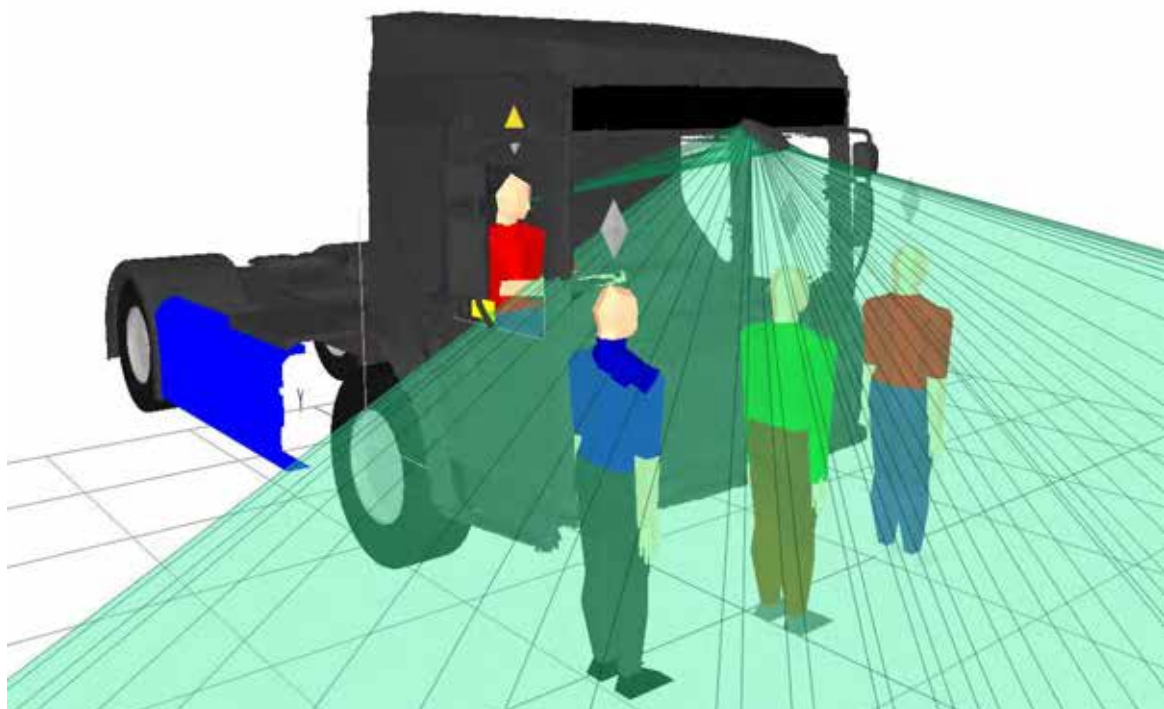


Figure 156. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

As well as providing good direct vision of pedestrians through the windows, it is also possible to see all three pedestrians through the Class VI mirror as shown in Figure 156.

4.1.4.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

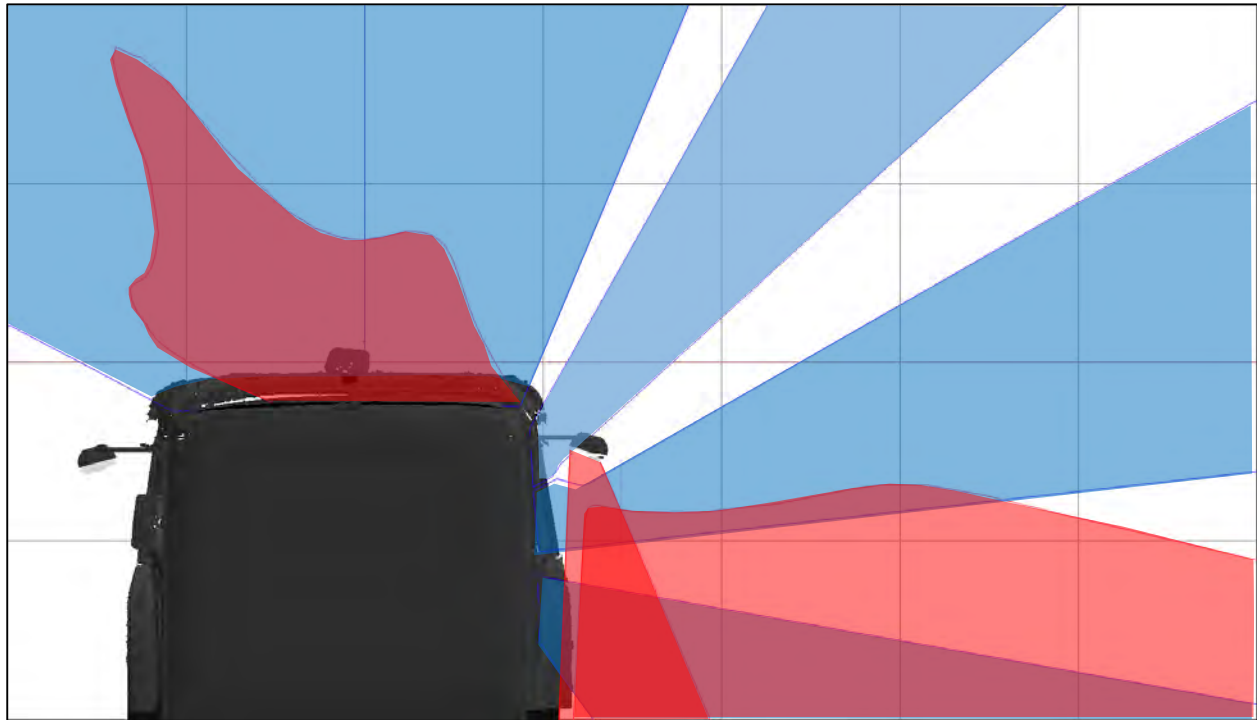


Figure 157. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 158, Figure 159 and Figure 160 show that the cyclist models as defined cannot be hidden from the direct vision of the driver even when they are directly adjacent to the cab side. They would also be visible at greater distances laterally away from the cab. As Figure 160 shows, the rear most cyclist is only partially visible due to the B-pillar.

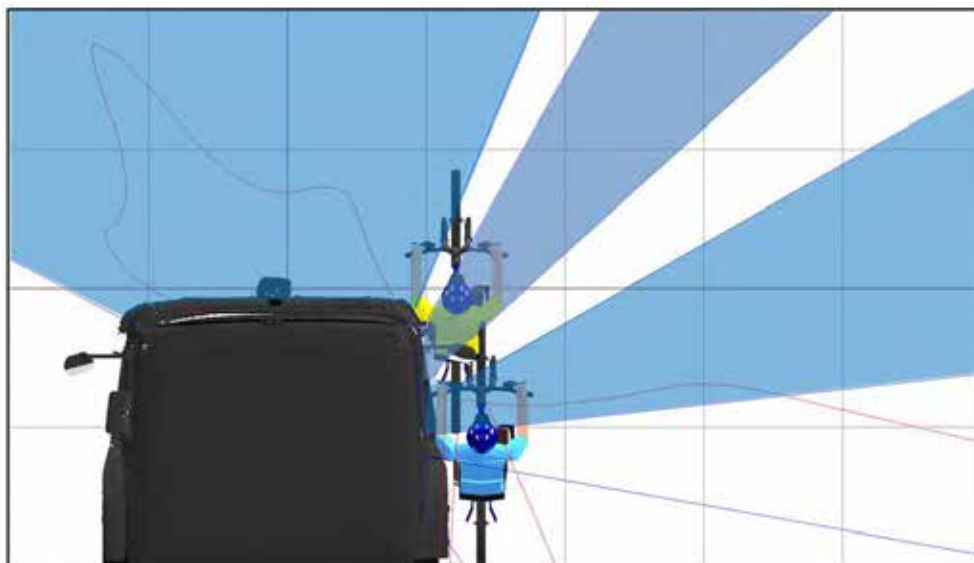


Figure 158. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist

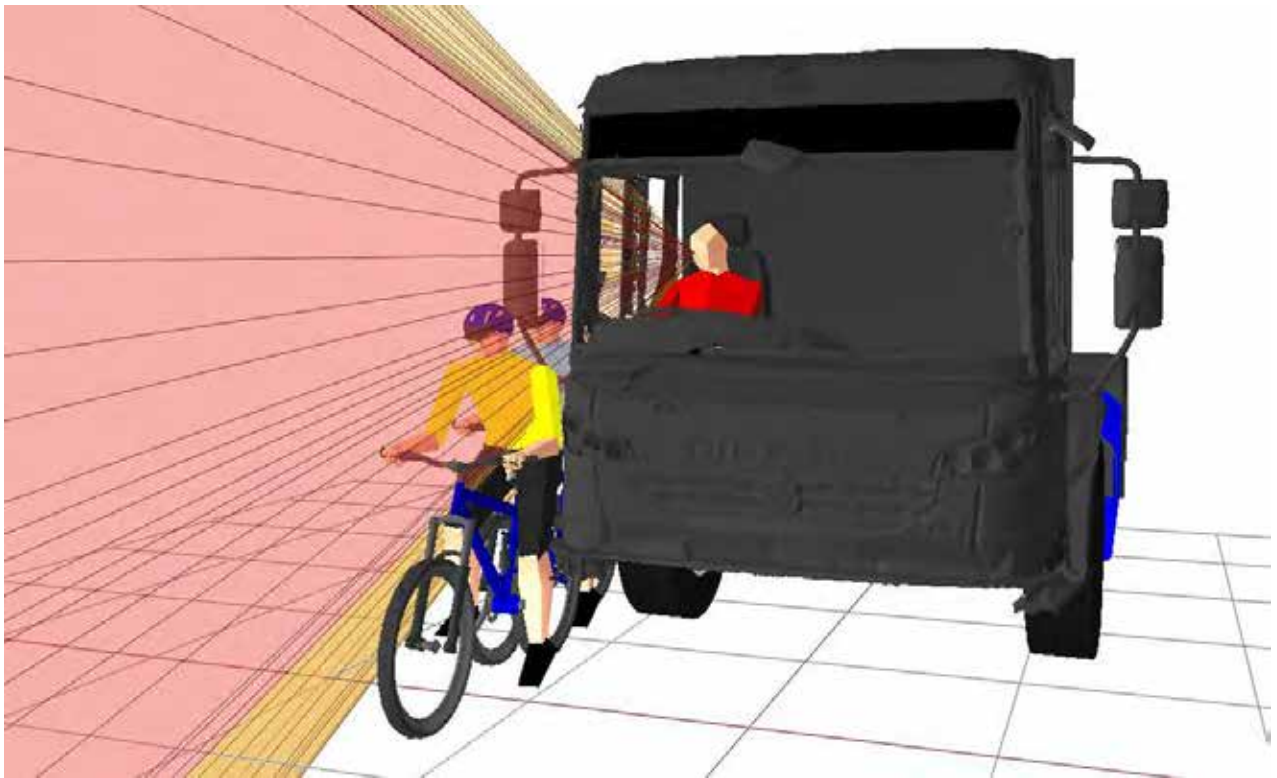


Figure 159. 3D view showing that both cyclists cannot be hidden from direct vision to the offside of the Dennis Eagle Elite 6



Figure 160. The view from the driver's eyes clearly shows the two cyclists are visible, even when positioned against the side of the vehicle.

For offside visibility of the cyclists there is no blind spot that could obscure a cyclist model as defined. Figure 160 shows that even with the cyclists touching the side of the cab they would still be visible to the driver.

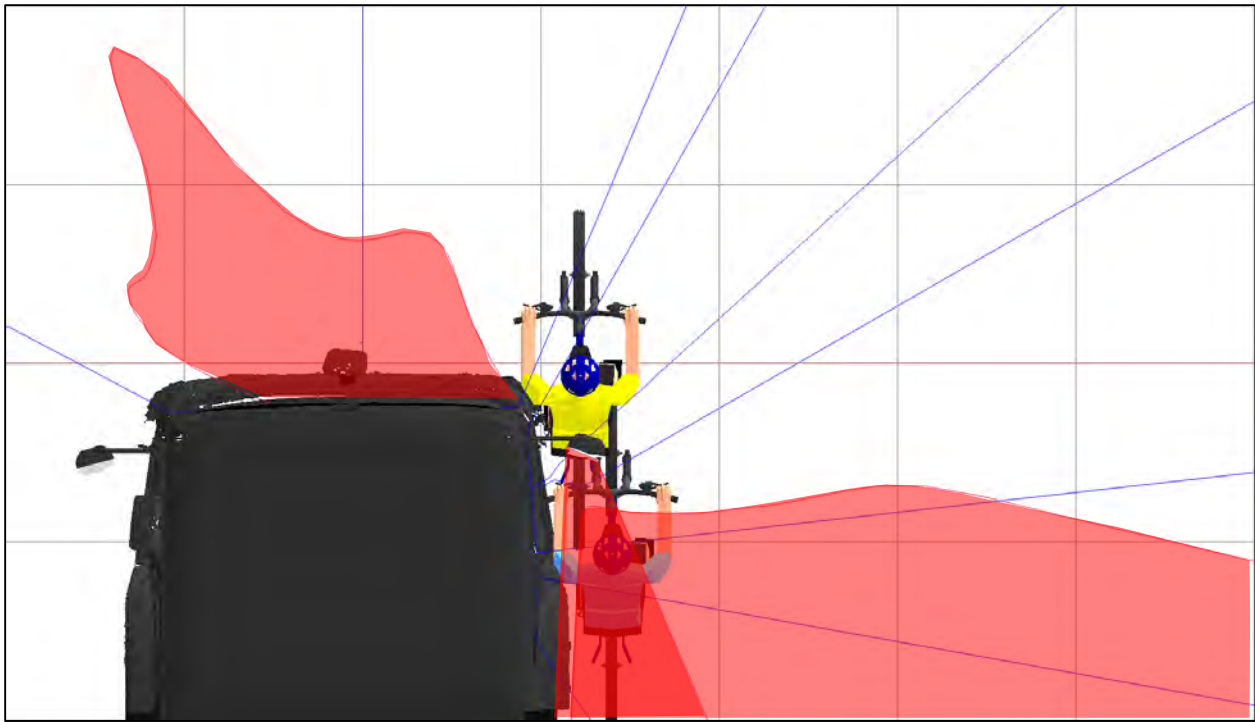


Figure 161. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

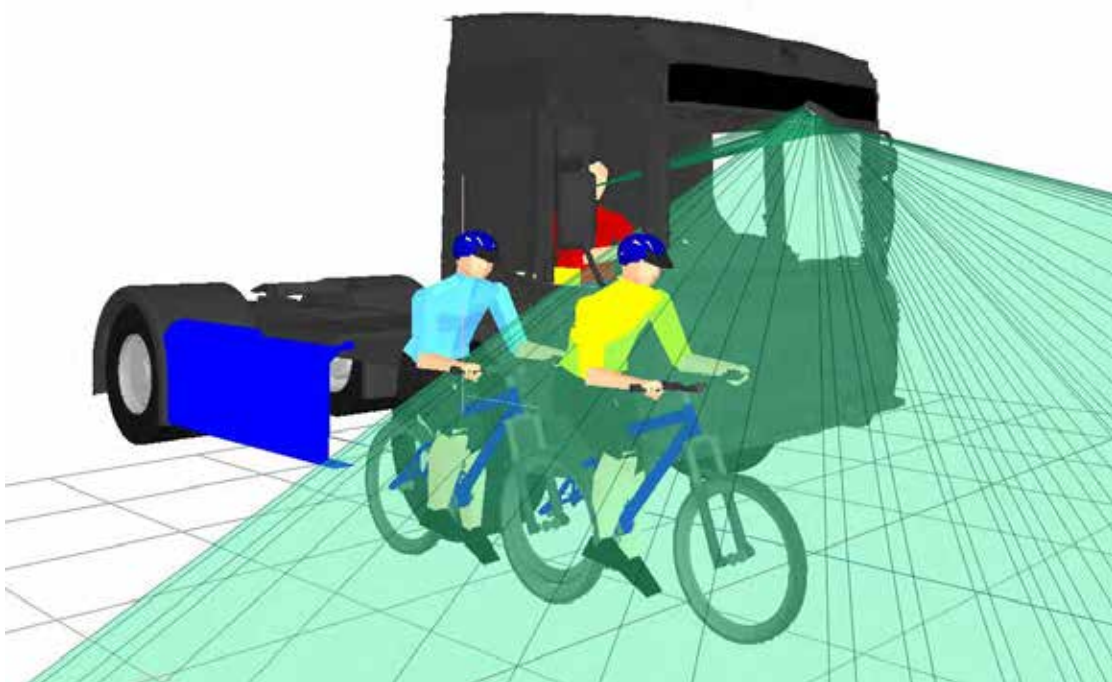


Figure 162. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

In addition to being visible in direct vision the cyclists are also visible in the mirrors. Figure 162 shows that part of the front (yellow) cyclist would also be visible in the Class VI mirror including their arms, lower legs and the front of the bicycle.

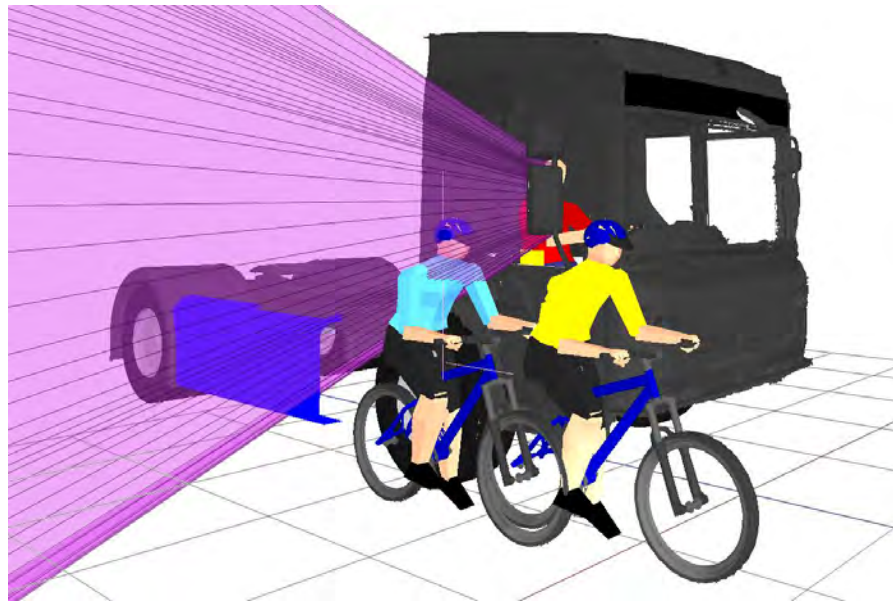


Figure 163. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class II mirror

Figure 163 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class II mirror. The cyclist would only be partially visible including their head and torso. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide a cyclist model as defined to the offside of the Dennis Eagle Elite 6 LEC.

4.1.4.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

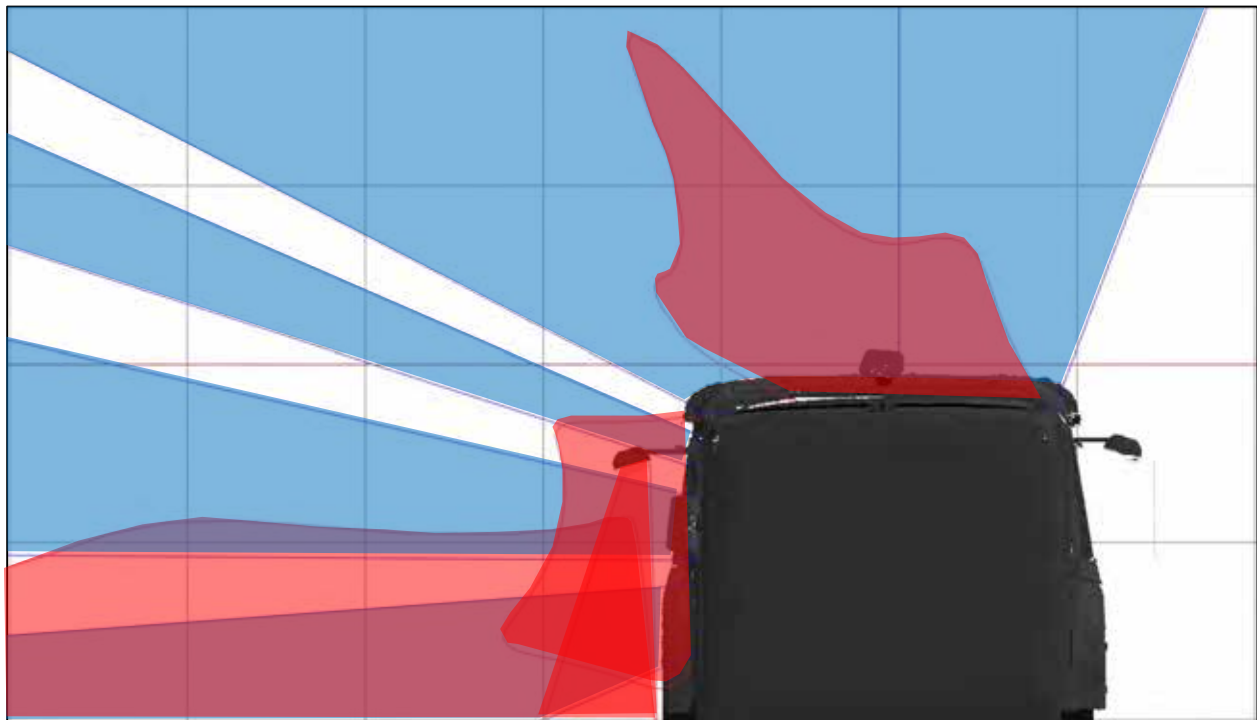


Figure 164. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 165, Figure 166 and Figure 167 show that both cyclists can be seen using direct vision. With the width of the A and B pillars as demonstrated by the vehicle, is unlikely that a cyclist could be hidden from direct view by these pillars if the cyclist is stationary next to a stationary vehicle.

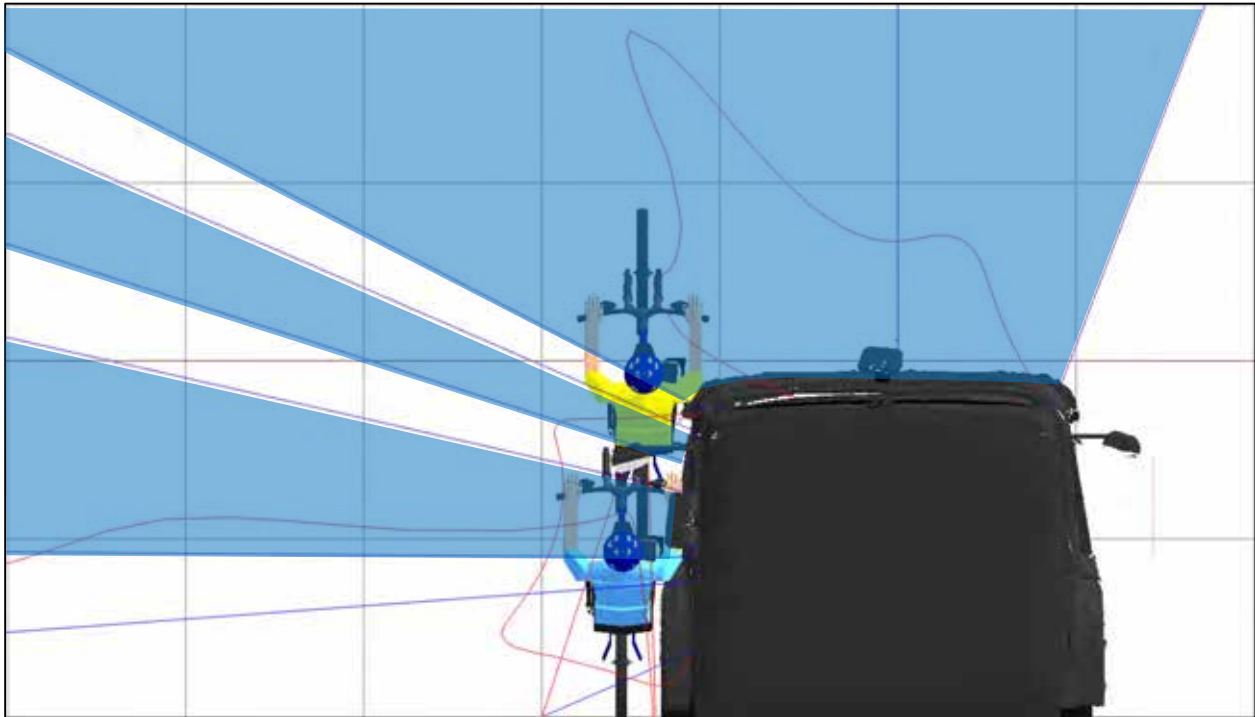


Figure 165. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th percentile UK male cyclist

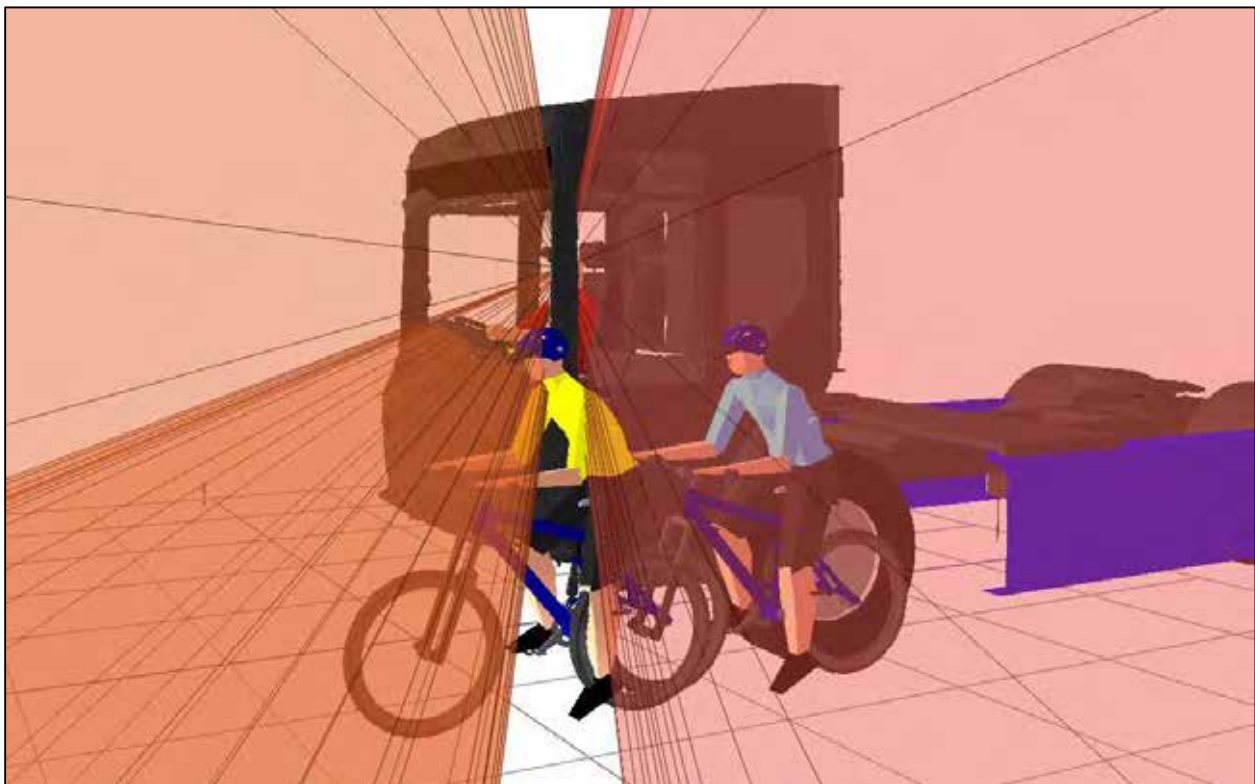


Figure 166. 3D view showing that the two human models be directly seen by the driver

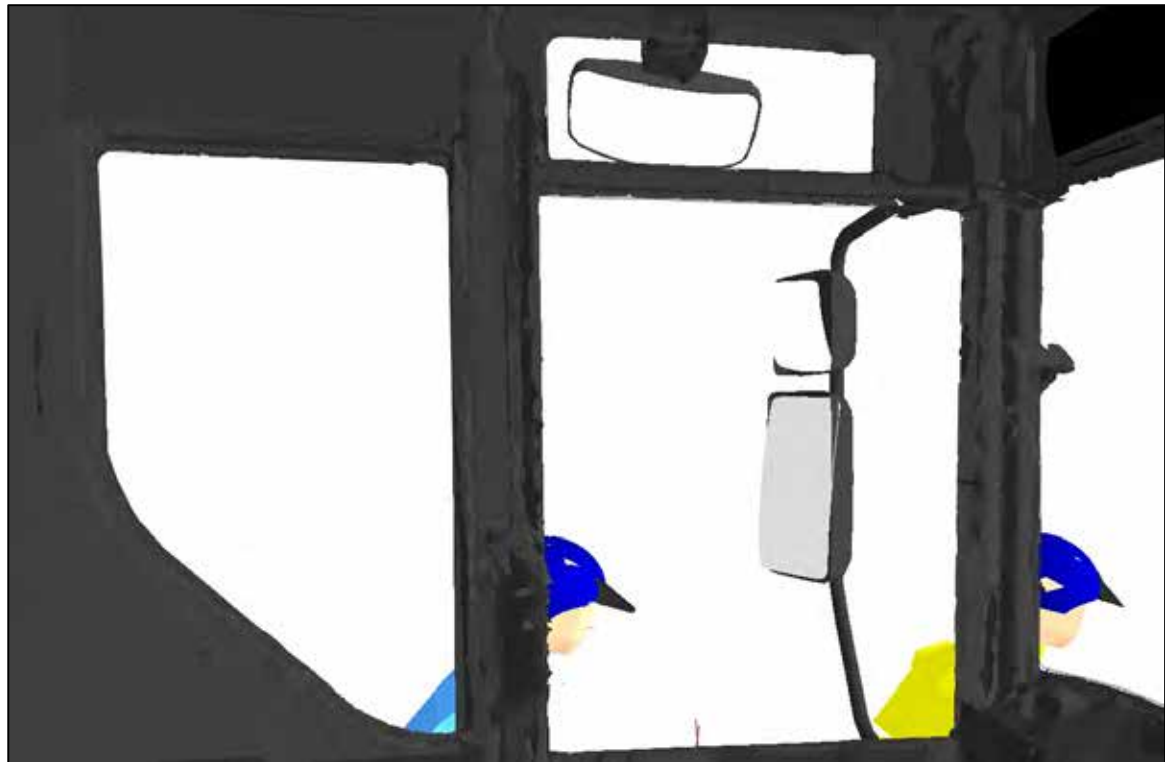


Figure 167. The view from the driver's eyes clearly shows the two cyclists are visible with direct vision.

For nearside visibility of the cyclists both can be seen from the driver's direct vision.

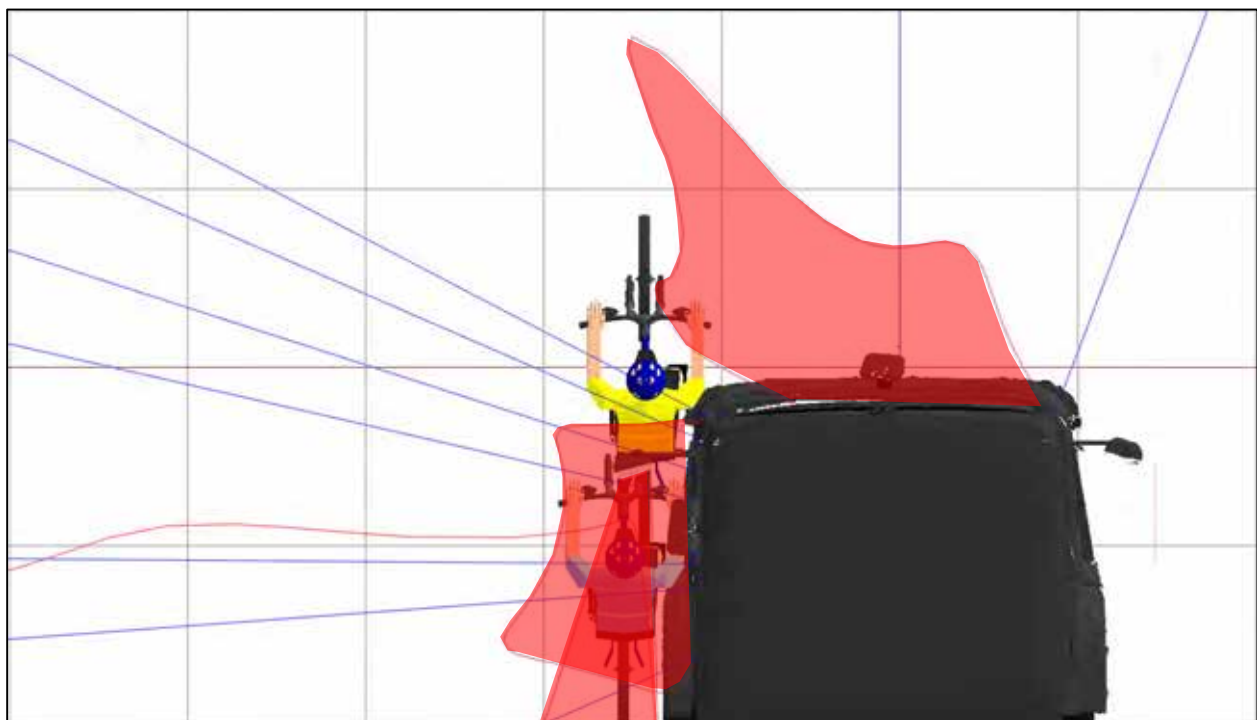


Figure 168. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

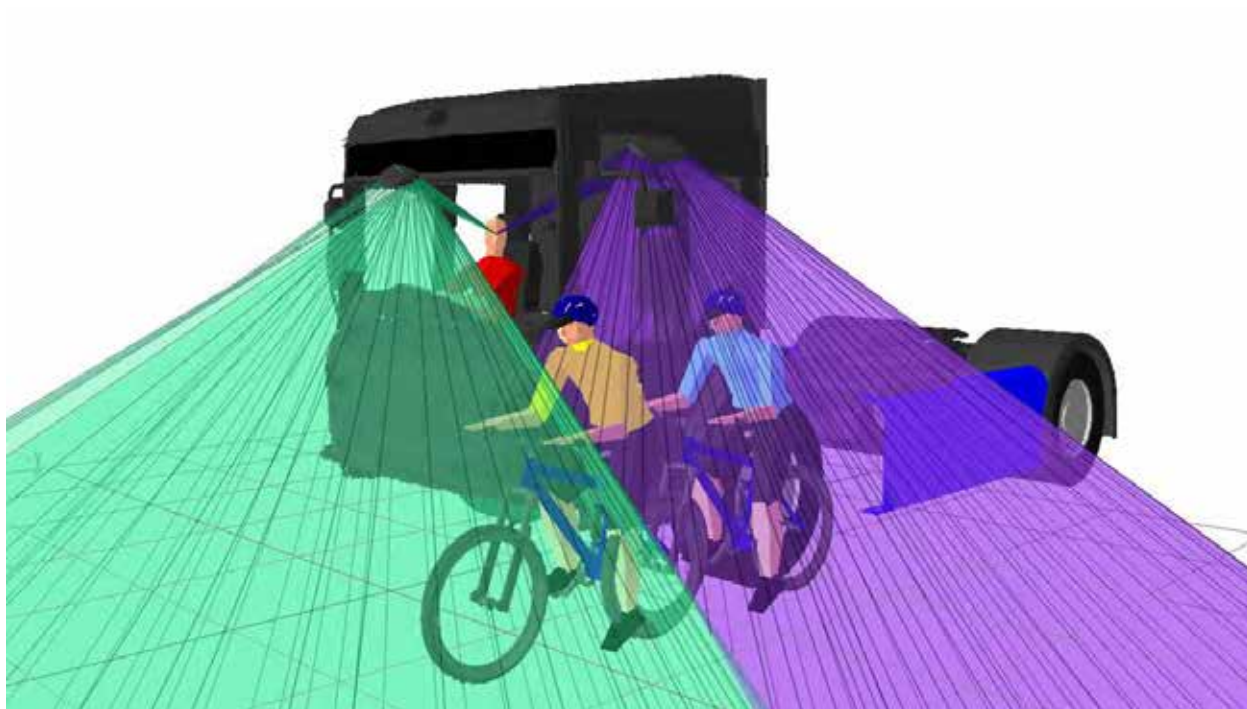


Figure 169. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

The two cyclists cannot be hidden from direct view to the nearside of the vehicle and as Figure 169 shows both are visible in the Class V and Class VI mirrors. The front (yellow) cyclist is partially visible in the Class VI mirror and the Class V mirror. Part of the rear (blue) cyclist's front wheel is visible in the Class VI and the cyclist is completely visible in the Class V mirror.

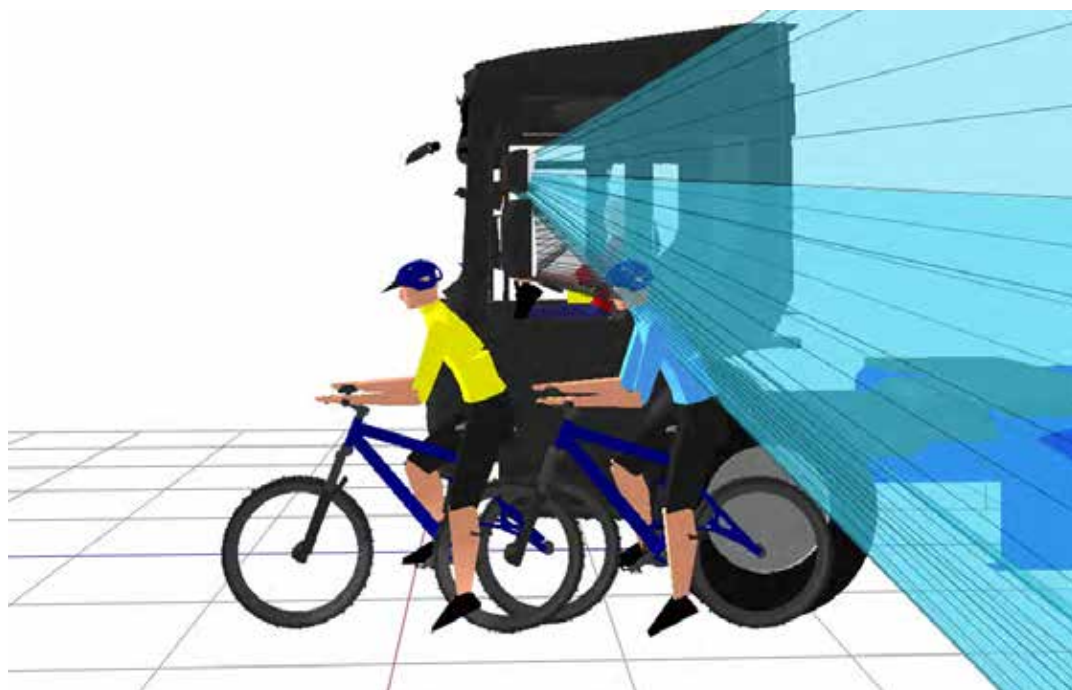


Figure 170. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is visible in the projection of the Class IV mirror

Figure 170 shows that the rear of the two cyclists (blue) is also visible in the projection of the nearside Class IV and Class II mirrors. The cyclist would only be partially visible including the head and back of the torso of the rider. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide a cyclist to the nearside of the Dennis Eagle Elite 6 for cyclist models as defined in the methodology section.

4.1.4.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

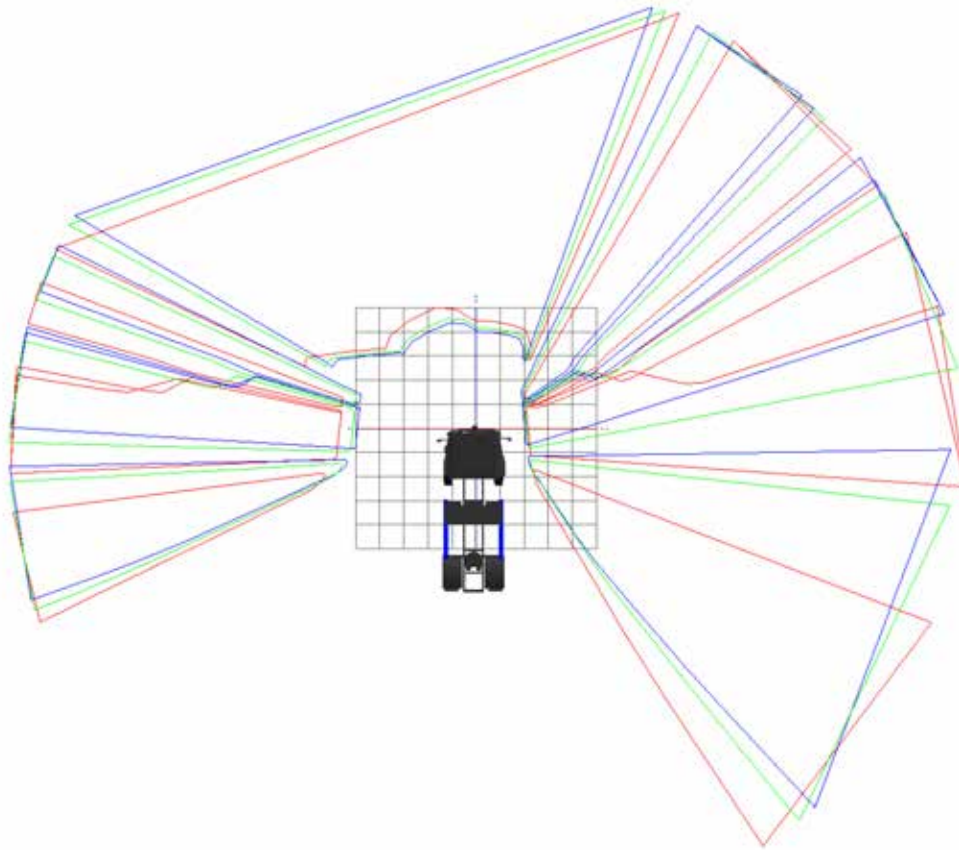


Figure 171. A plan view of the projection of the windscreen and side windows onto the ground plane for the Dennis Eagle Elite 6 for a range of driver eye positions. Red=smallest driver (5th %ile UK female stature), Green=average sized driver (50th %ile UK male stature), and Blue=tallest driver (95th %ile UK male stature).

4.1.5 MAN TGS N3 DISTRIBUTION - 50TH %ILE MALE DRIVER



Figure 172. Evaluation model of MAN TGS N3 Distribution variant vehicle

4.1.5.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 173 shows a top-down view of all of the window projections for the MAN TGS N3 cab with a 50th %ile UK Male Driver. The image on the right of Figure 173 shows the areas of these projections that intersect with the ground. Figure 174 shows the same for the the mirror projections and Figure 175 shows the two combined. Any area outside of the coloured projections is effectively a blind spot at the ground plane.

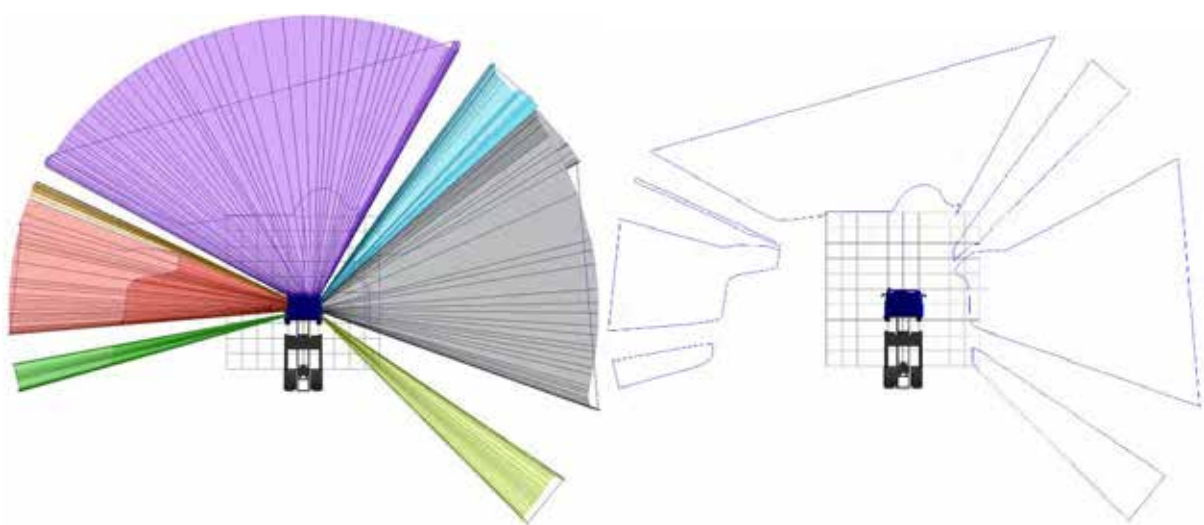


Figure 173. The projection of the windscreen and window apertures at the ground plane for the MAN TGS N3

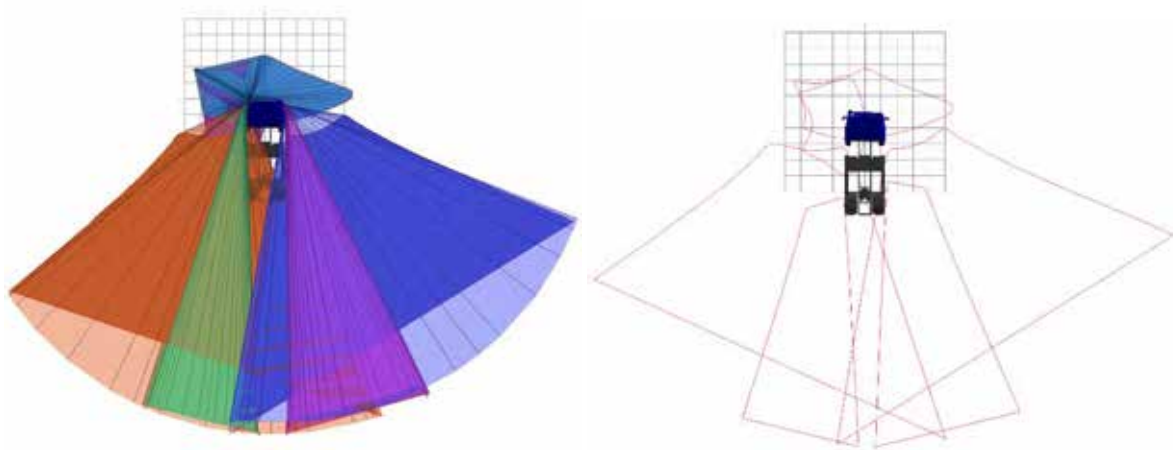


Figure 174. The projection of the mirrors at the ground plane for the MAN TGS N3

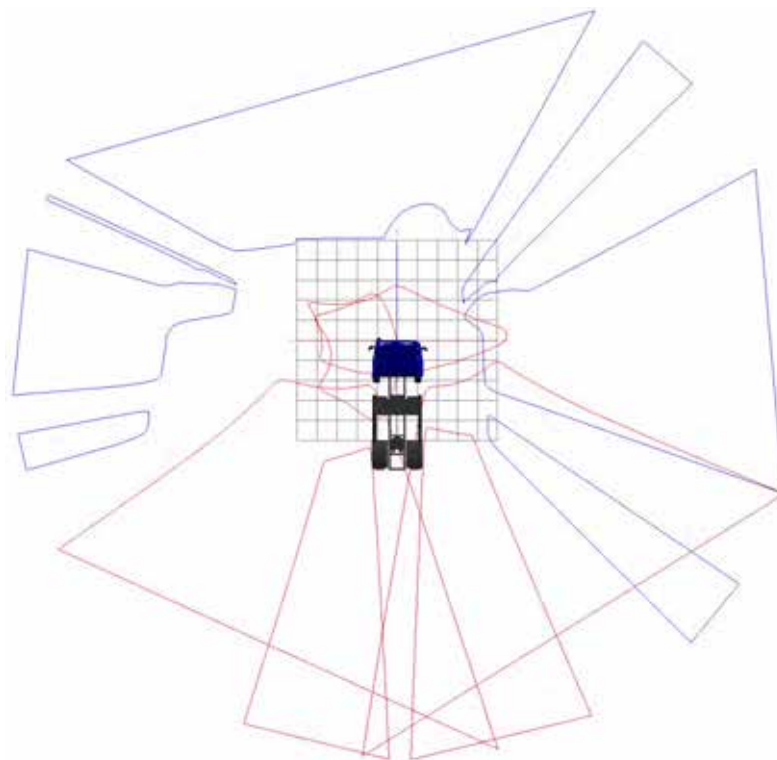


Figure 175. The combined direct and indirect vision projections at the ground plane for the MAN TGS N3

Figure 176 through Figure 180 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 181 and Figure 182 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

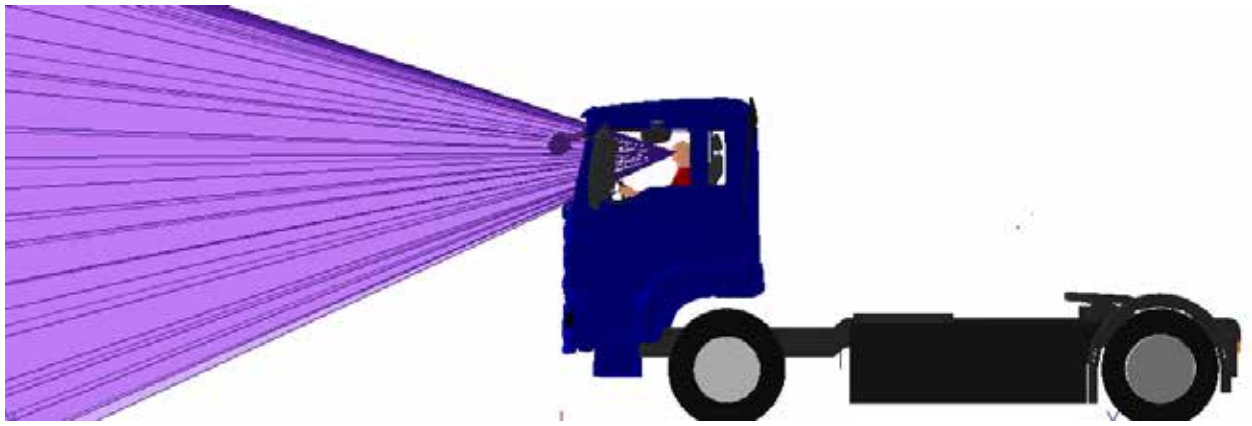


Figure 176. A side view of the windscreen aperture projection for the MAN TGS N3

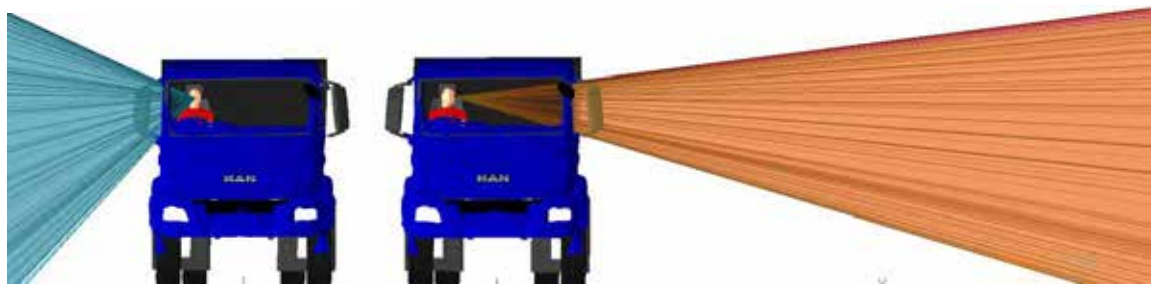


Figure 177. Frontal views of the off side and near side door window projections for the MAN TGS N3

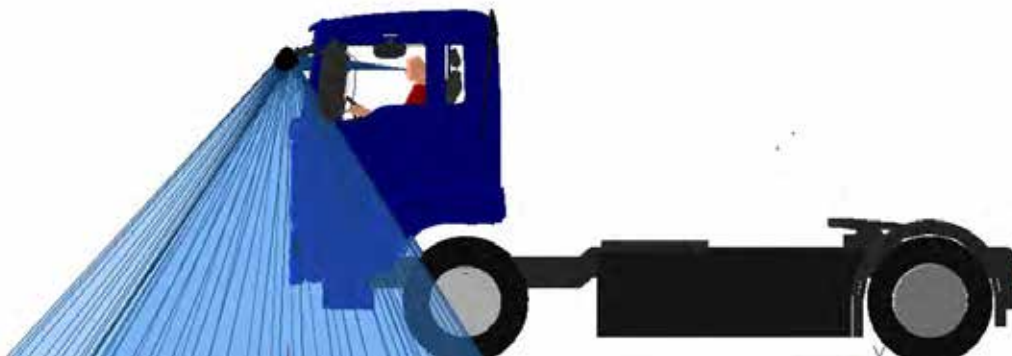


Figure 178. A side view of the Class VI mirror projection for the MAN TGS N3

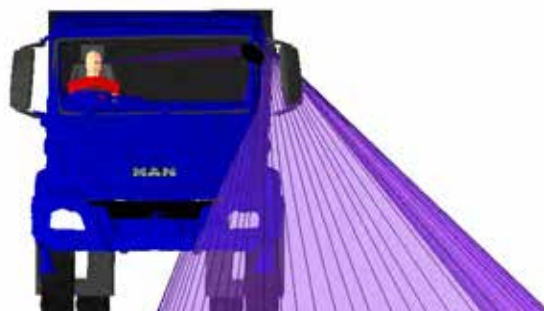


Figure 179. A front view of the Class V mirror projection for the MAN TGS N3

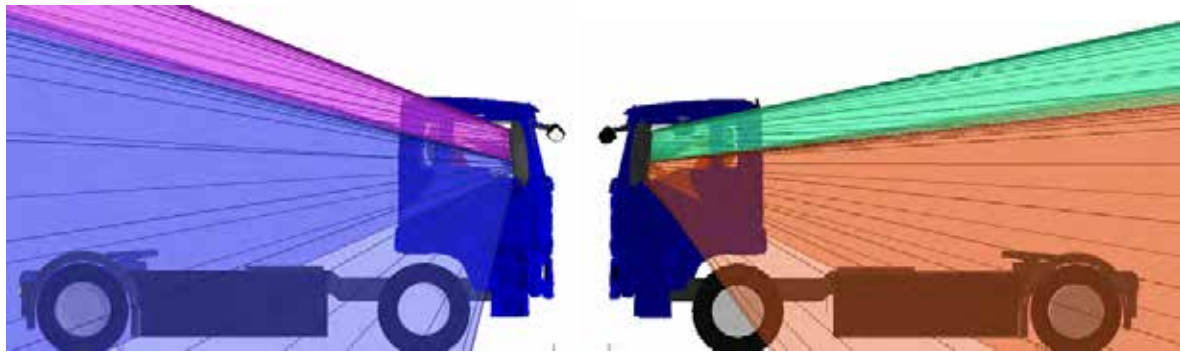


Figure 180. Side views of the combined Class II and Class IV mirror projections for the MAN TGS N3

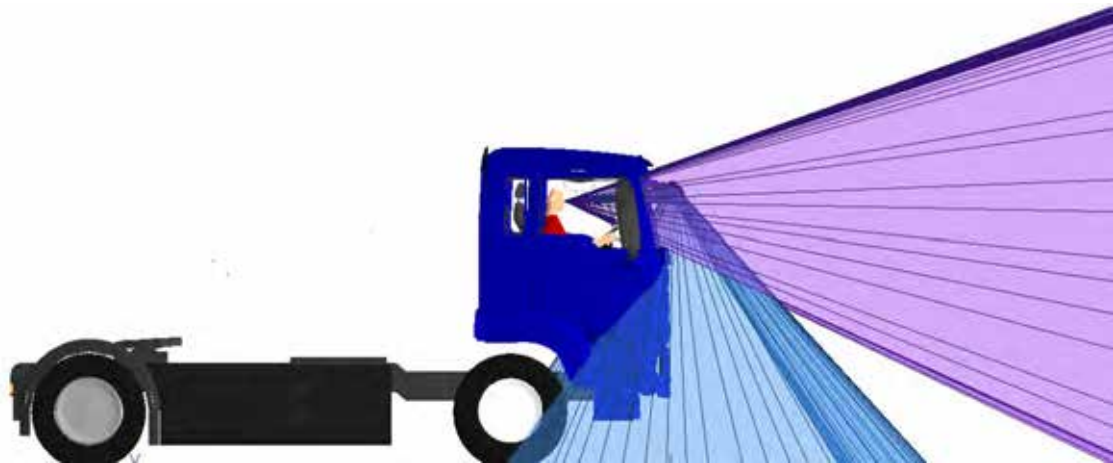


Figure 181. Combined projection of the windscreen and Class VI mirror to the front of the MAN TGS N3

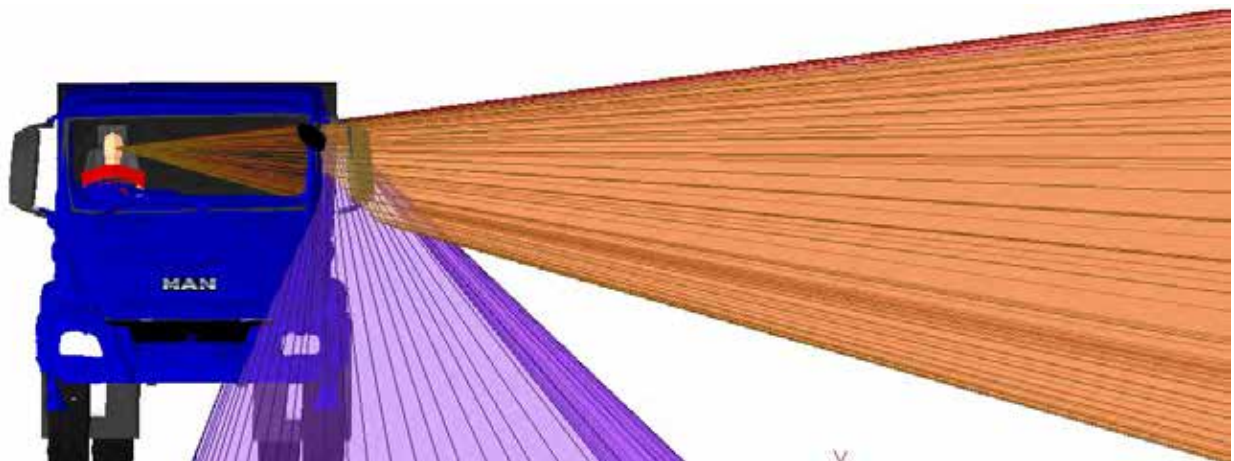


Figure 182. Combined projection of the near side windows and Class V mirror to the side of the MAN TGS N3

4.1.5.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 183 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

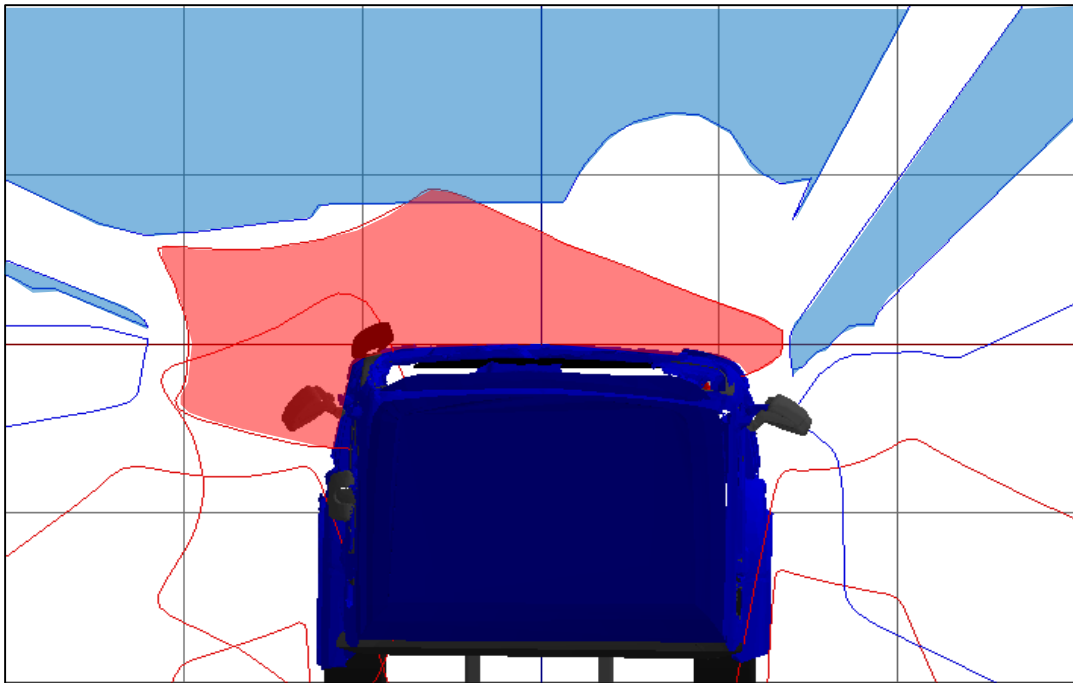


Figure 183. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 175. However Figure 184 and Figure 185 show that there is a clear space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.

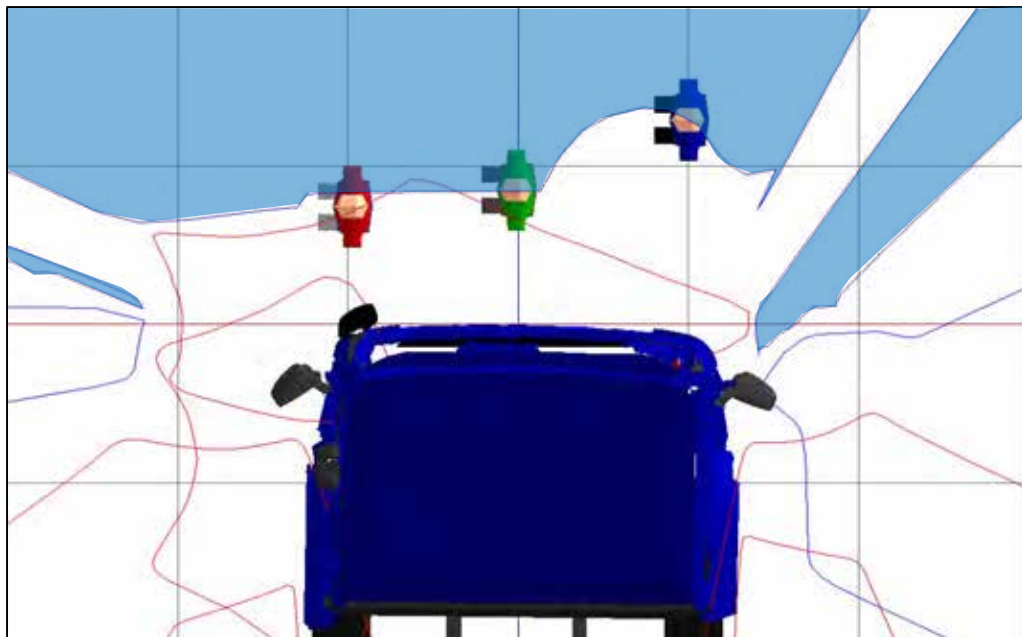


Figure 184. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian



Figure 185. 3D view showing that the three human models can stand 1122mm (blue), 613mm (green) and 546mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture

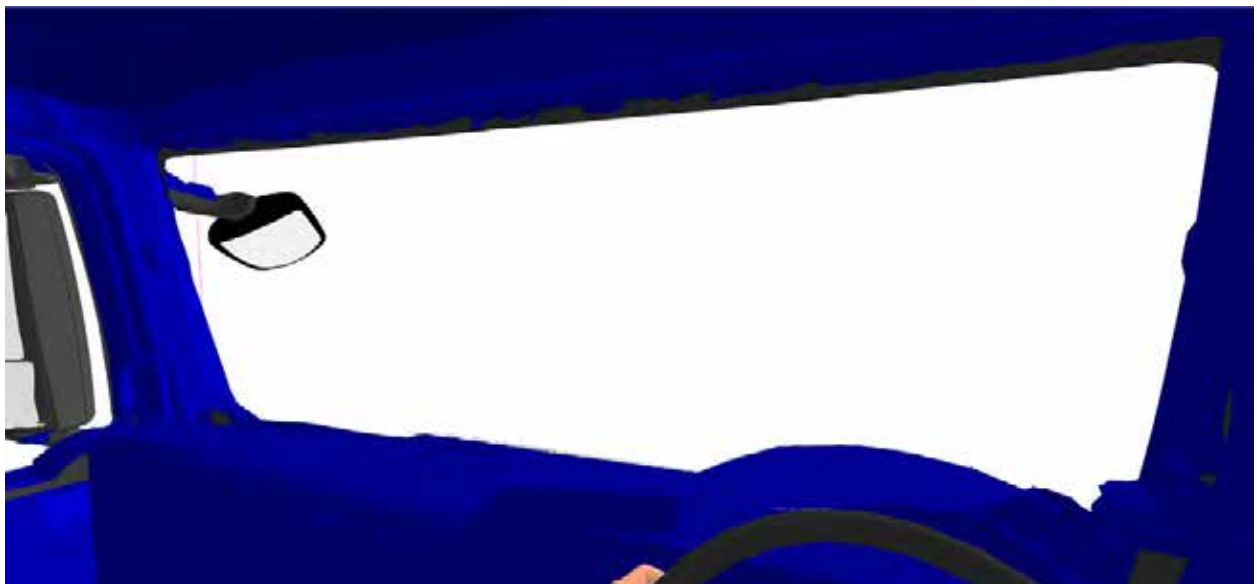


Figure 186. The view from the driver's eyes clearly shows the three pedestrians are hidden from view.

For forwards visibility of the pedestrians all three can be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 1122mm from the front of the vehicle, the left (red) pedestrian is positioned at 546mm from the front of the vehicle and the central (green) pedestrian is positioned at 613mm from the front of the vehicle. These figures represent a considerable distance between the pedestrians and the front of the vehicle in which pedestrians would presumably be comfortable to walk, with the potential of being unseen.

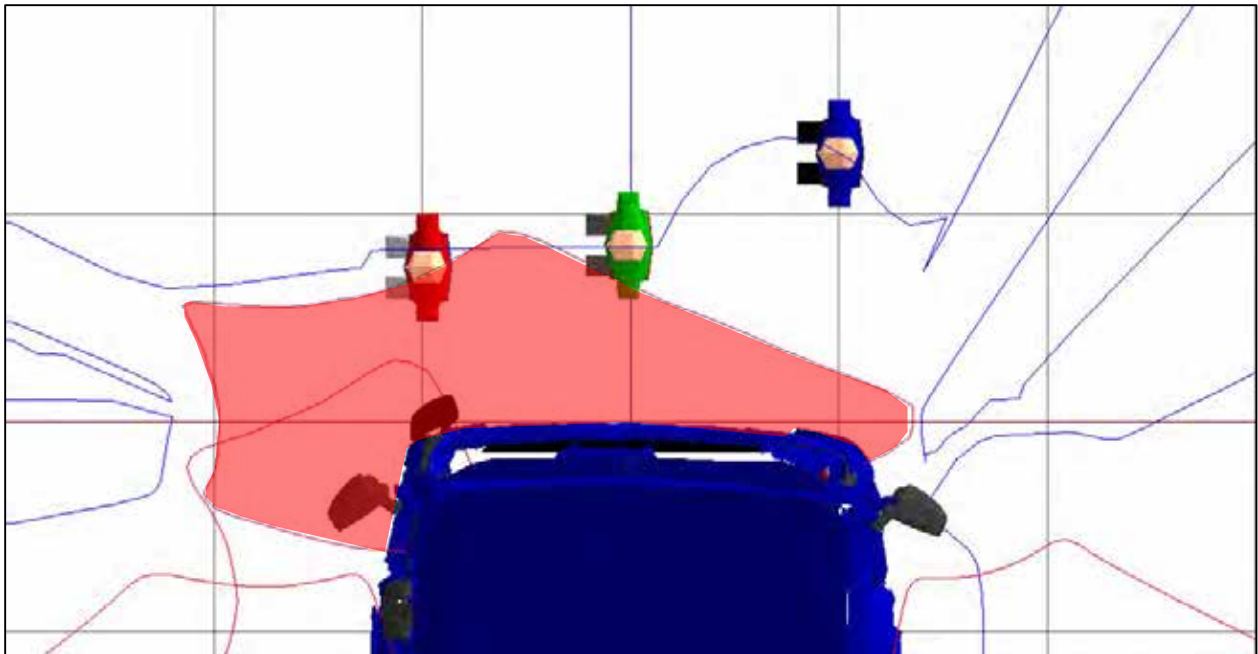


Figure 187. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian



Figure 188. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 188 shows that the pedestrian to the left (red) and centre (green) would be completely visible and the pedestrian to the right (blue) would be visible from the waist down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide the defined pedestrian models tested to the front of the MAN TGS N3.

4.1.5.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

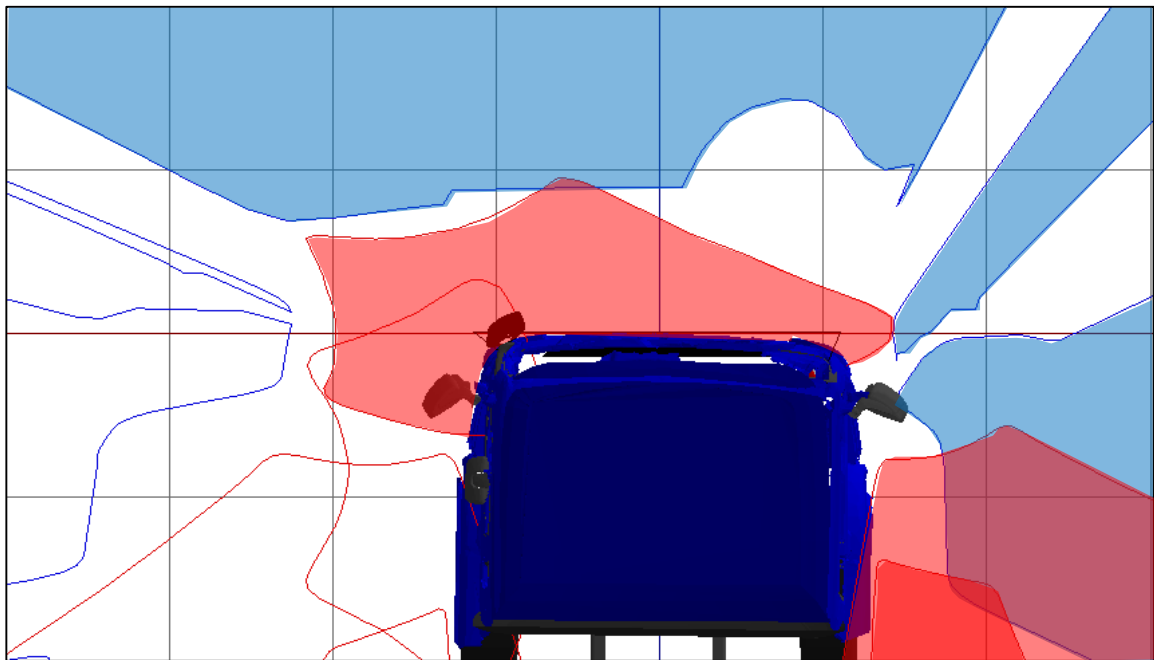


Figure 189. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 190 shows that a both cyclists can be obscured from the direct vision of the driver, with the front (yellow) cyclist being directly adjacent to the vehicle and the rear (blue) cyclist being 160mm from the side of the vehicle.

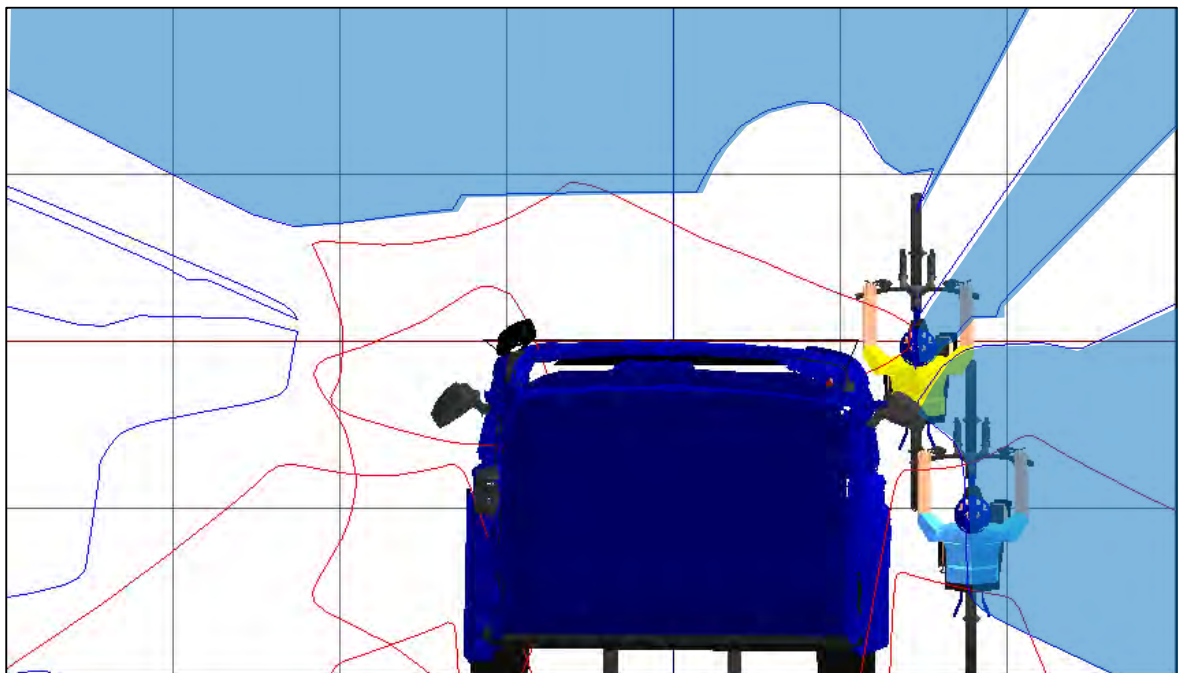


Figure 190. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist



Figure 191. 3D view showing that both cyclists can be hidden from direct vision to the offside of the MAN TGS N3

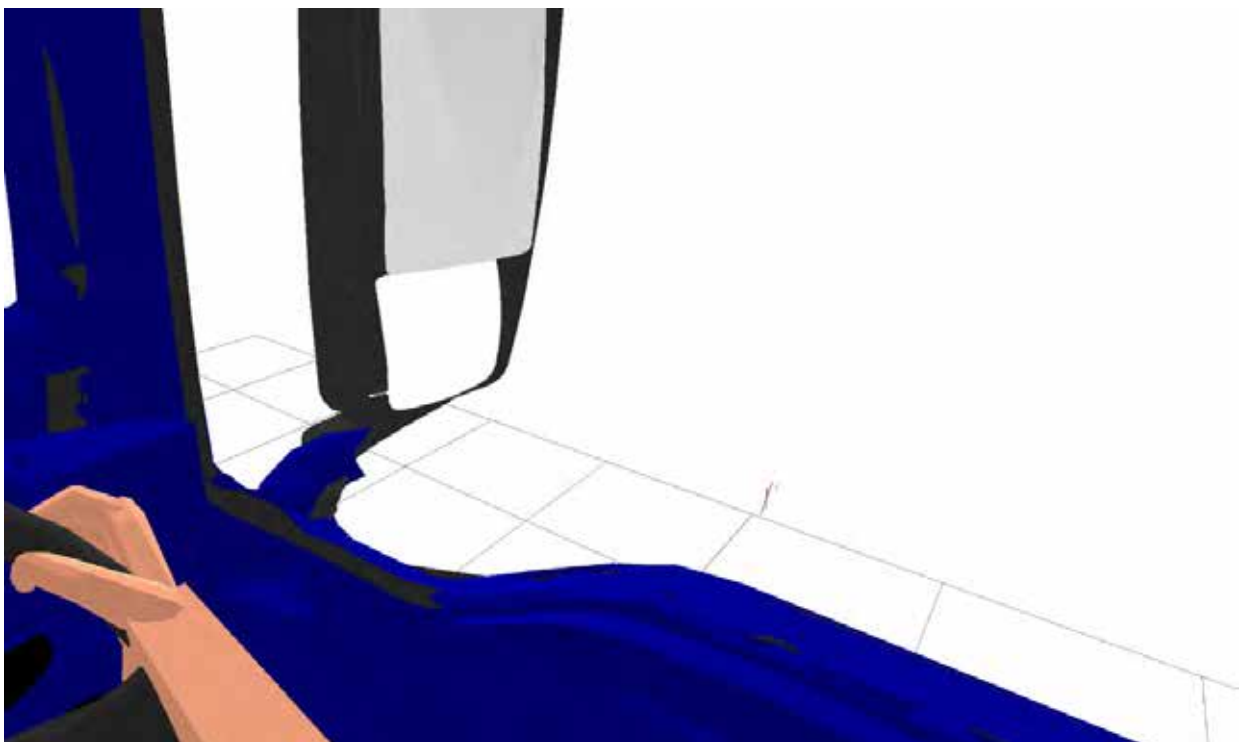


Figure 192. The view from the driver's eyes clearly shows the two cyclists are not visible, even when positioned against the side of the vehicle.

Figure 192 shows the view through the driver's eyes demonstrating that both cyclists can be obscured.

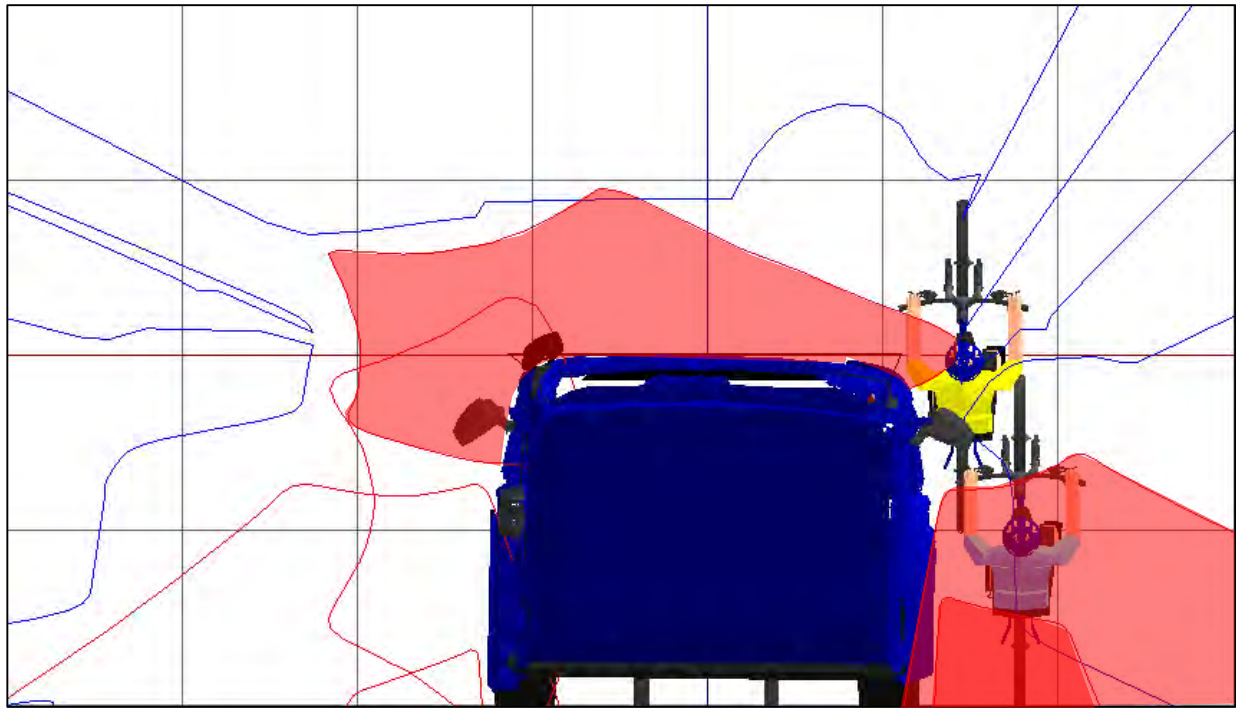


Figure 193. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

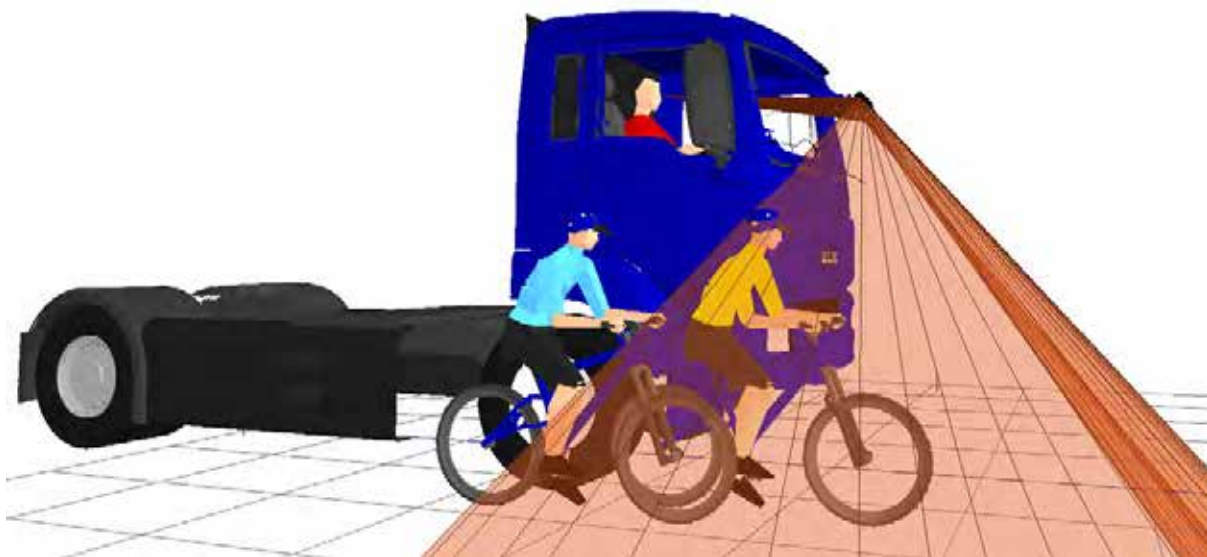


Figure 194. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

Despite being not visible in direct vision the cyclists are visible in the mirrors. Figure 194 shows that theoretically both cyclists are visible in the Class VI mirror. However, due to limitations of the projection technique, the rear cyclist (blue) would actually be hidden from view by the cab of the vehicle. However, part of the front (yellow) cyclist would be visible in the Class VI mirror including their arms and the front of the bicycle.

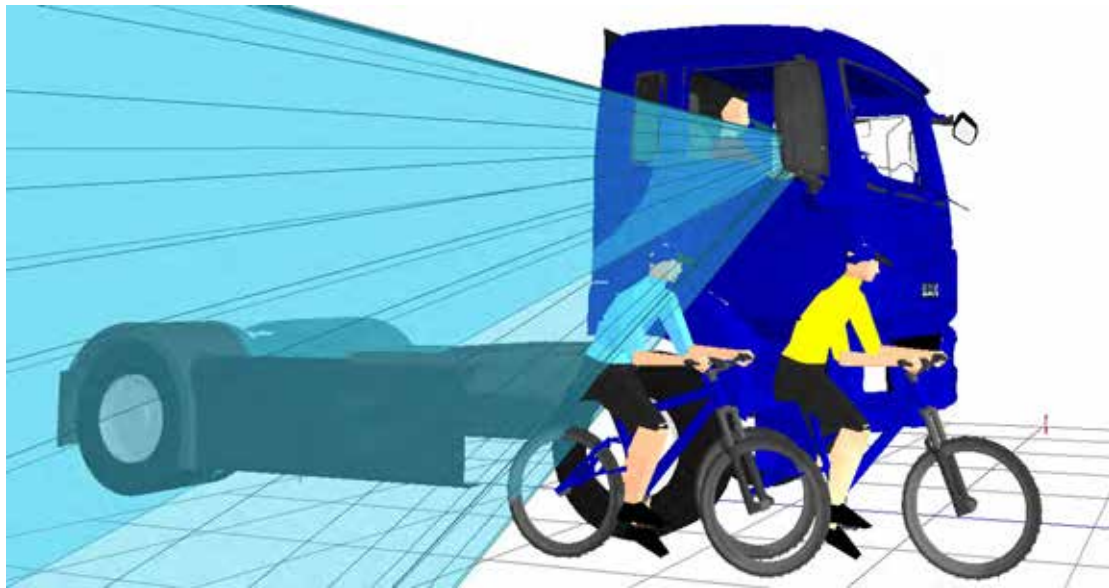


Figure 195. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 195 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and upper body. The projections show that for a driver using their mirrors, it is not possible to hide a cyclist as defined to the offside of the MAN TGS N3.

4.1.5.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

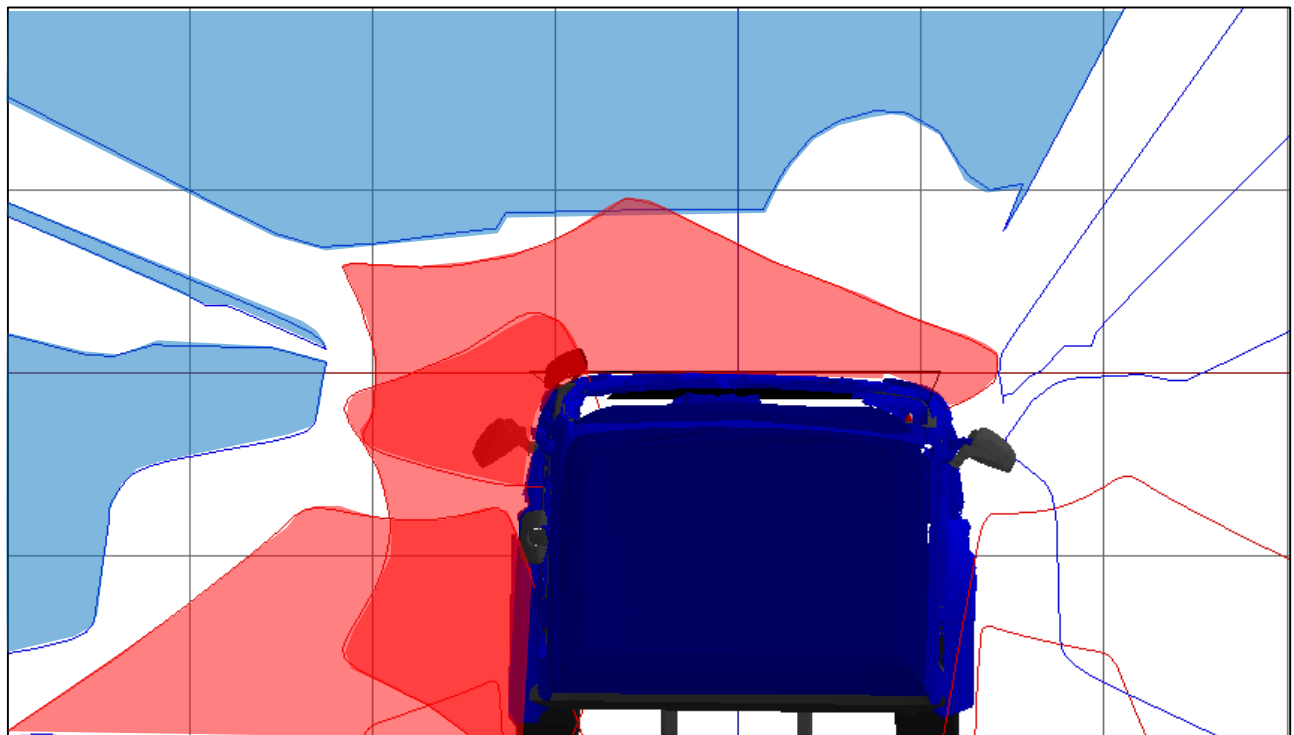


Figure 196. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 197 and Figure 198 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

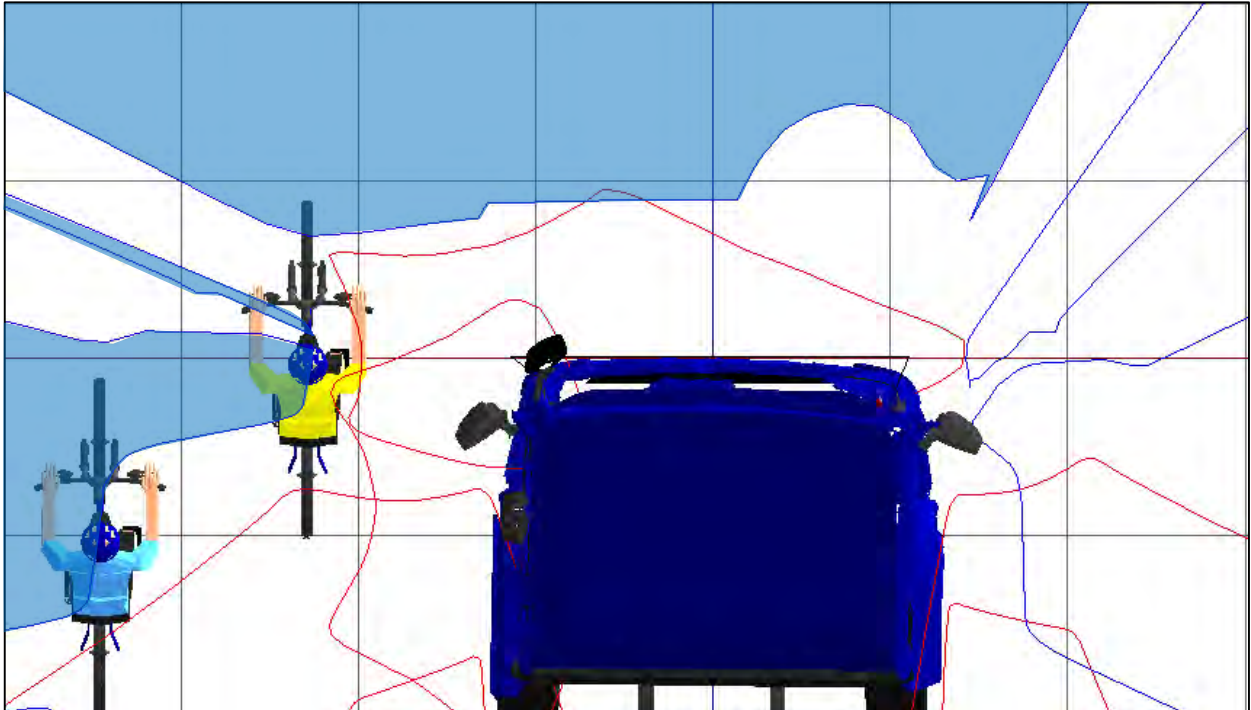


Figure 197. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

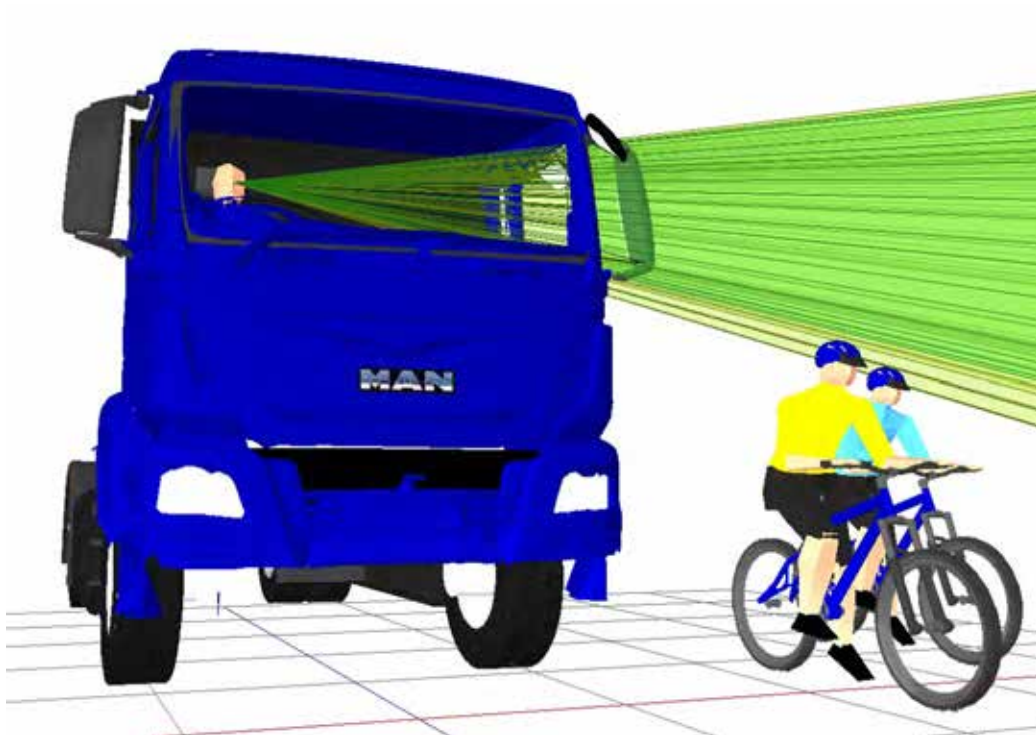


Figure 198. 3D view showing that the two human models can be positioned 760mm (yellow) and 1951mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture

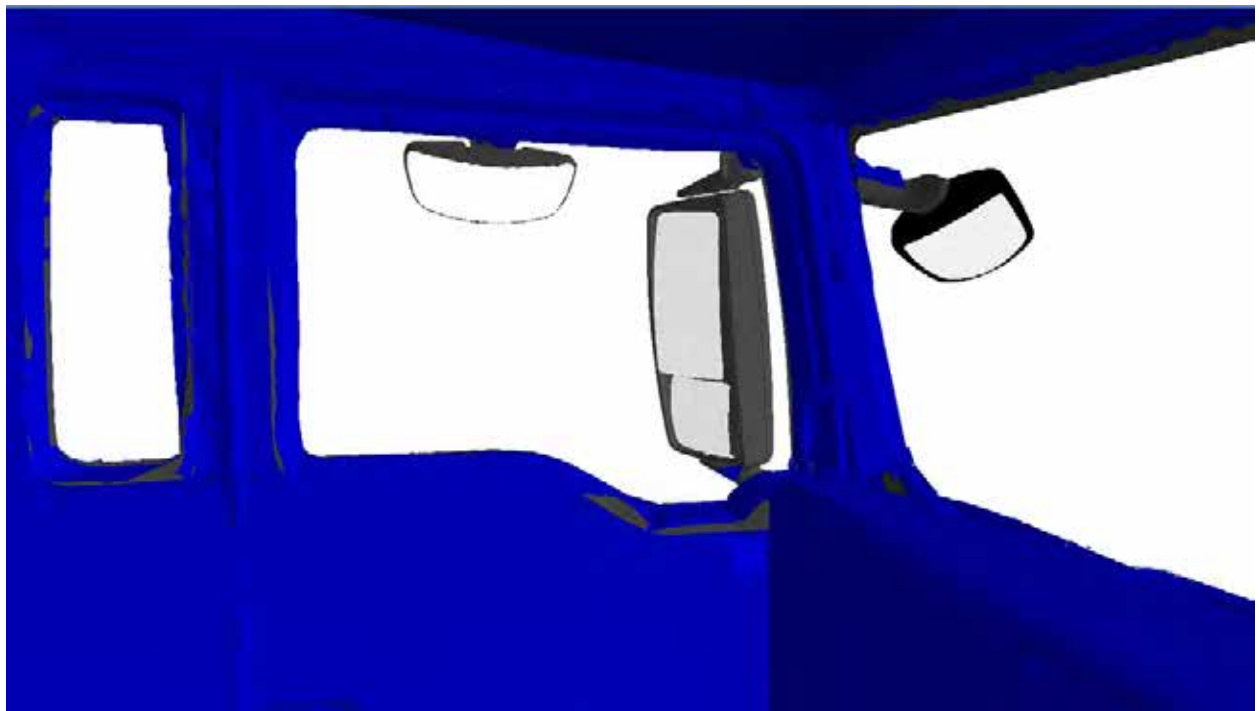


Figure 199. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 760mm from the side of the vehicle, the rear (blue) cyclist is positioned at 1951mm from the side of the vehicle.

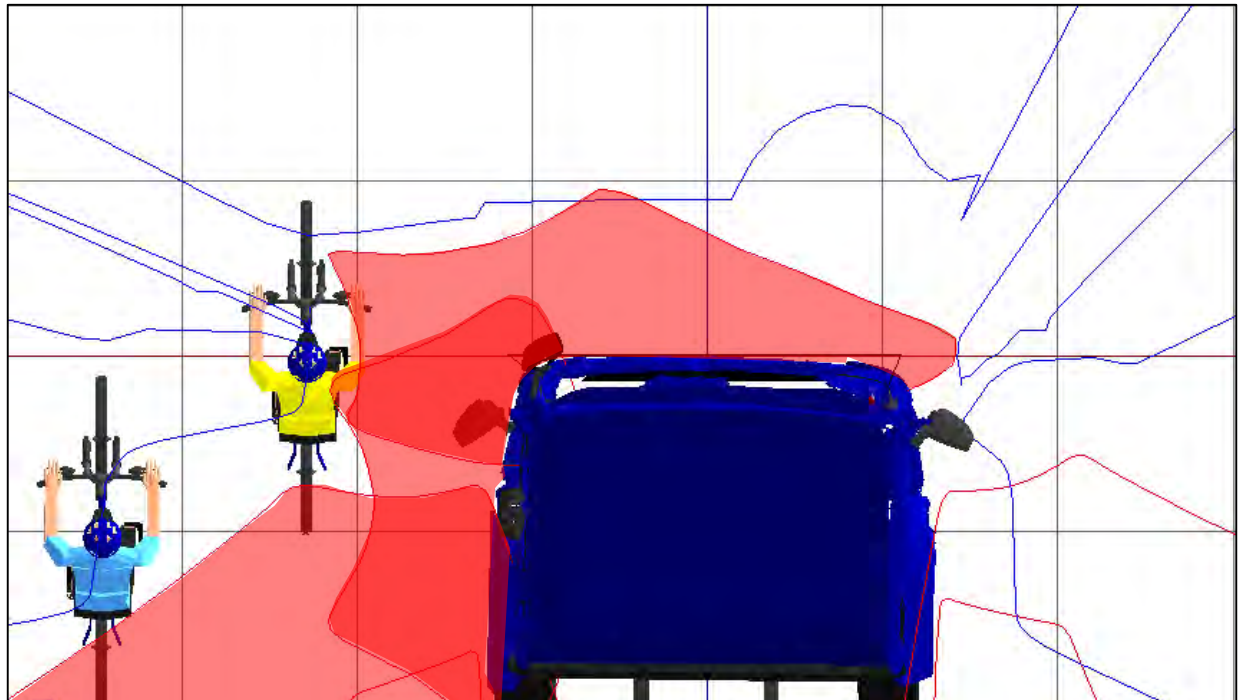


Figure 200. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

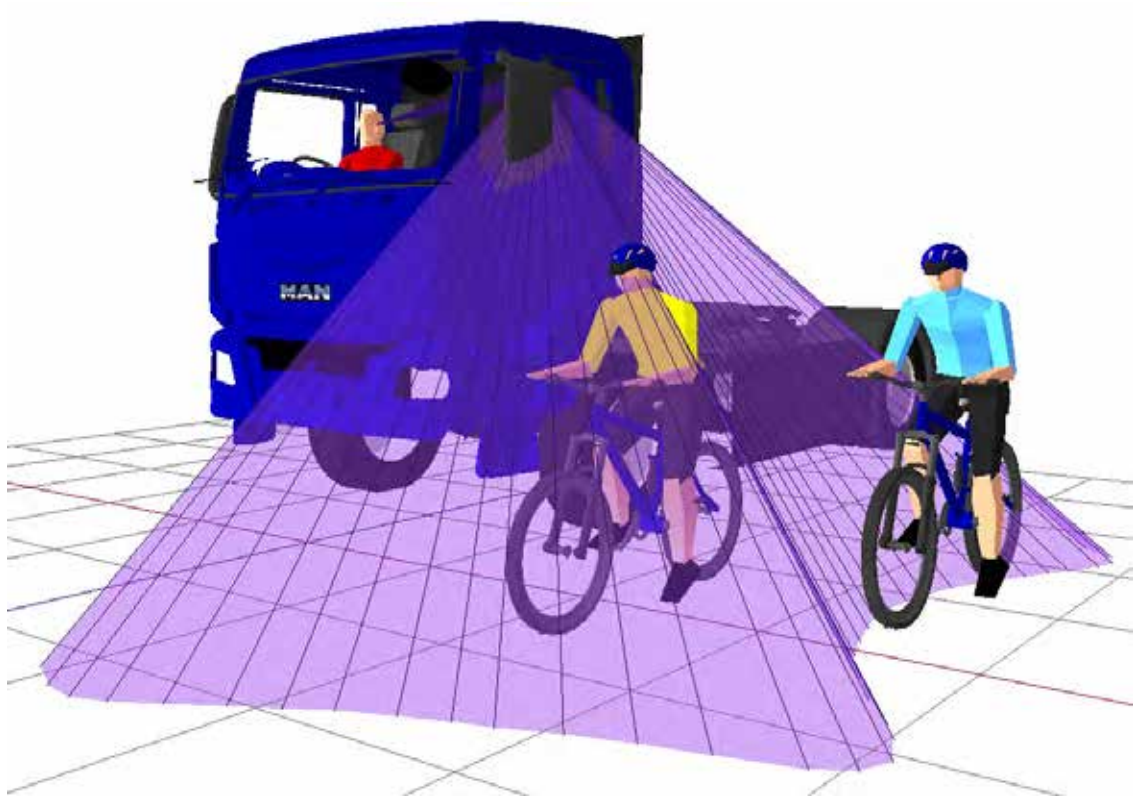


Figure 201. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 201 shows that both are visible in the Class V mirrors. The front (yellow) cyclist is completely visible in the Class VI mirror and all bar their head in the Class V mirror. The rear (blue) cyclist's rear wheel is partially visible in the class V mirror. This would appear as a distorted bicycle wheel in the bottom left corner of the Class V mirror.



Figure 202. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is visible in the projection of the Class IV mirror

Figure 202 shows that the rear of the two cyclists (blue) is also visible in the projection of the nearside Class IV mirror. The cyclist would only be partially visible including the torso of the rider and the rear wheel of the cycle, at the edge of the mirror. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide a cyclist as defined to the nearside of the MAN TGS N3.

4.1.5.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

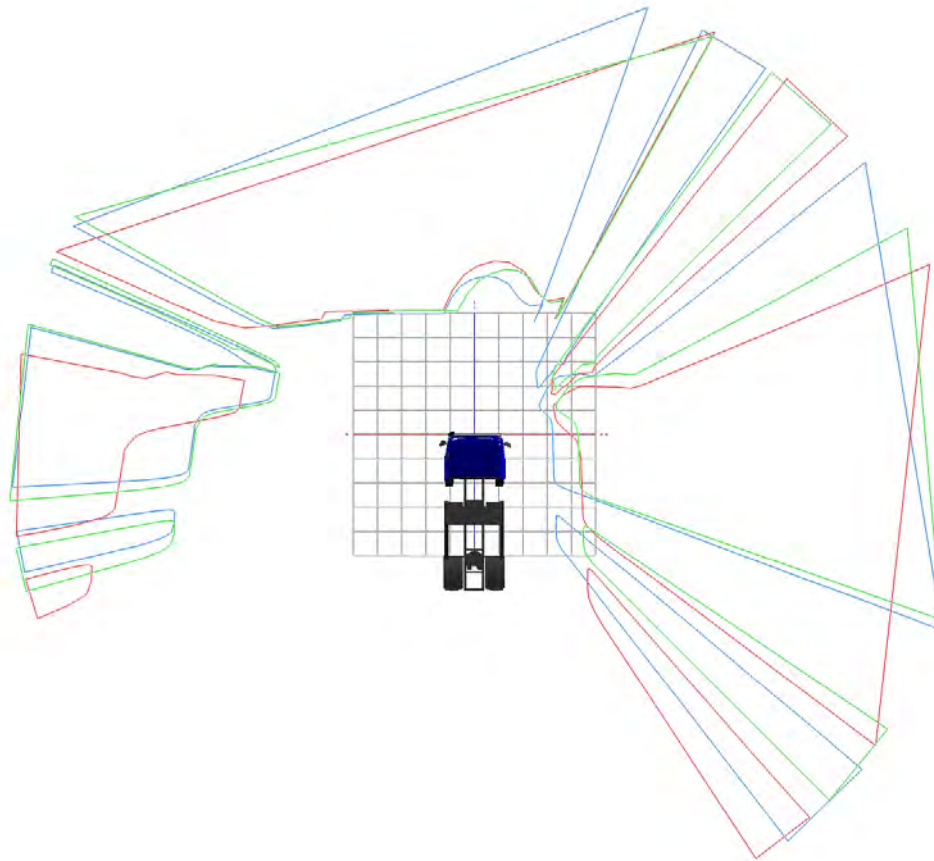


Figure 203. A plan view of the projection of the windscreen and side windows onto the ground plane for the MAN TGS N3 for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.1.6 MAN TGS N3G CONSTRUCTION - 50TH %ILE MALE DRIVER



Figure 204. Evaluation model of MAN TGS N3G variant vehicle

4.1.6.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 205 shows a top-down view of all of the window projections for the MAN TGS N3G cab with a 50th %ile UK Male Driver. The image on the right of Figure 205 shows the areas of these projections that intersect with the ground. Figure 206 shows the same for the the mirror projections and Figure 207 shows the two combined. Any area outside of the coloured projections is effectively a blind spot at the ground plane.

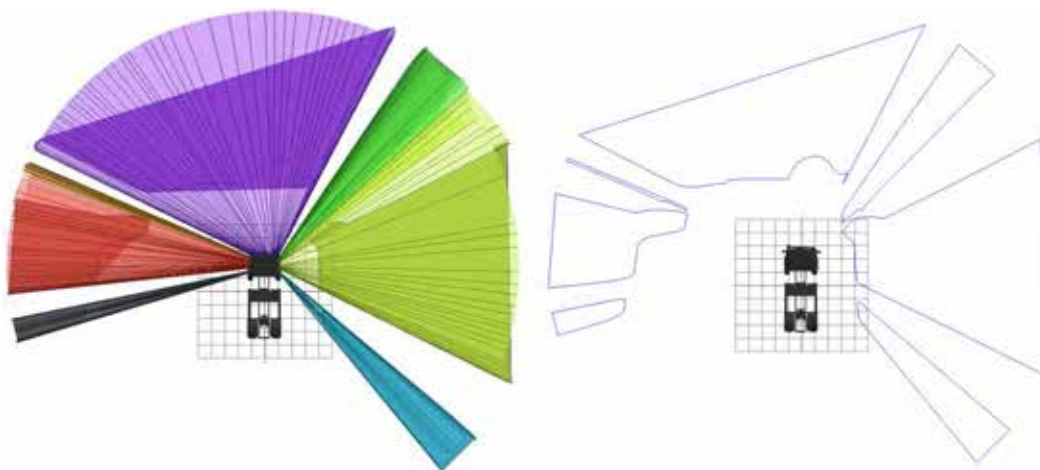


Figure 205. The projection of the windscreen and window apertures at the ground plane for the MAN TGS N3G

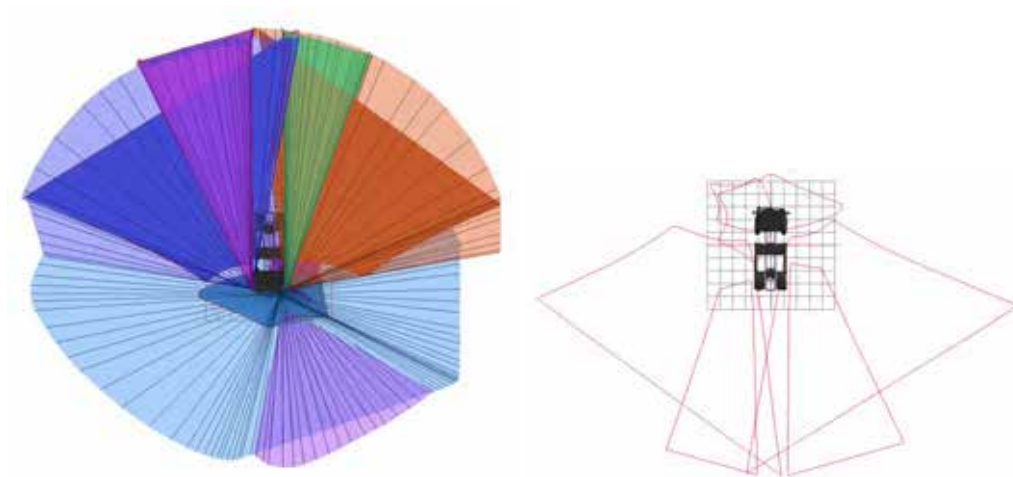


Figure 206. The projection of the mirrors at the ground plane for the MAN TGS N3G

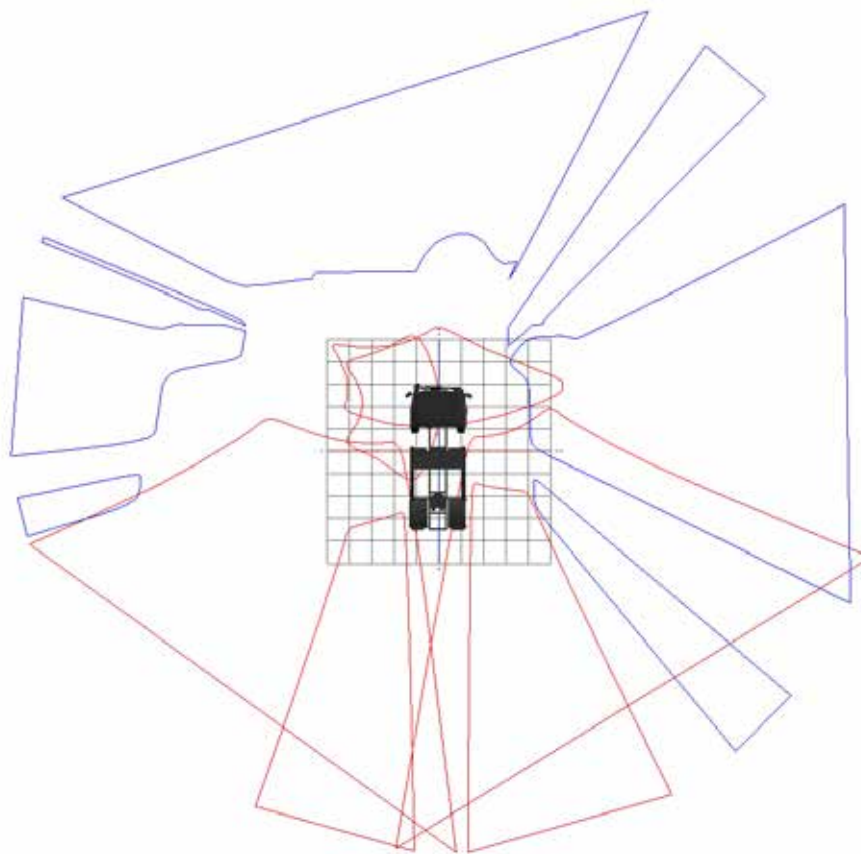


Figure 207. The combined direct and indirect vision projections at the ground plane for the MAN TGS N3G

Figure 208 through Figure 212 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 213 and Figure 214 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

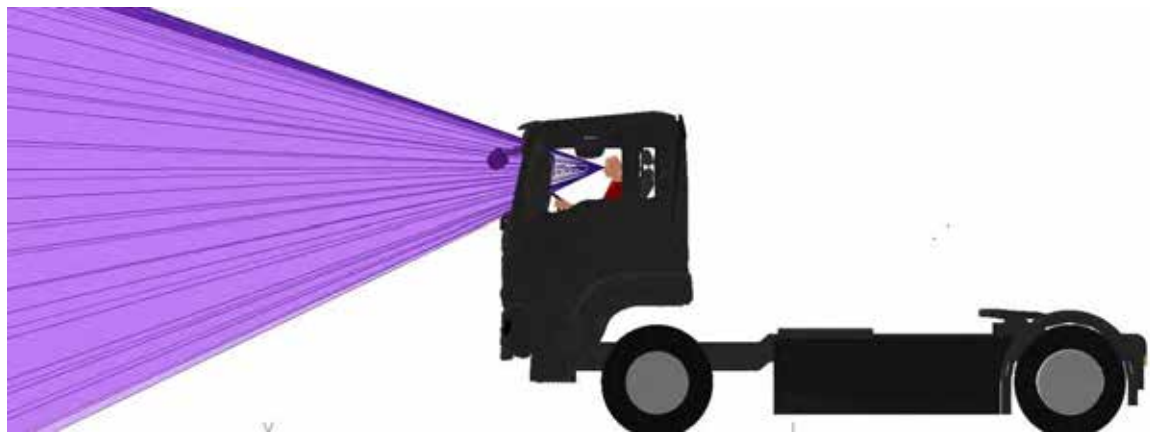


Figure 208. A side view of the windscreen aperture projection for the MAN TGS N3G

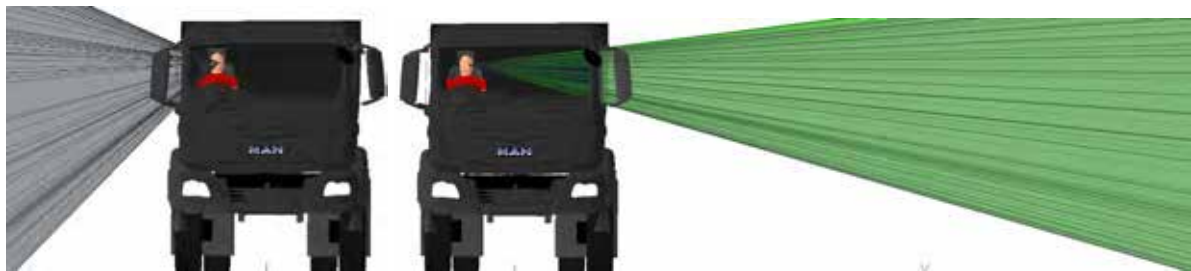


Figure 209. Frontal views of the off side and near side door window projections for the MAN TGS N3G



Figure 210. A side view of the Class VI mirror projection for the MAN TGS N3G

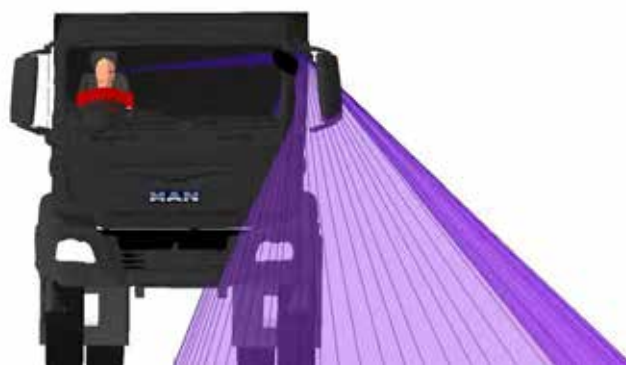


Figure 211. A front view of the Class V mirror projection for the MAN TGS N3G



Figure 212. Side views of the combined Class II and Class IV mirror projections for the MAN TGS N3G

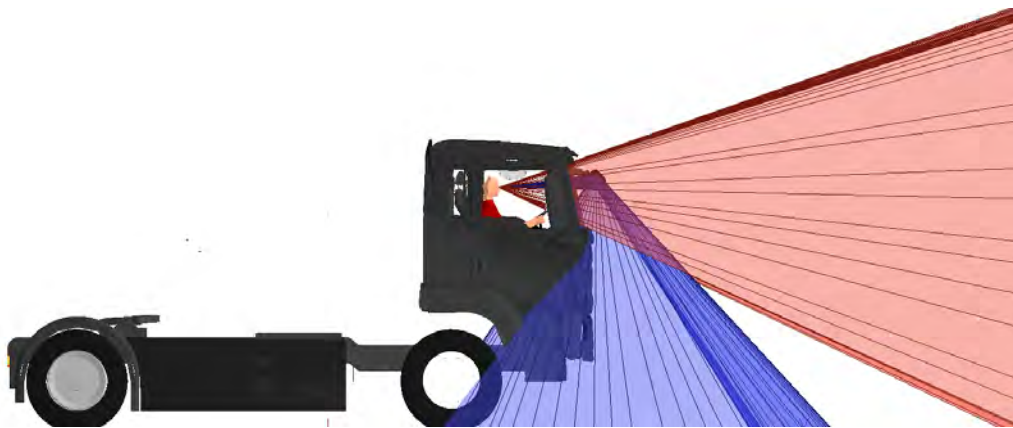


Figure 213. Combined projection of the windscreen and Class VI mirror to the front of the MAN TGS N3G

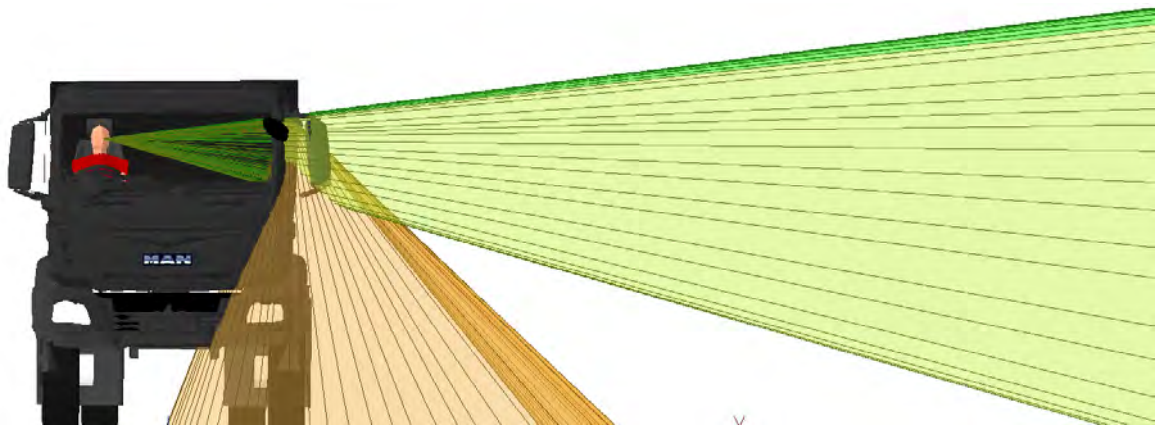


Figure 214. Combined projection of the near side windows and Class V mirror to the side of the MAN TGS N3G

4.1.6.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 215 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

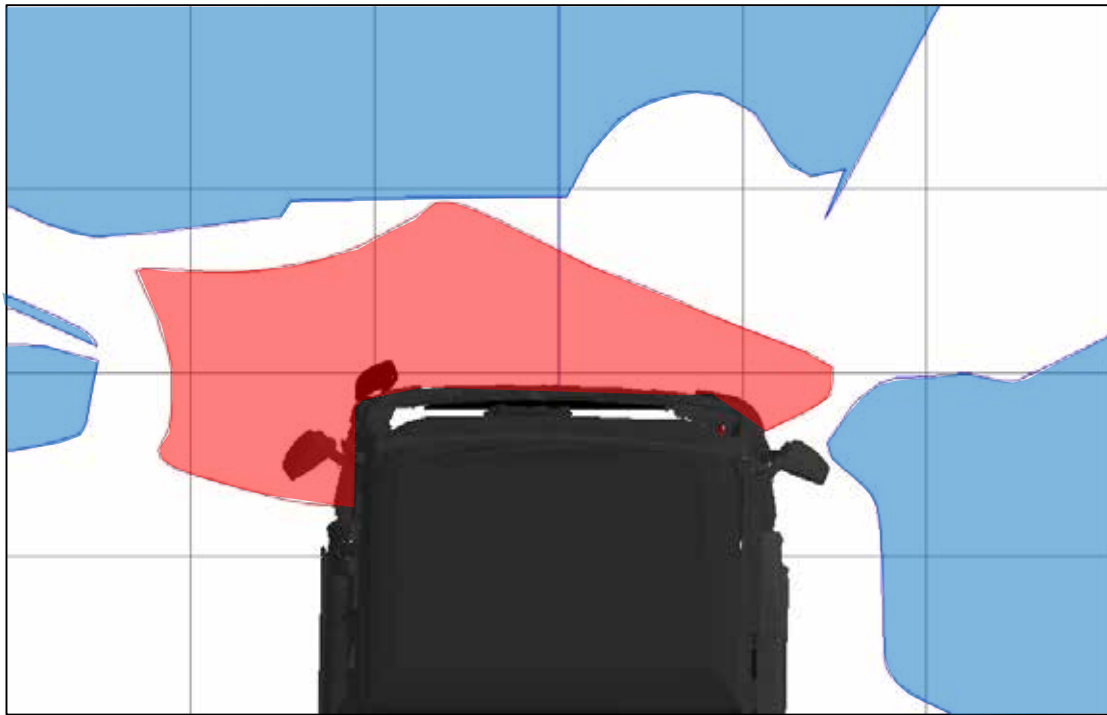


Figure 215. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 207. However Figure 216 and Figure 217 show that there is a clear space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.

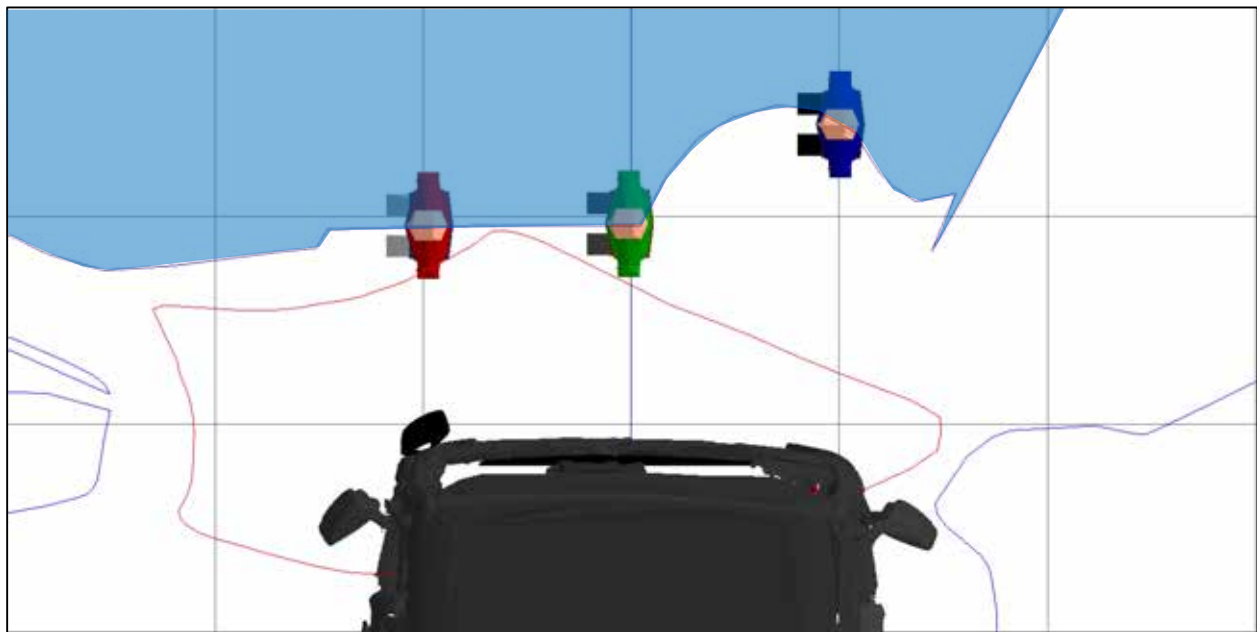


Figure 216. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

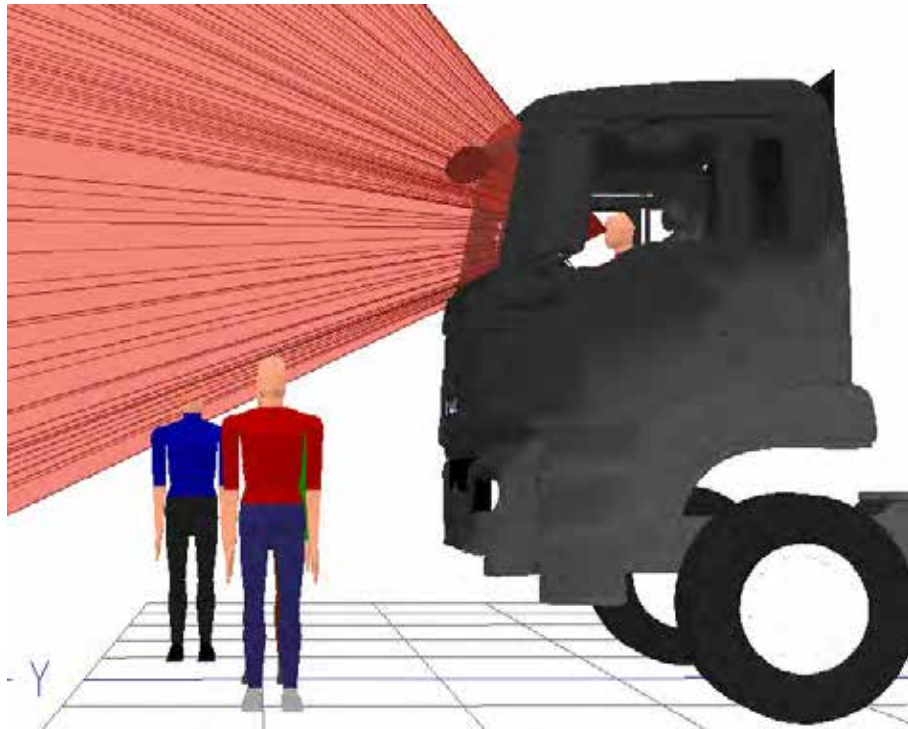


Figure 217. 3D view showing that the three human models can stand 1296mm (blue), 789mm (green) and 786mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 218. The view from the driver's eyes clearly shows the three pedestrians are hidden from view.

For forwards visibility of the pedestrians all three can be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 1296mm from the front of the vehicle, the left (red) pedestrian is positioned at 786mm from the front of the vehicle and the central (green) pedestrian is positioned at 789mm from the front of the vehicle.

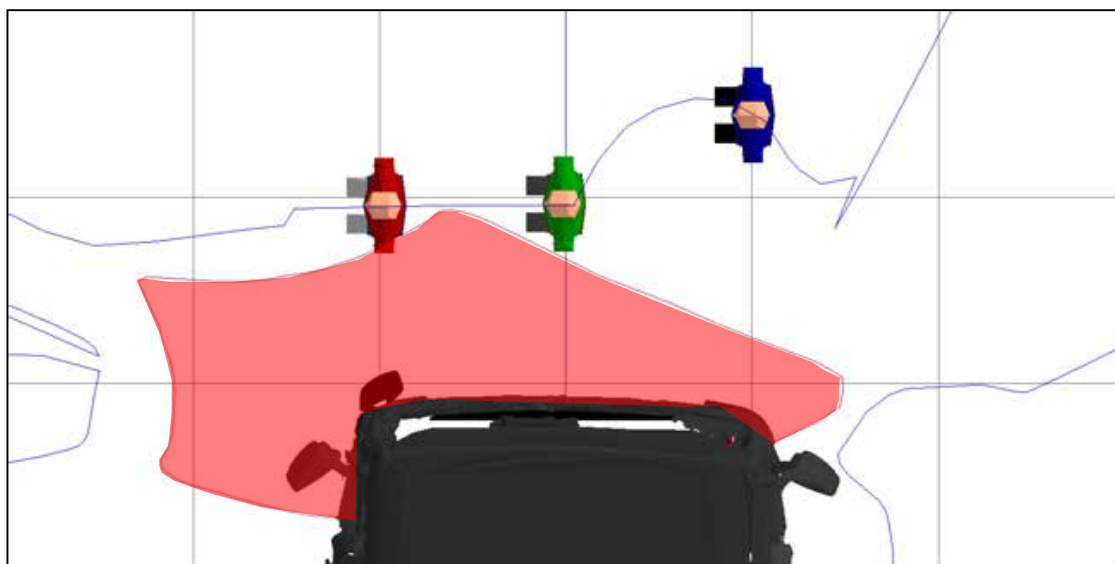


Figure 219. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

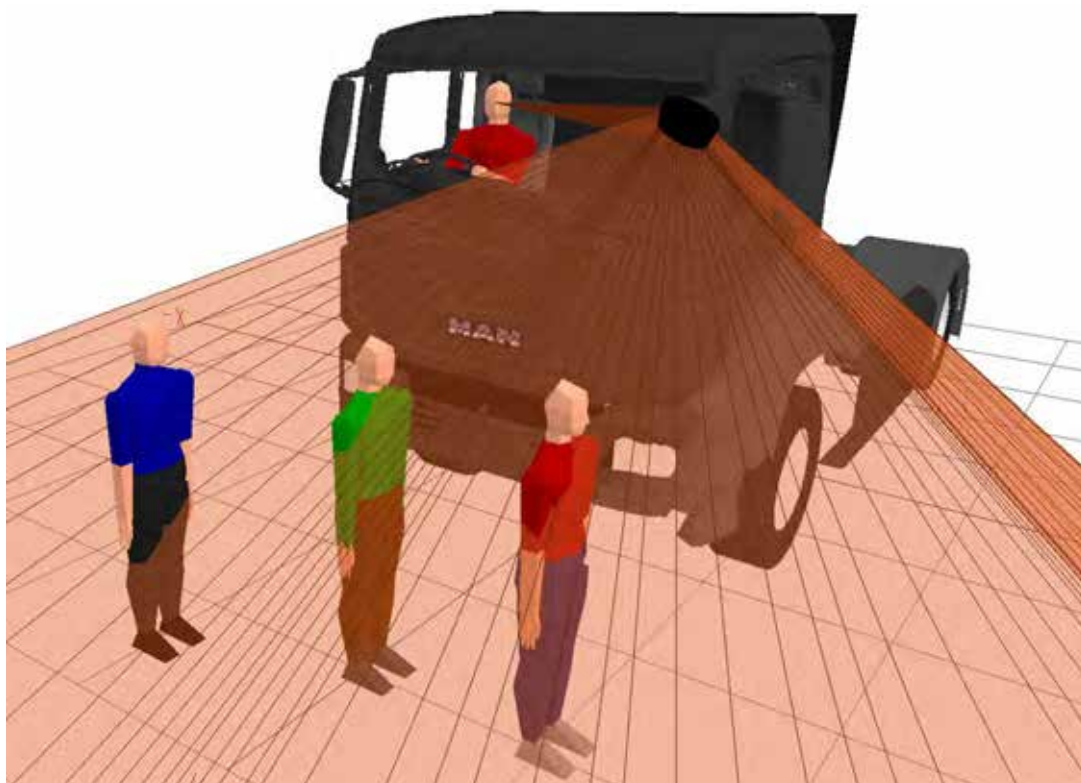


Figure 220. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 220 shows that the pedestrian to the left (red) and centre (green) would be visible from the shoulder down, and the pedestrian to the right (blue) would be visible from the waist down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide the pedestrian models that have been tested to the front of the MAN TGS N3G.

4.1.6.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

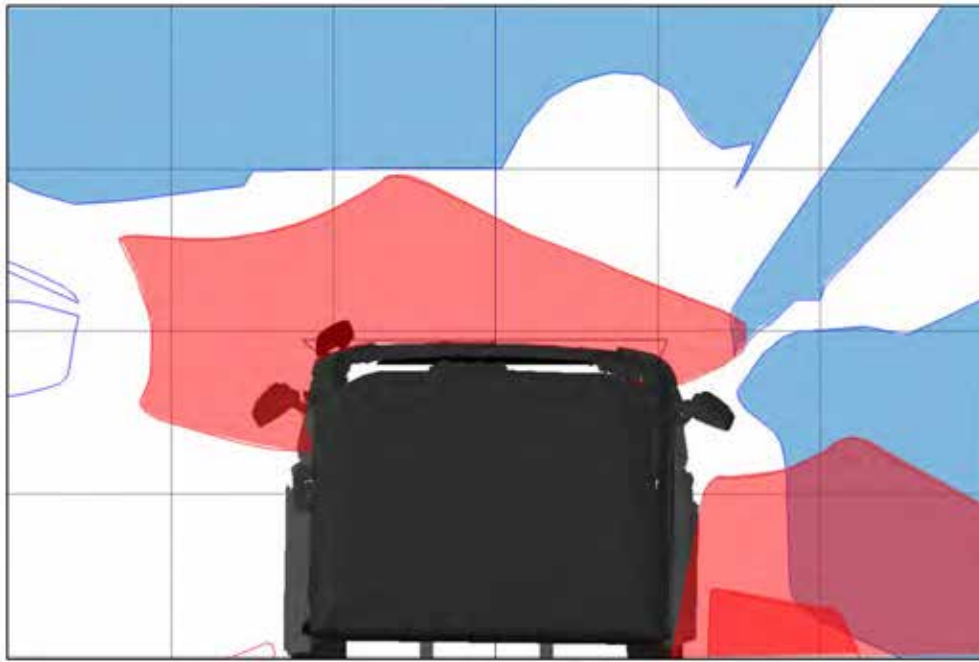


Figure 221. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 222 shows that a both cyclists can be obscured from the direct vision of the driver, with the front (yellow) cyclist being directly adjacent to the vehicle and the rear (blue) cyclist being 240mm from the side of the vehicle.

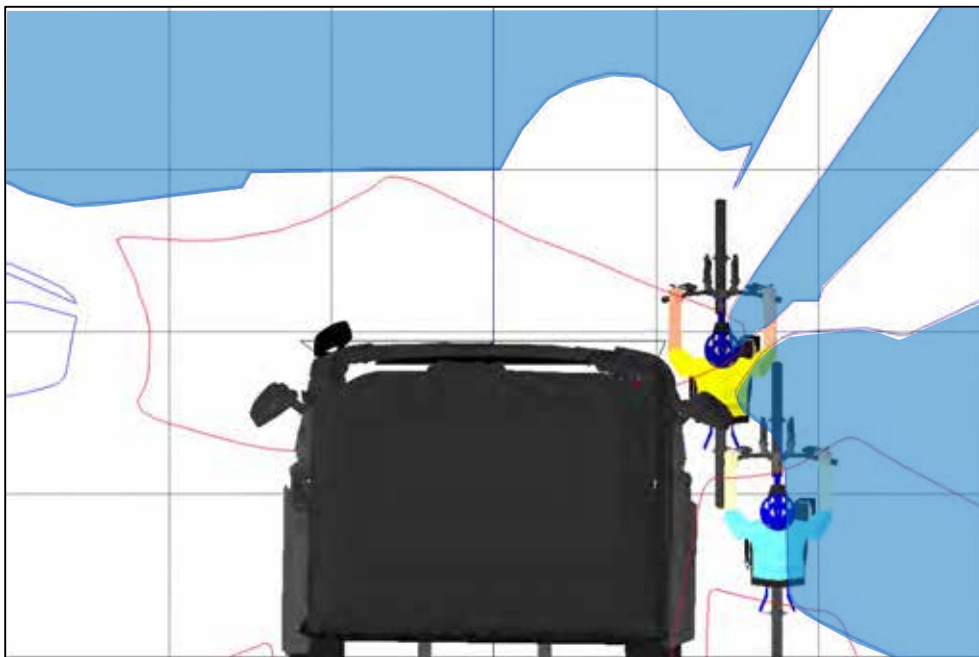


Figure 222. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist



Figure 223. 3D view showing that both cyclists can be hidden from direct vision to the offside of the MAN TGS N3G

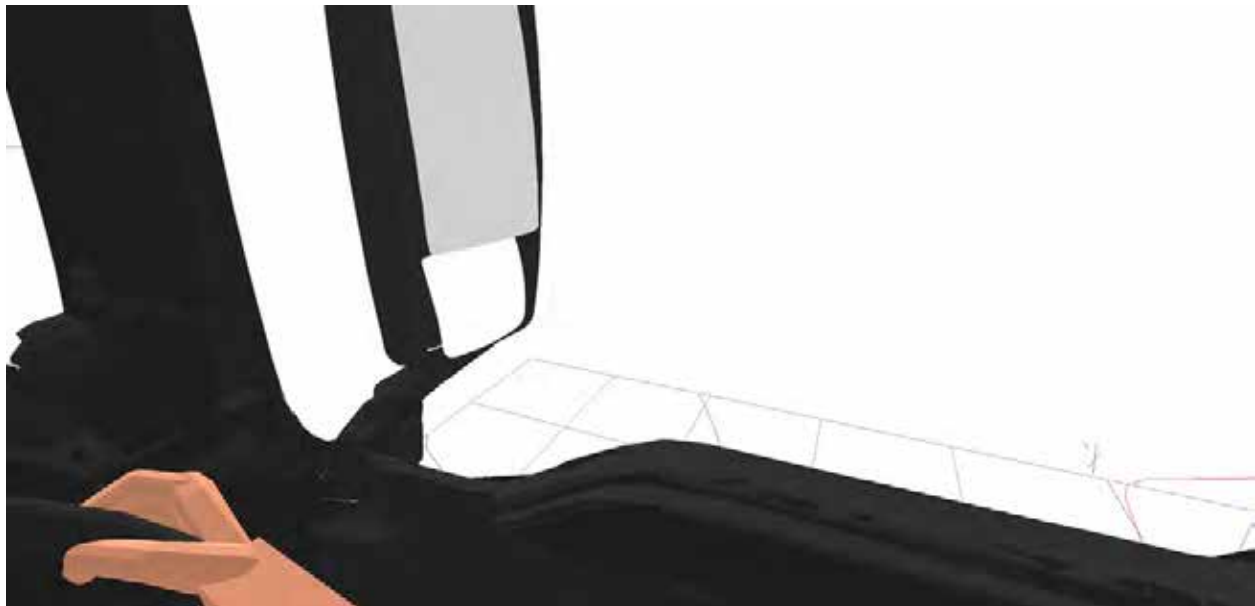


Figure 224. The view from the driver's eyes clearly shows the two cyclists are not visible

For offside direct visibility of the cyclists there is a blind spot that can obscure both cyclists. Figure 64 shows the view through the driver's eyes through the window.

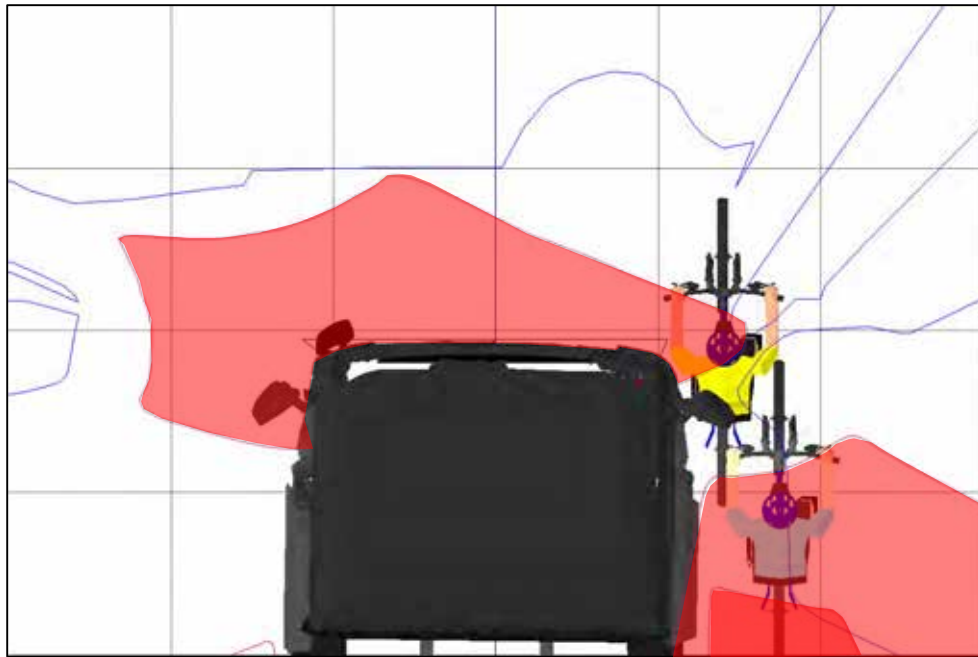


Figure 225. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

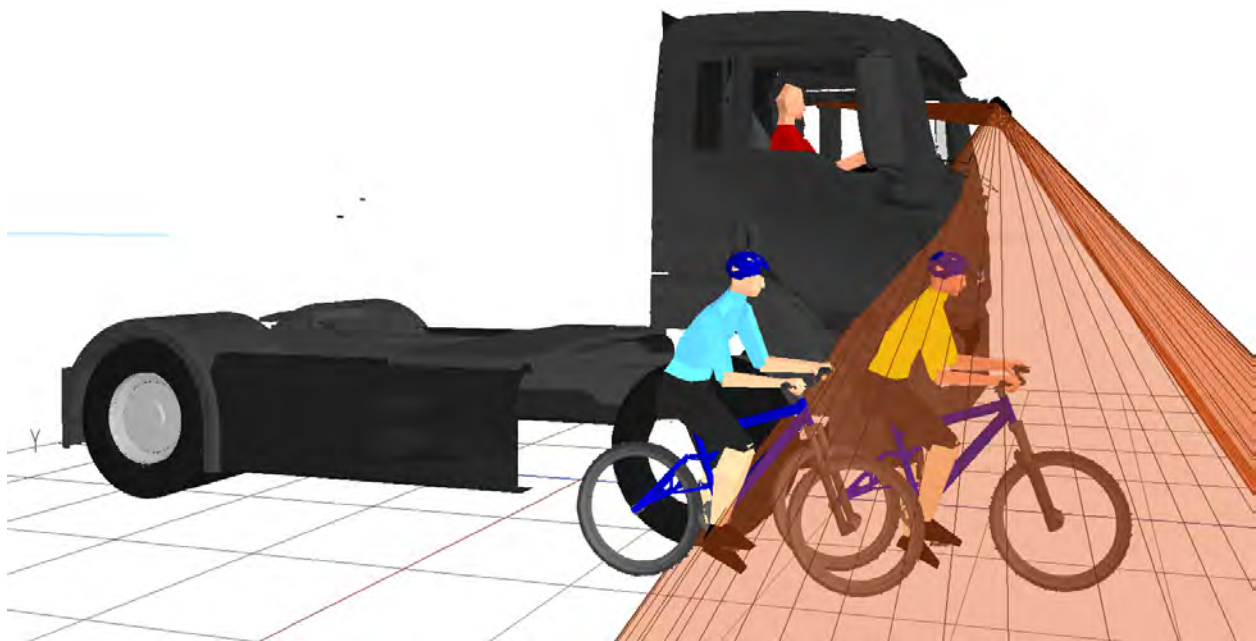


Figure 226. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

Despite not being visible through direct vision, the cyclists are visible in the mirrors. Figure 226 shows that theoretically both cyclists are visible in the Class VI mirror. However, due to limitations of the projection technique, the rear cyclist (blue) would actually be hidden from view by the cab of the vehicle. However, part of the front (yellow) cyclist would be visible in the Class VI mirror including their arms and the front of the bicycle.

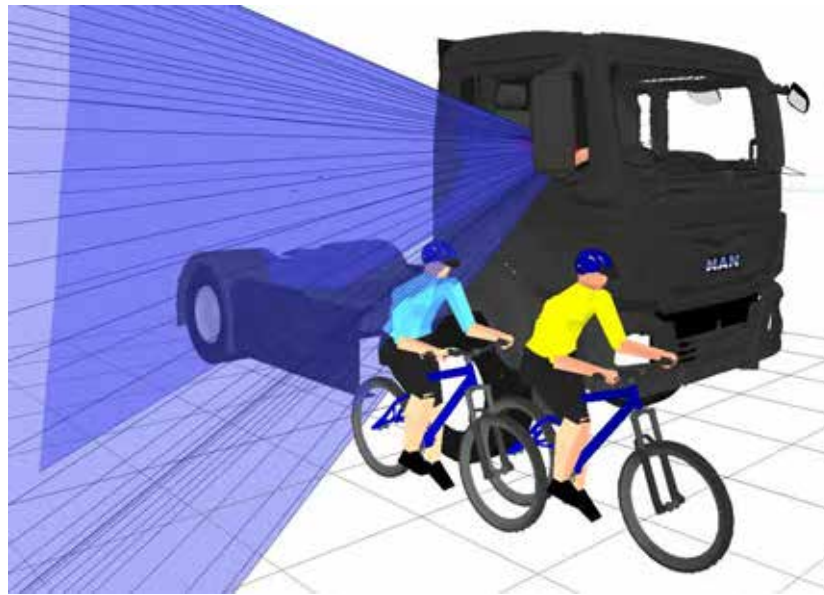


Figure 227. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 227 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and shoulders. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide a cyclist as defined in the positions shown to the offside of the MAN TGS N3G.

4.1.6.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

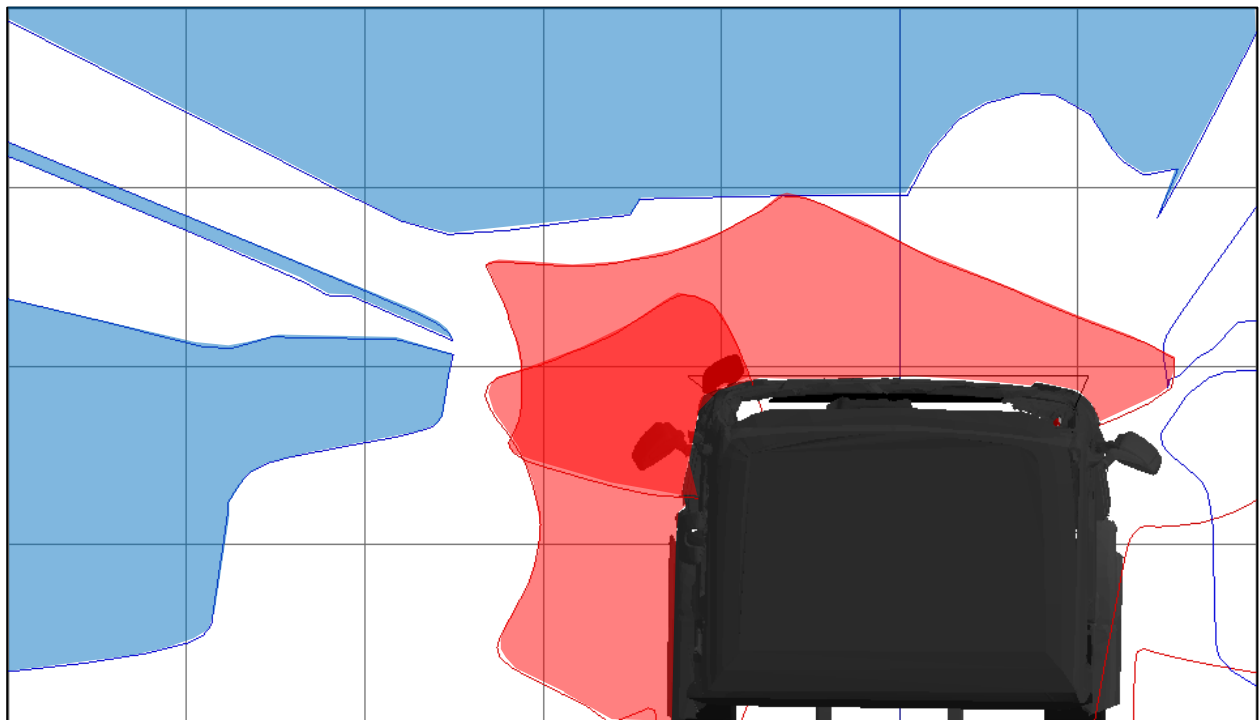


Figure 228. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 229 and Figure 230 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

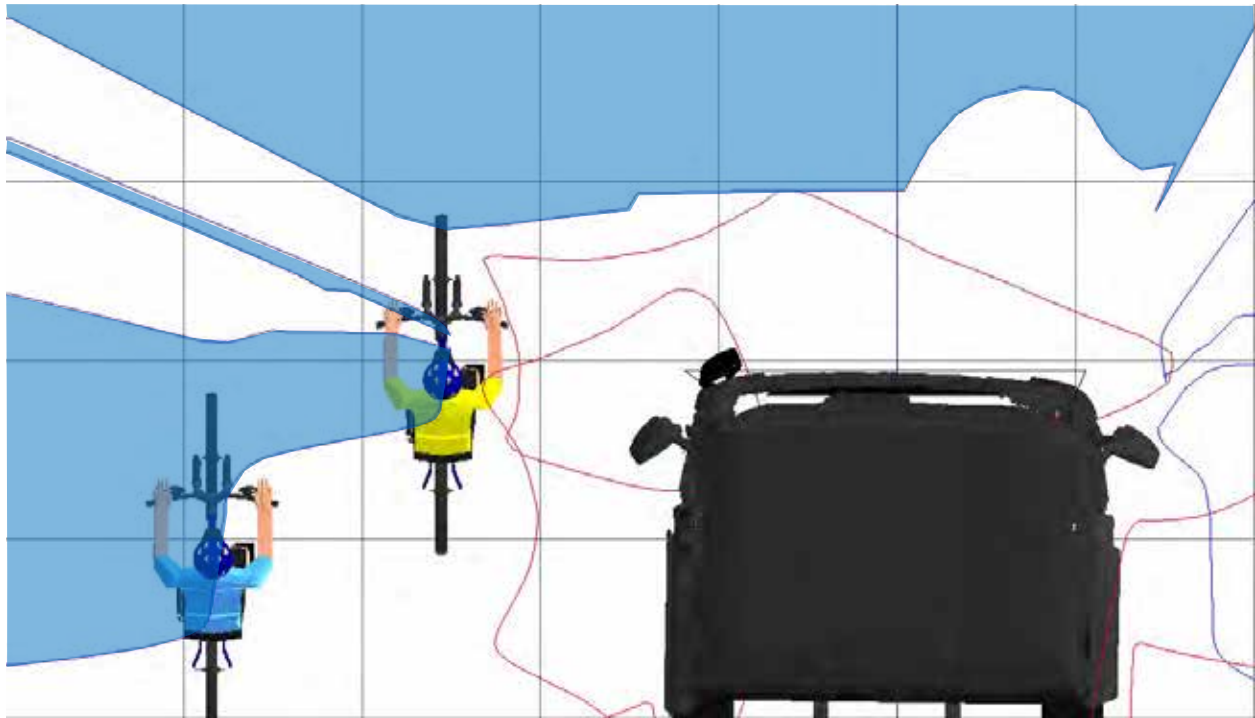


Figure 229. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

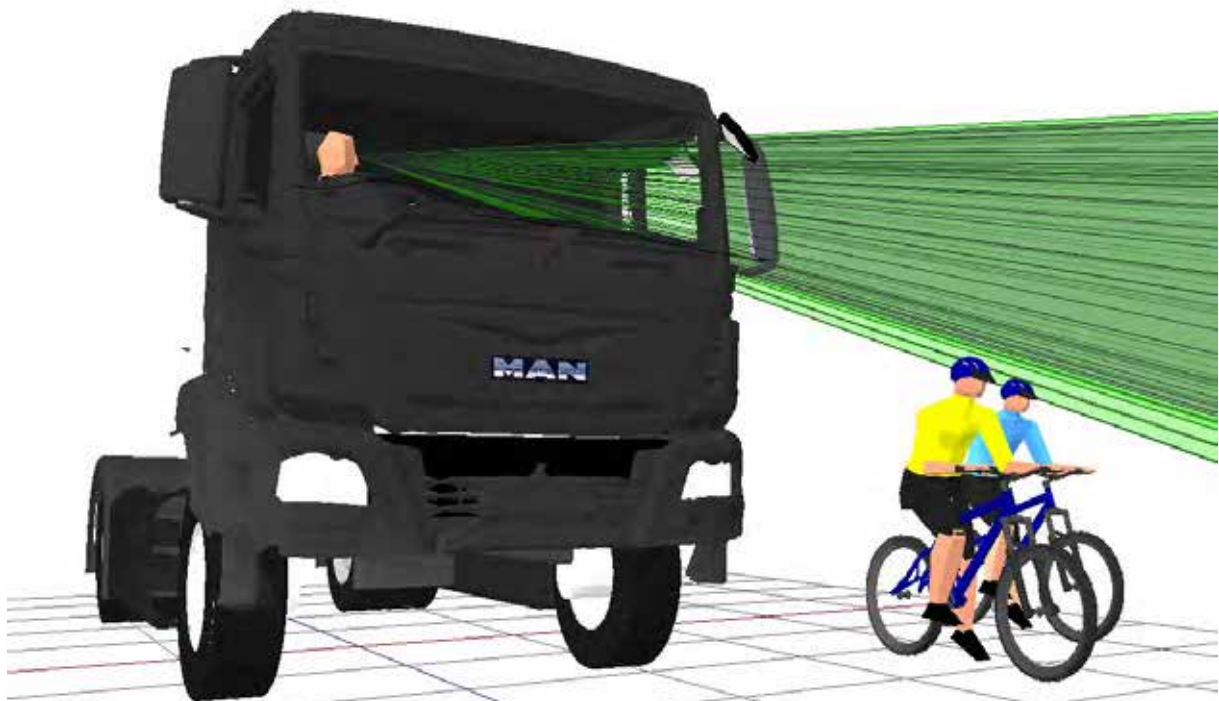


Figure 230. 3D view showing that the two human models can be positioned 1102mm (yellow) and 2218mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture

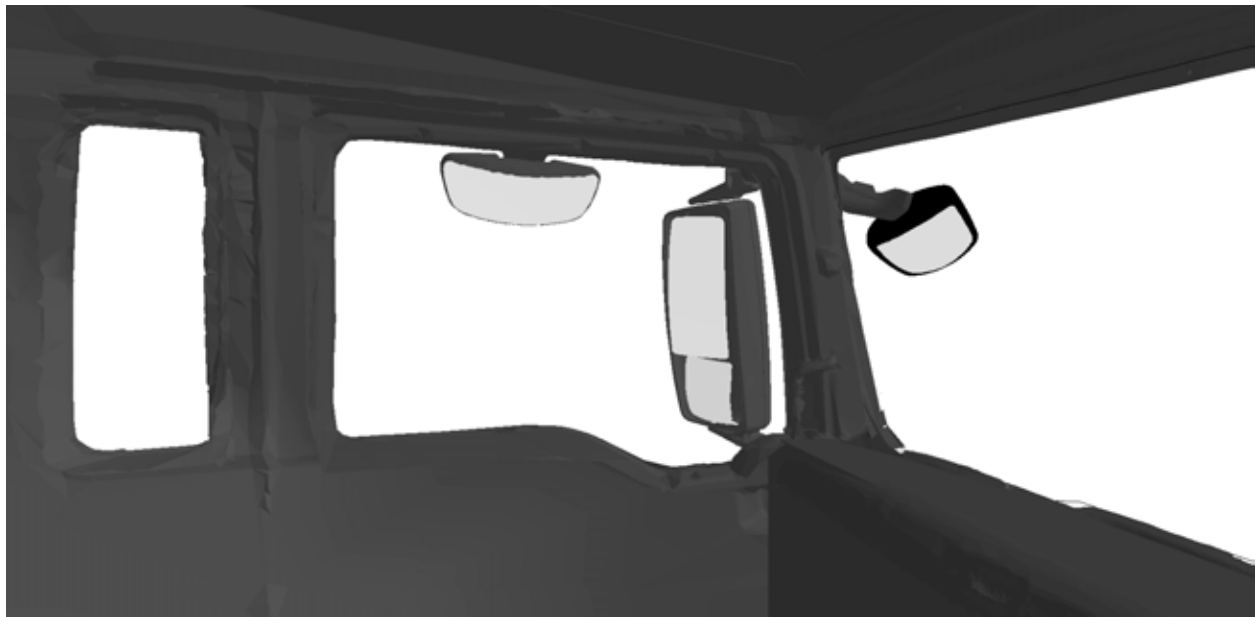


Figure 231. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 1102mm from the side of the vehicle; the rear (blue) cyclist is positioned at 2218mm from the side of the vehicle.

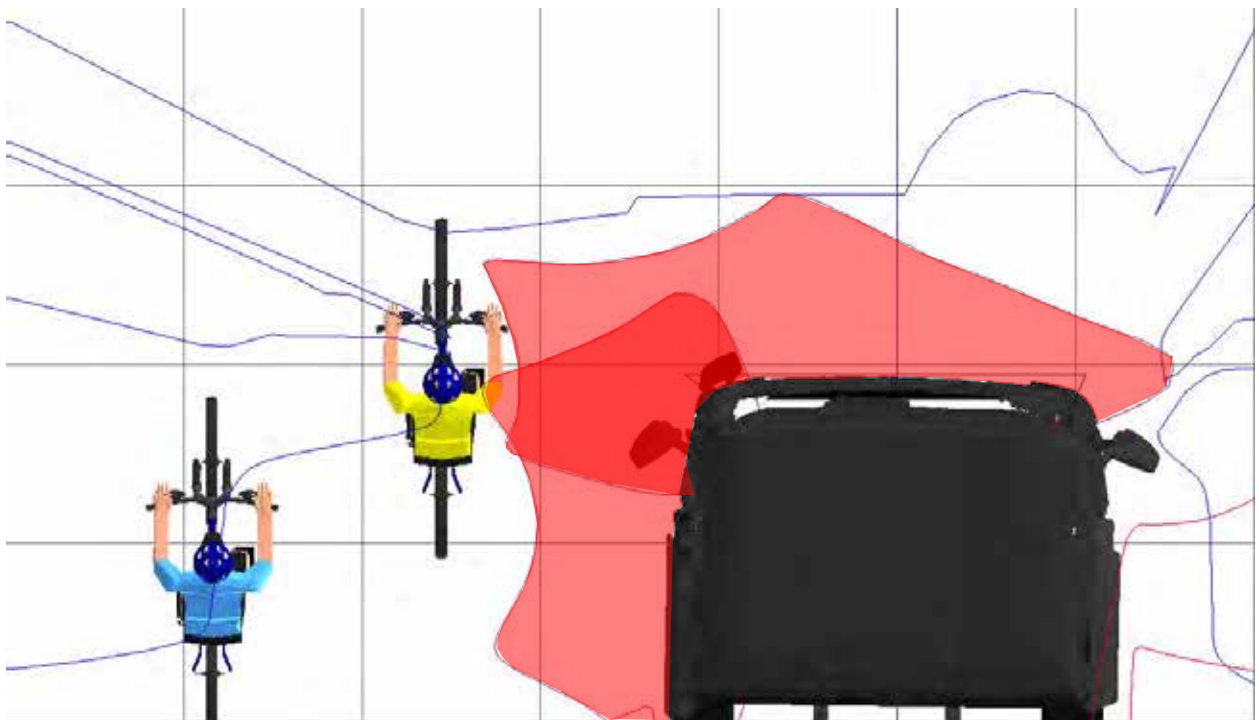


Figure 232. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

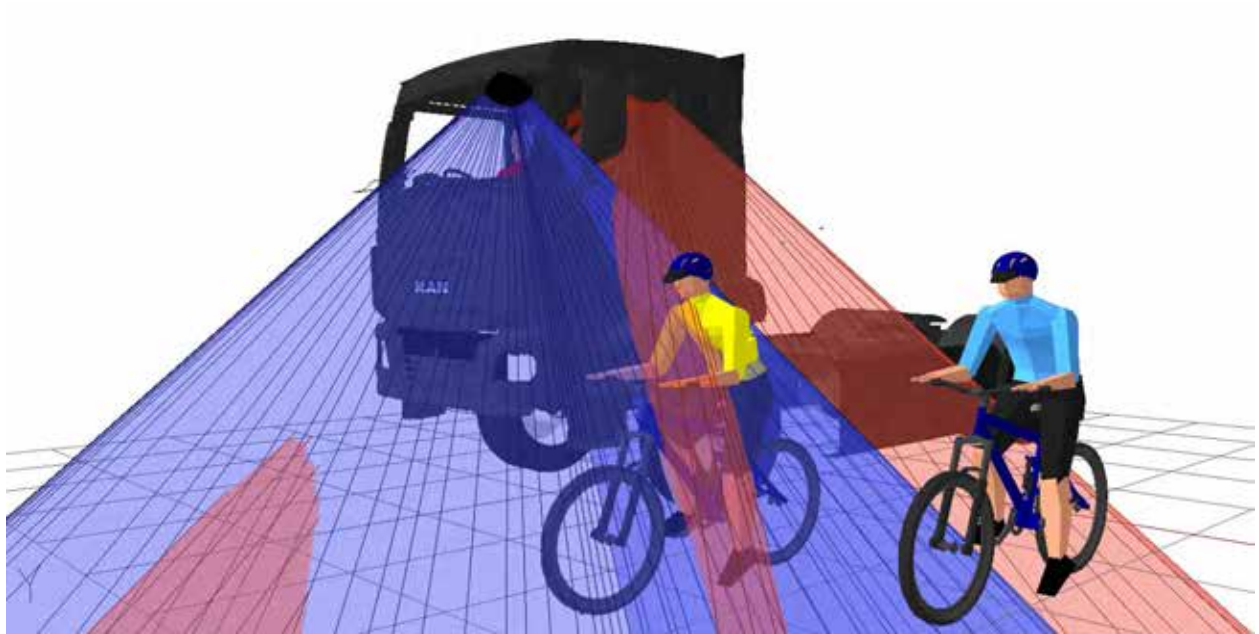


Figure 233. 3D view showing that the Front (yellow) cyclists positioned to the nearside of the vehicle is visible in the projection of the Class V and / or Class VI mirrors, but that the rearmost Cyclist is not visible in either mirror

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 233 shows that the front (yellow) cyclist is visible in the Class V and Class VI mirrors. The rear (blue) cyclist is not visible in any mirror in the location shown.

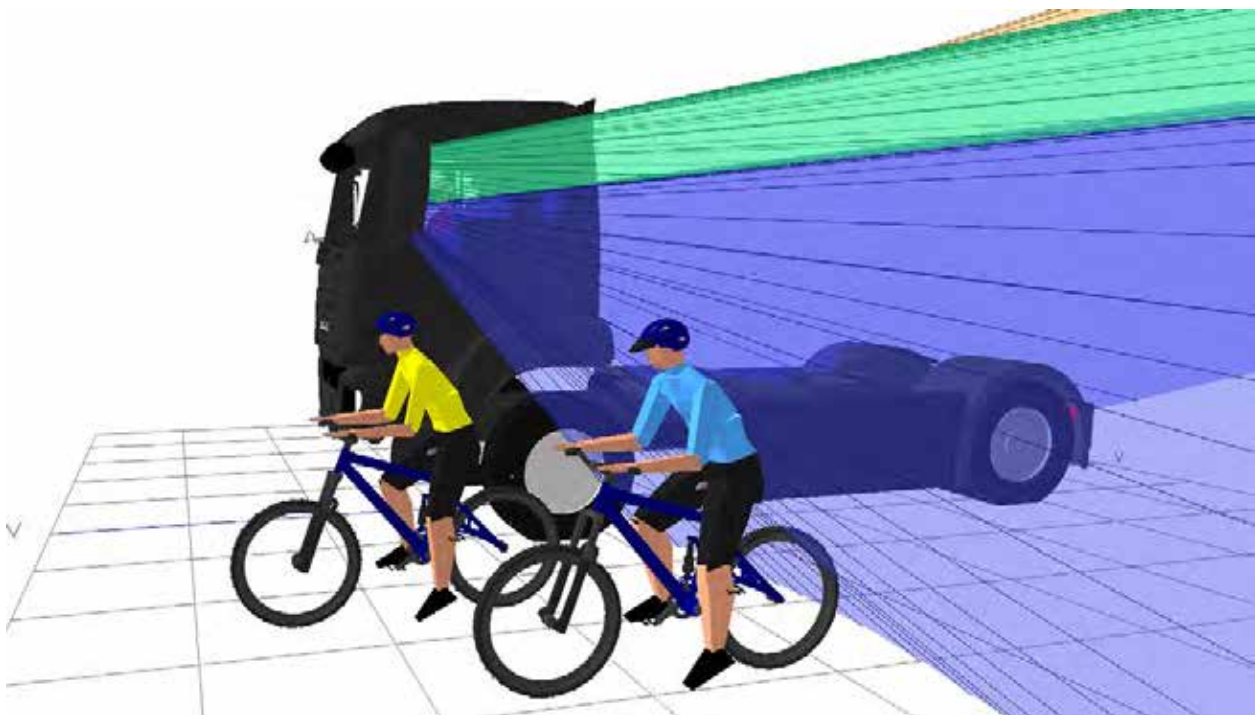


Figure 234. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is not visible in the projection of the Class IV or Class II mirror

The analysis shows that there are locations on the nearside of the vehicle, adjacent to the driver's cab, in which cyclists can be completely obscured from the driver using both direct and indirect vision.

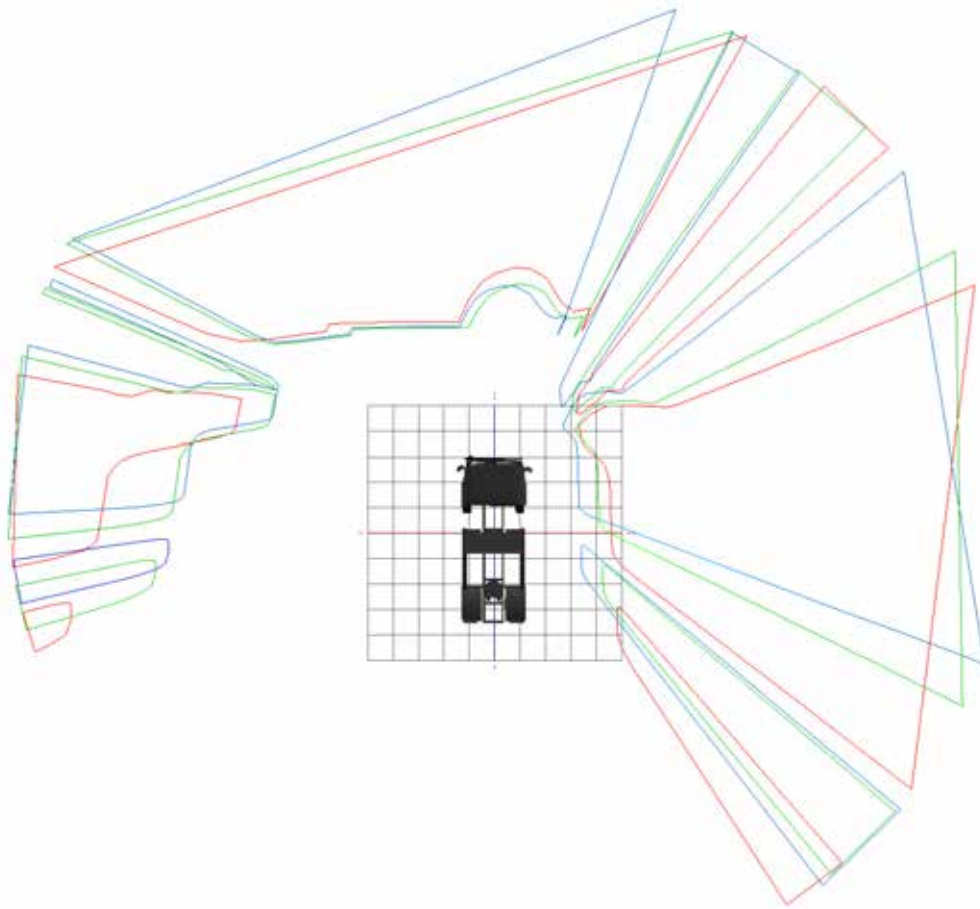
4.1.6.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

Figure 235. A plan view of the projection of the windscreen and side windows onto the ground plane for the MAN TGS N3G for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.1.7 MAN TGX N3 DISTRIBUTION - 50TH %ILE MALE DRIVER



Figure 236. Evaluation model of MAN TGX N3 variant vehicle

4.1.7.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 237 shows a top-down view of all of the window projections for the MAN TGX N3 cab with a 50th %ile UK Male Driver. The image on the right of Figure 237 shows the areas of these projections that intersect with the ground. Figure 238 shows the same for the the mirror projections and Figure 239 shows the two combined. Any area outside of the coloured projections is effectively a blind spot at the ground plane.

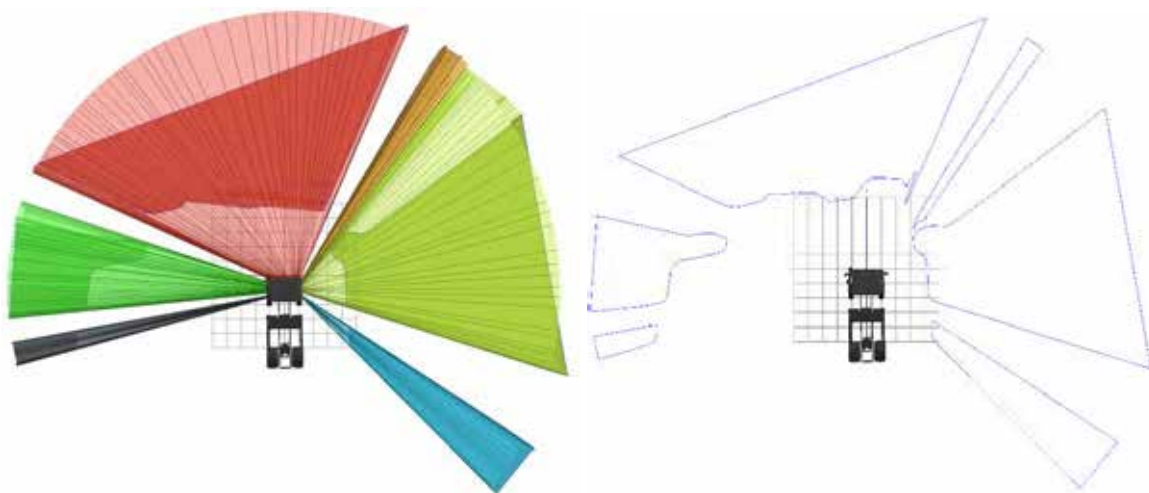


Figure 237. The projection of the windscreen and window apertures at the ground plane for the MAN TGX N3

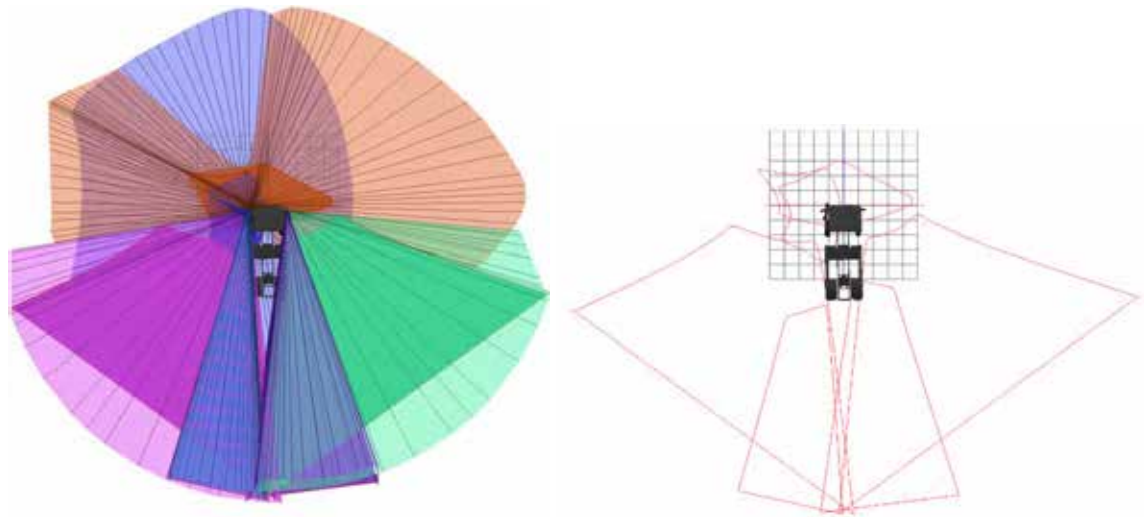


Figure 238. The projection of the mirrors at the ground plane for the MAN TGX N3

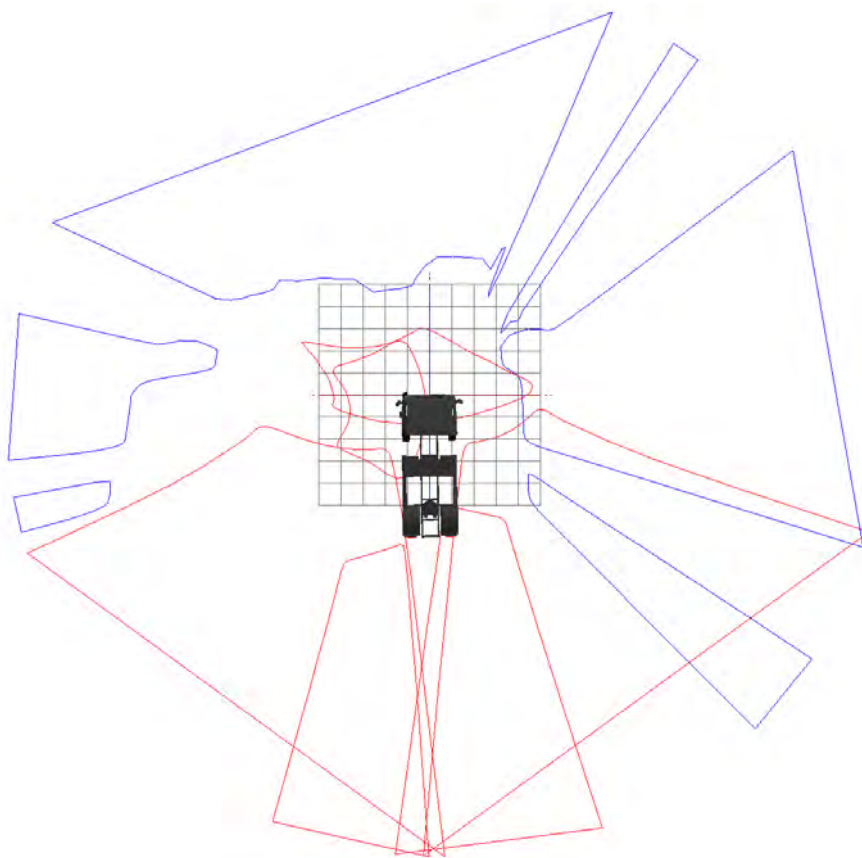


Figure 239. The combined direct and indirect vision projections at the ground plane for the MAN TGX N3

Figure 240 through Figure 244 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 245 and Figure 246 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

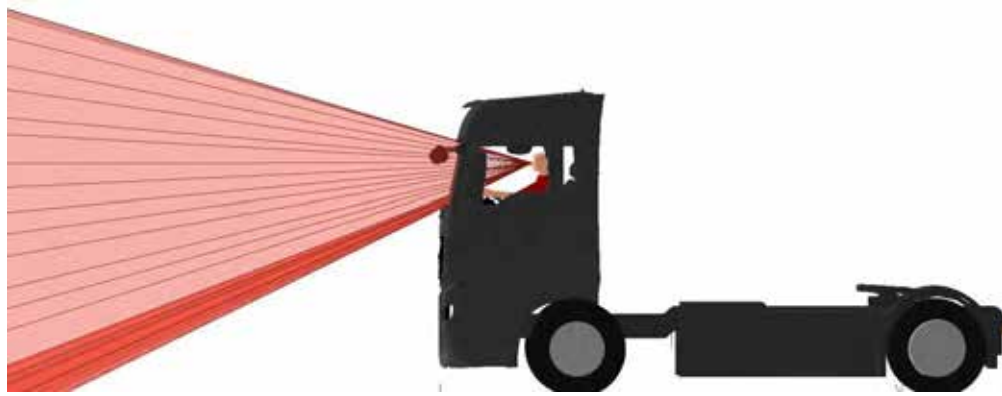


Figure 240. A side view of the windscreen aperture projection for the MAN TGX N3



Figure 241. Frontal views of the off side and near side door window projections for the MAN TGX N3



Figure 242. A side view of the Class VI mirror projection for the MAN TGX N3



Figure 243. A front view of the Class V mirror projection for the MAN TGX N3

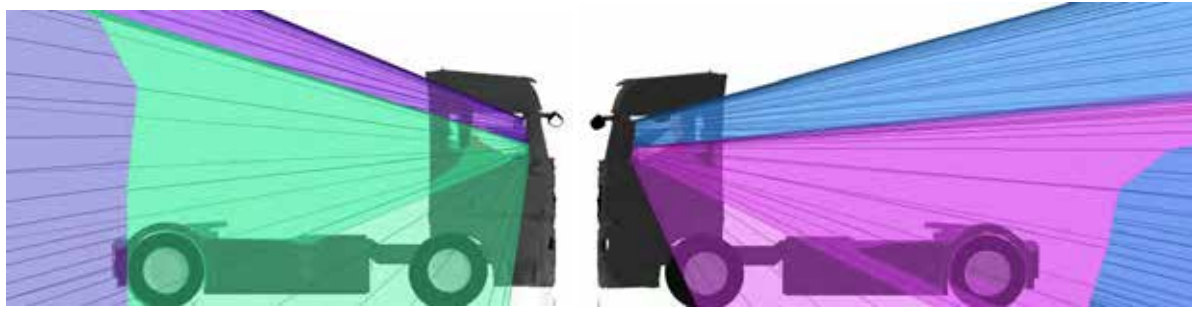


Figure 244. Side views of the combined Class II and Class IV mirror projections for the MAN TGX N3

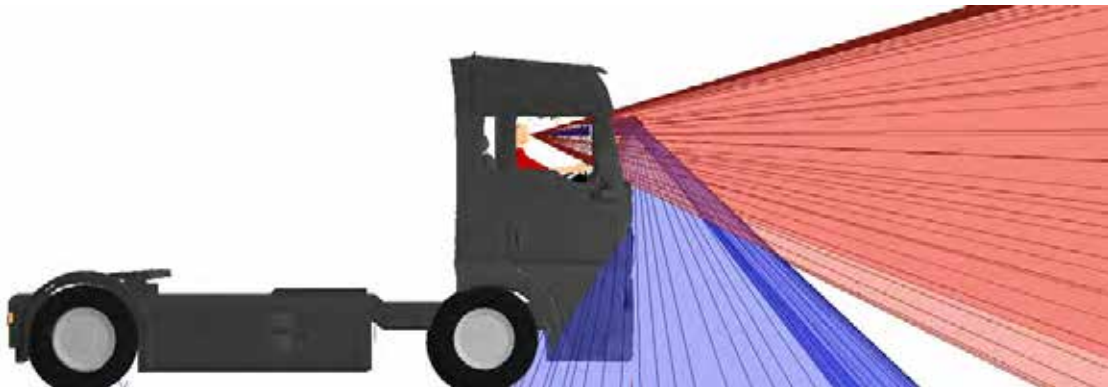


Figure 245. Combined projection of the windscreen and Class VI mirror to the front of the MAN TGX N3

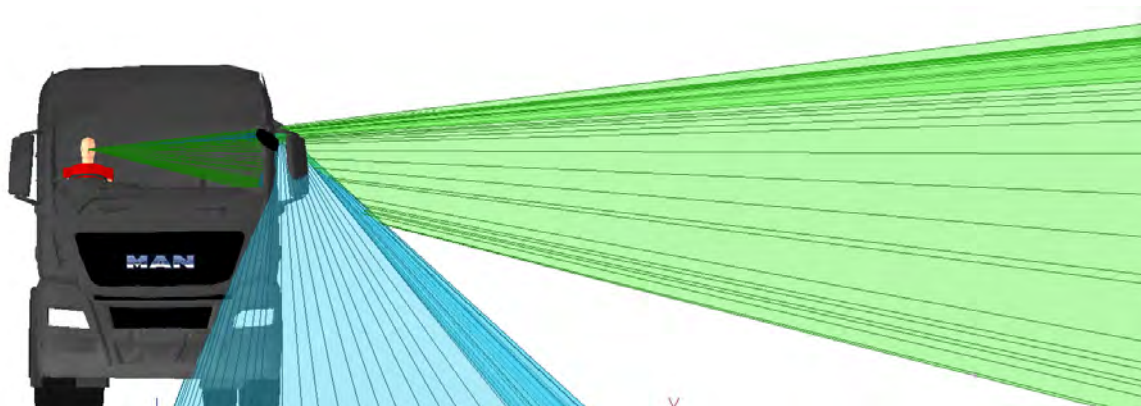


Figure 246. Combined projection of the near side windows and Class V mirror to the side of the MAN TGX N3

4.1.7.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 247 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

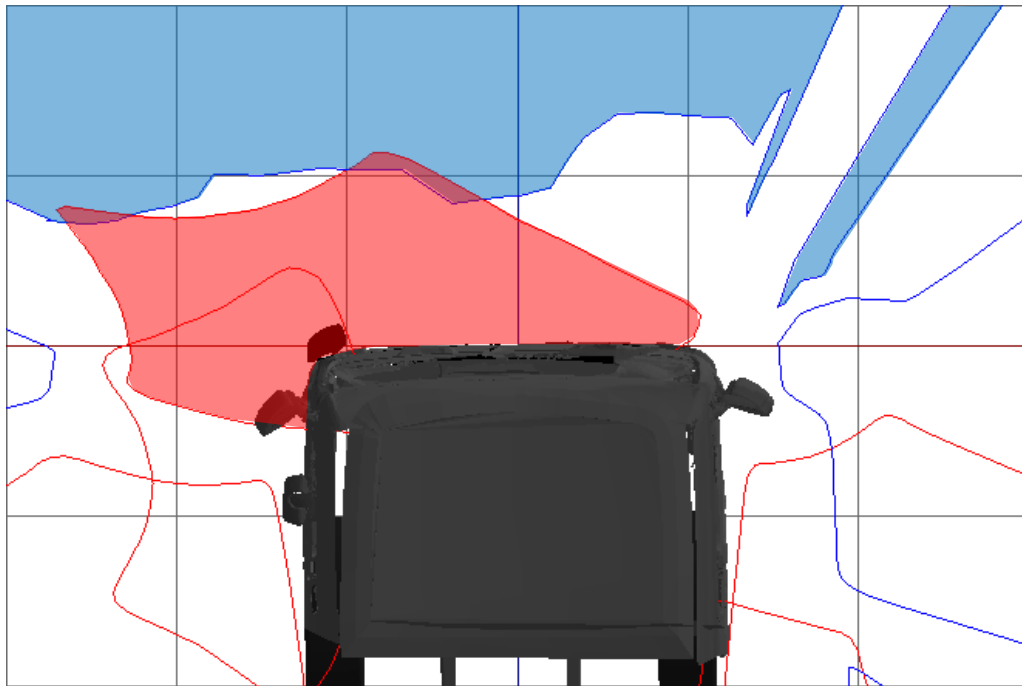


Figure 247. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 239. However Figure 248 and Figure 249 show that there is a clear space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.



Figure 248. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

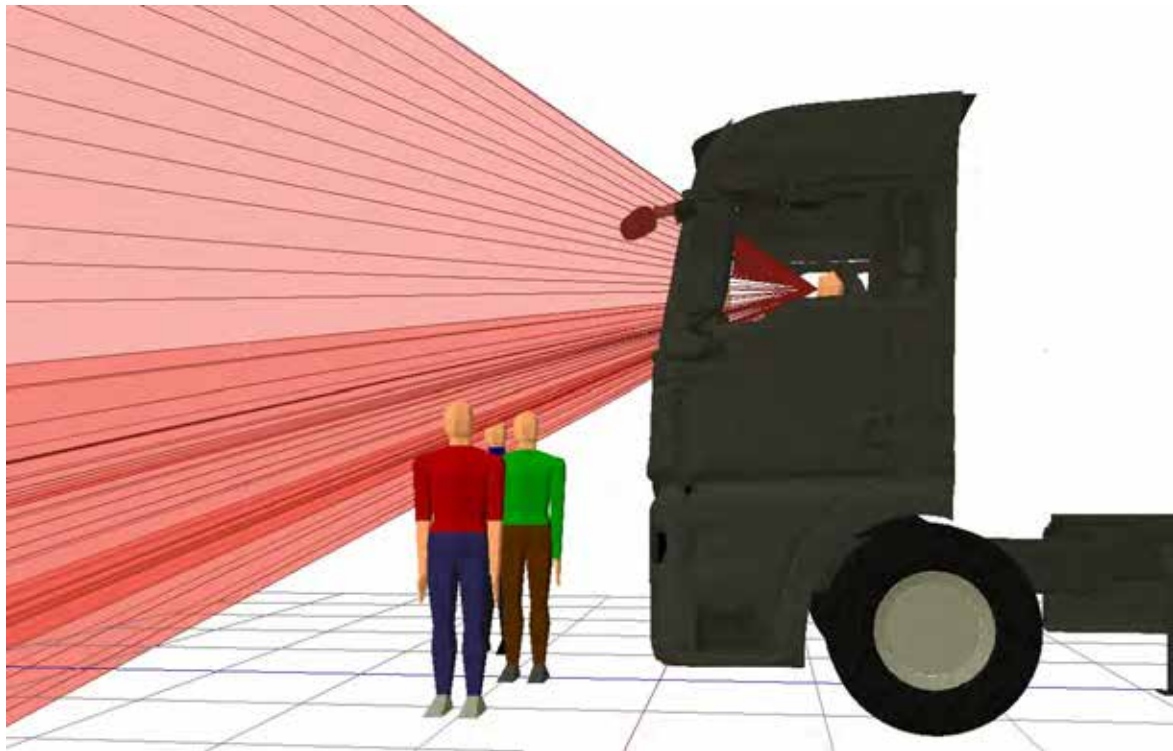


Figure 249. 3D view showing that the three human models can stand 1140mm (blue), 647mm (green) and 843mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 250. The view from the driver's eyes clearly shows the three pedestrians are hidden from view.

For forwards visibility of the pedestrians all three can be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 1140mm from the front of the vehicle, the left (red) pedestrian is positioned at 647mm from the front of the vehicle and the central (green) pedestrian is positioned at 843mm from the front of the vehicle. These figures represent a considerable distance between the pedestrians and the front of the vehicle in which pedestrians would presumably be comfortable to walk, with the potential of being unseen.

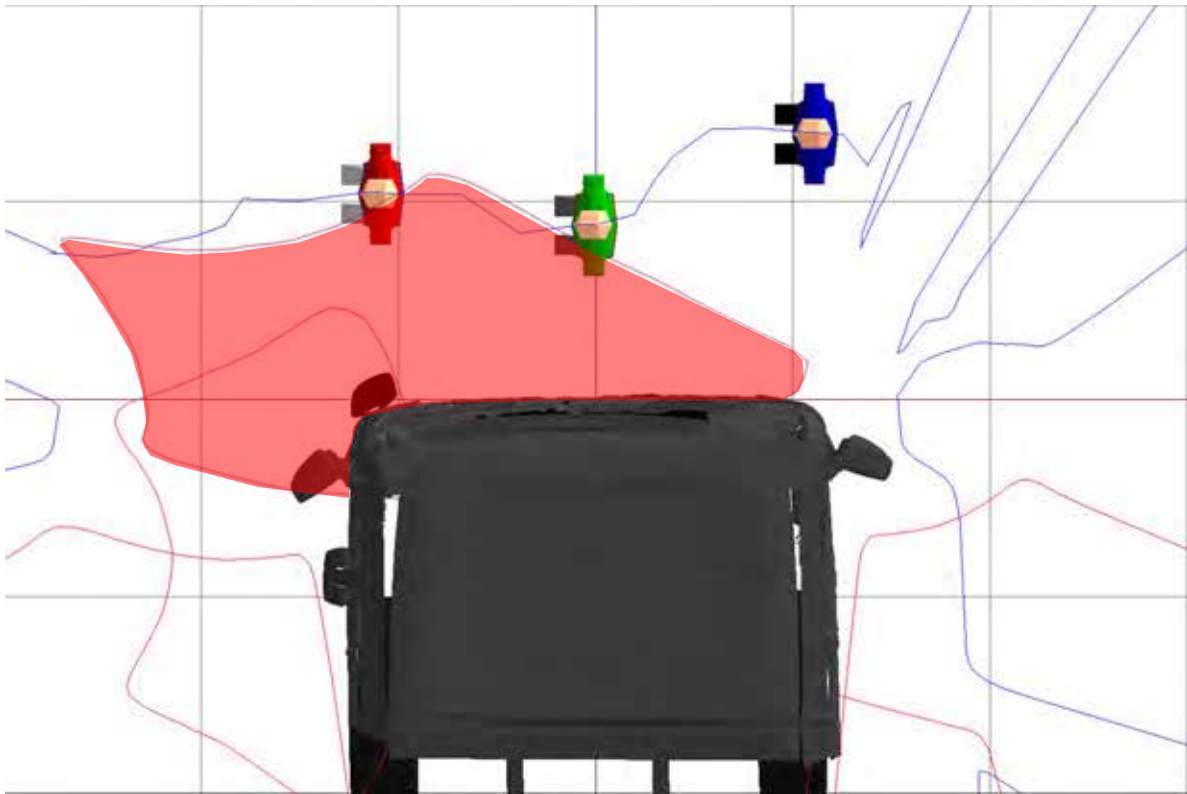


Figure 251. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian



Figure 252. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 252 shows that the pedestrian to the left (red) and centre (green) would be completely visible and the pedestrian to the right (blue) would be visible from waist down. Thus, for a driver using their mirrors, it is not possible to hide a pedestrian as defined to the front of the MAN TGX N3.

4.1.7.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

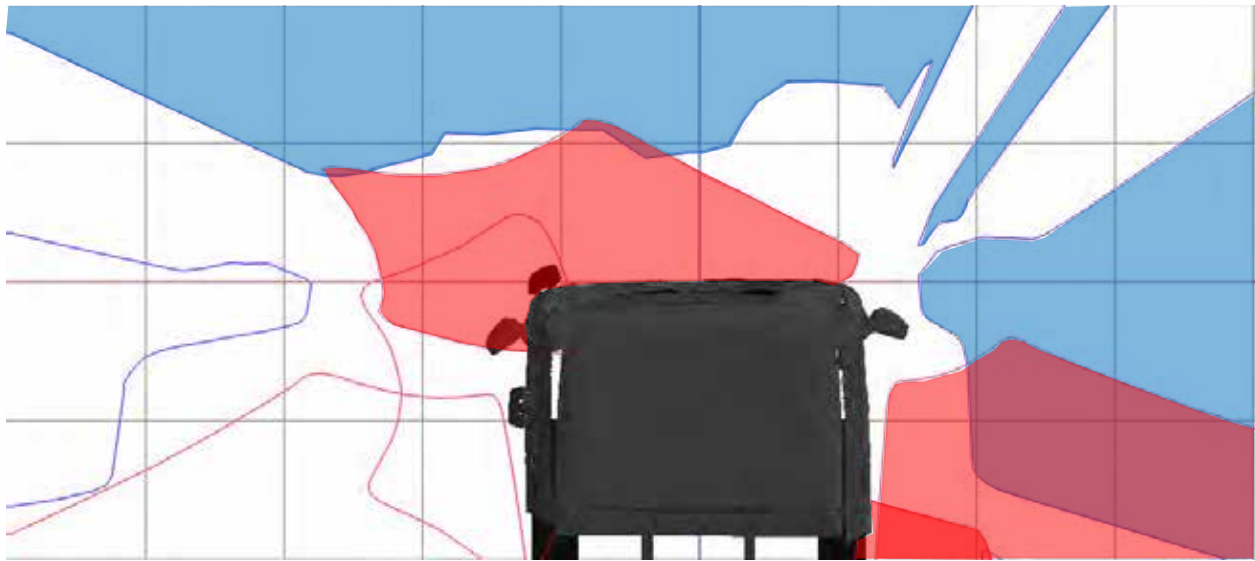


Figure 253. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

From Figure 254 it is clear that the visible areas at a height representative of a cyclist are closer to the vehicle than those taken at ground level shown in Figure 239. Figure 254, Figure 255 and Figure 256 show that, in terms of direct vision, there are significant gaps which allow cyclists to be hidden from the driver’s view.

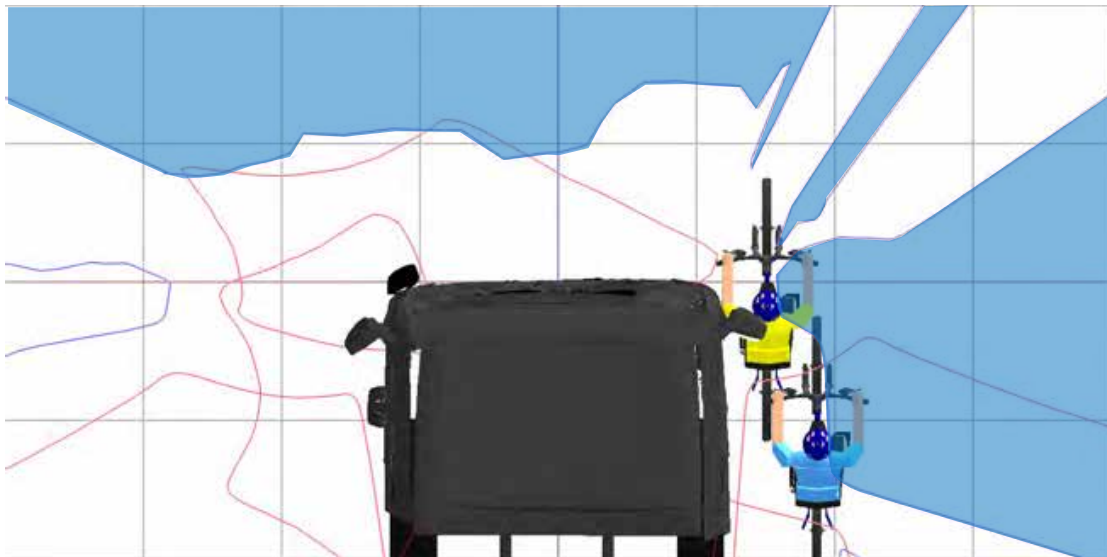


Figure 254. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist

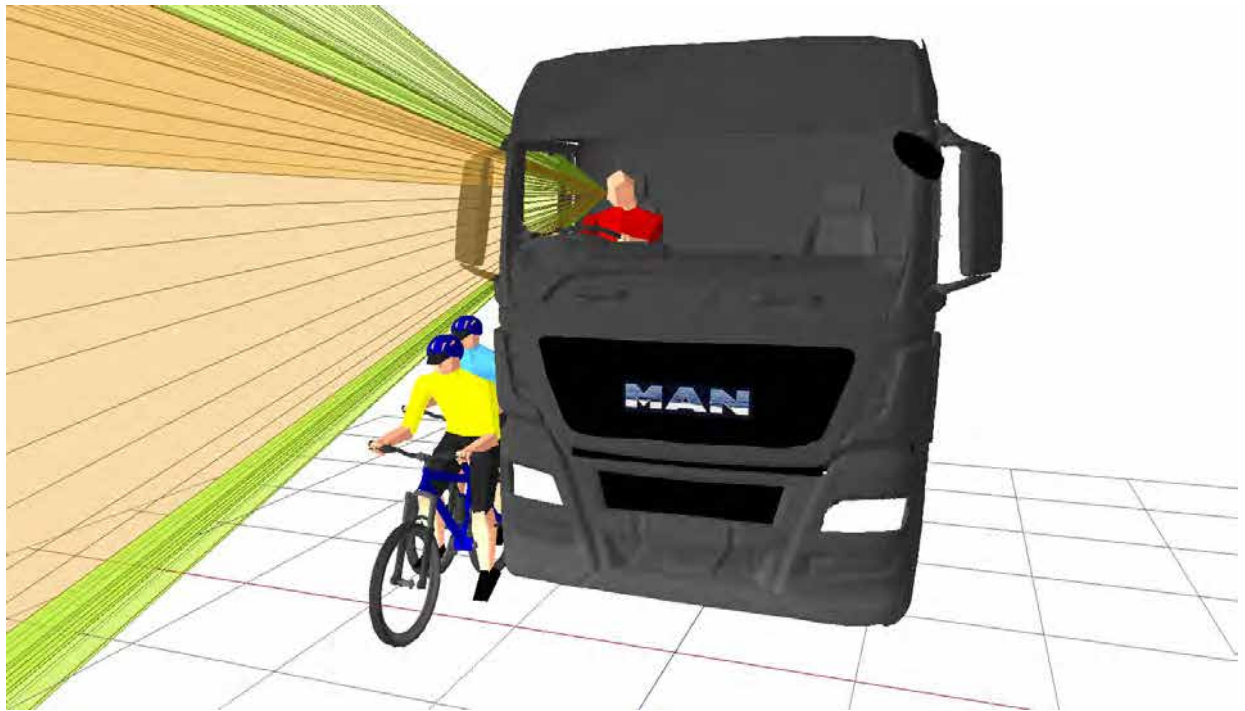


Figure 255. 3D view showing that both cyclists can be hidden from direct vision to the offside of the MAN TGX N3

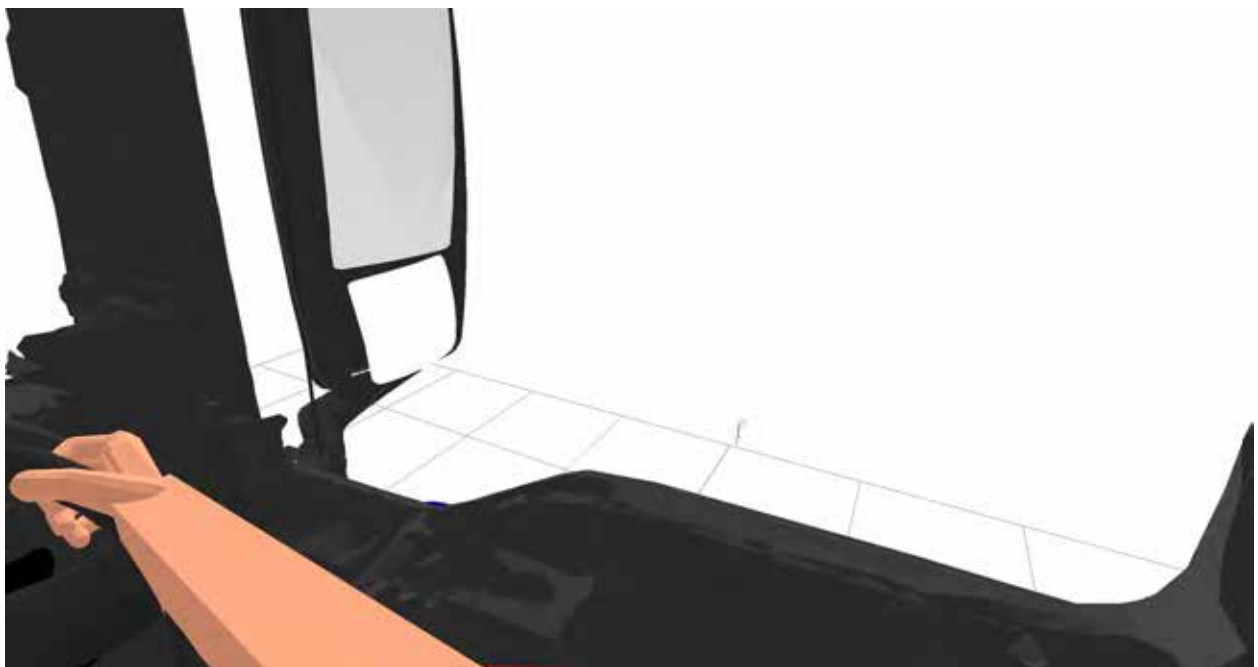


Figure 256. The view from the driver's eyes clearly shows the two cyclists are not visible

For offside visibility of the cyclists both can be hidden from the direct view of the driver with the front (yellow) cyclist being adjacent to the vehicle and the rear (blue) cyclist being 297mm from the side of the cab.

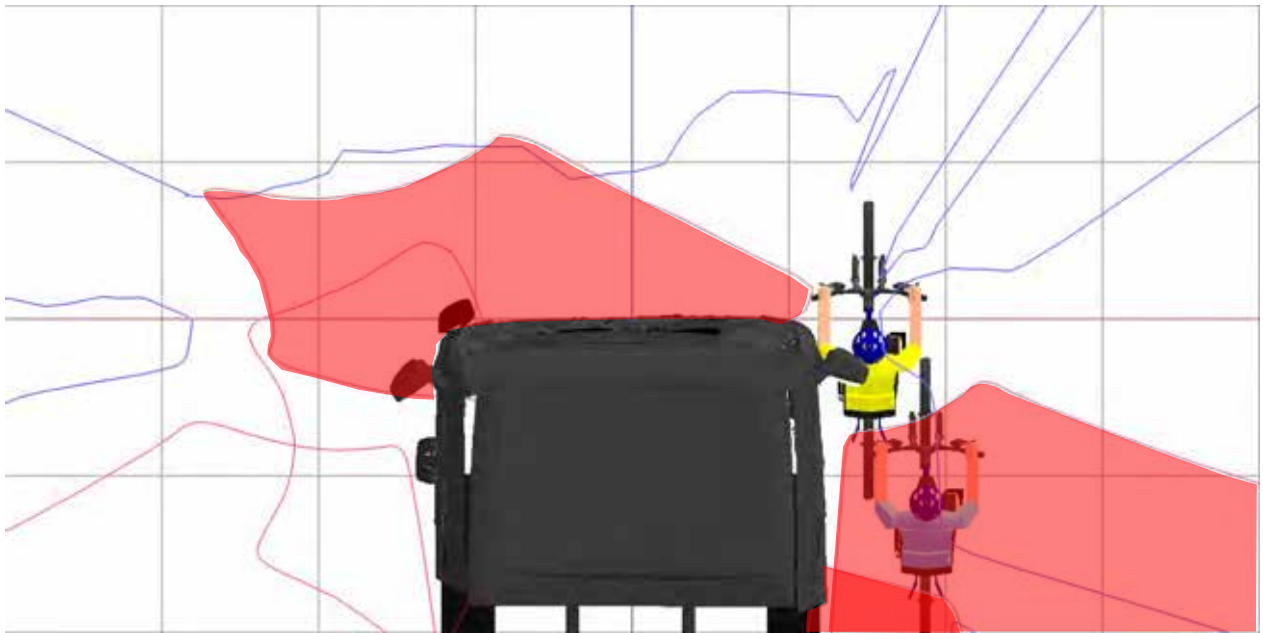


Figure 257. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

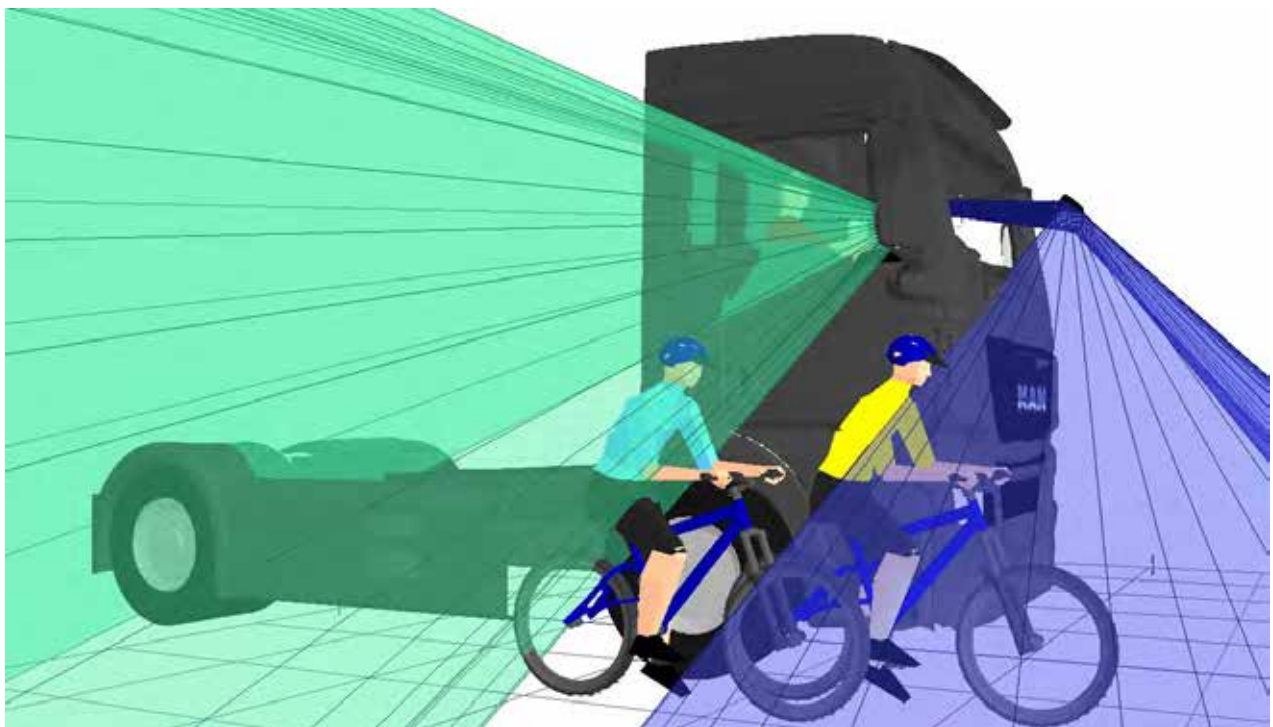


Figure 258. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI and the rear (blue) cyclist is visible in the Class IV mirror

Figure 258 shows that the front (yellow) cyclist would be partially visible in the Class VI mirror (front wheel and handle bars are beyond the front of the vehicle) and that the rear (blue) cyclist would be partially visible in the Class IV mirror. Thus, for a driver using their mirrors, it is not possible to hide a cyclists in the positions shown to the side of the MAN TGX N3.

4.1.7.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

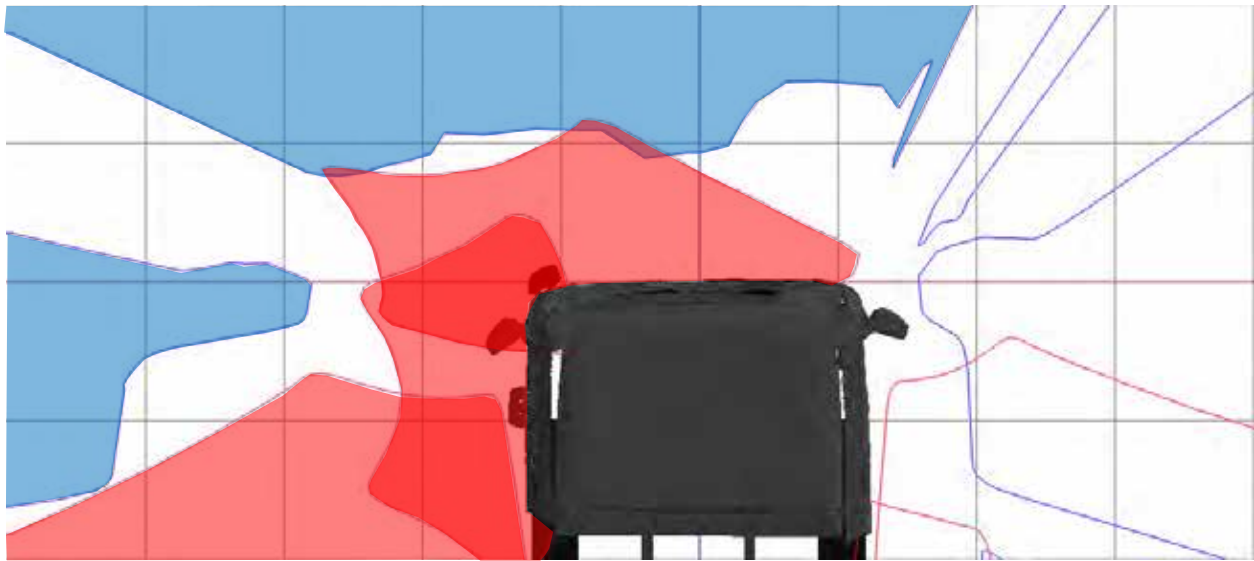


Figure 259. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 260 and Figure 261 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view. It should also be noted that in this case, there is no gap between the A-pillar and the mirror housing for the Class II and Class IV mirrors for the driver to see through, creating a large A-pillar blind spot.

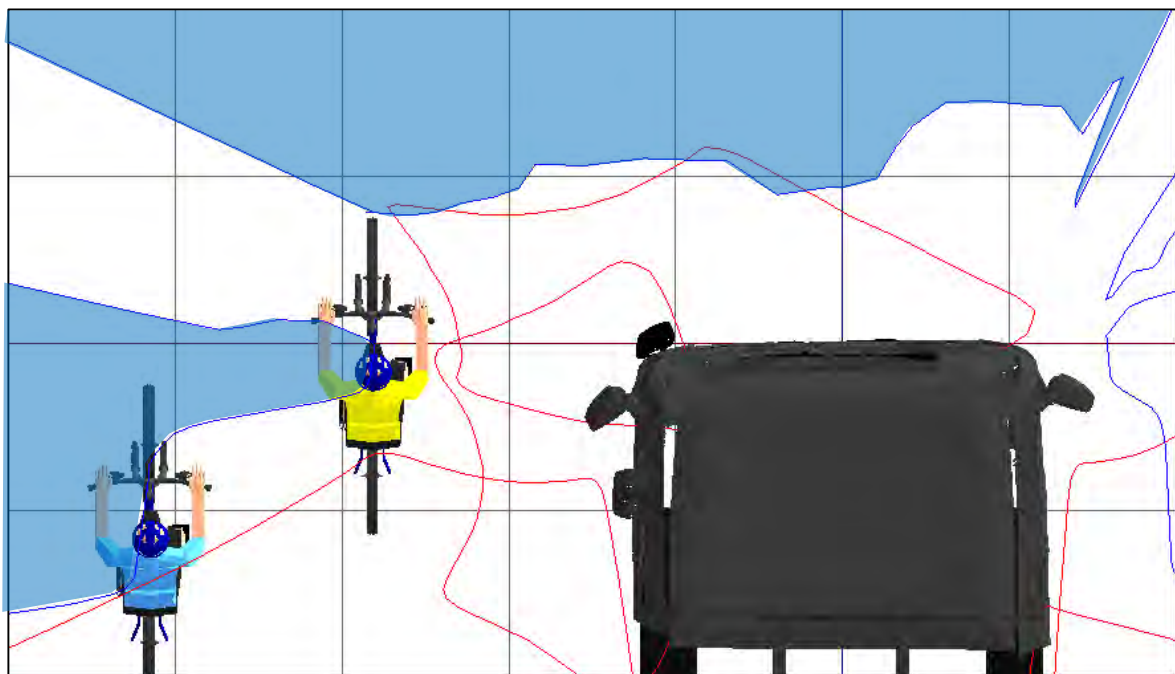


Figure 260. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

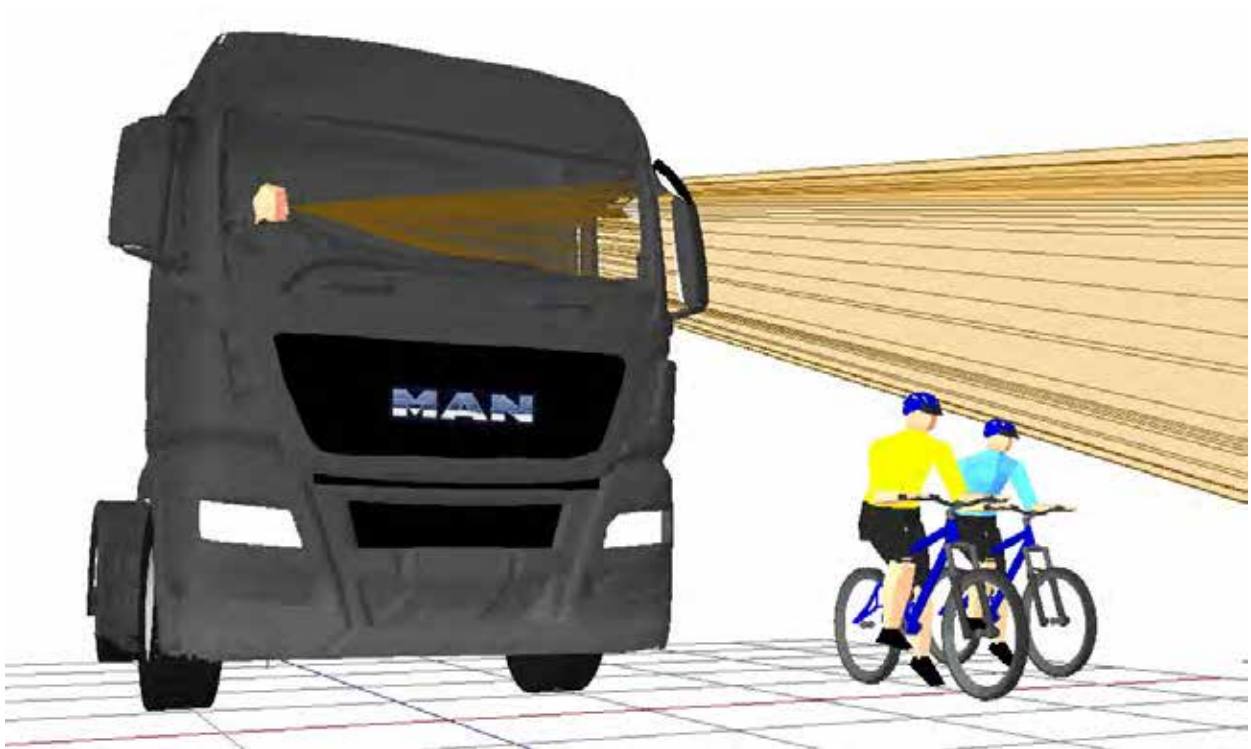


Figure 261. 3D view showing that the two human models can be positioned 1220mm (yellow) and 2592mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 262. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 1220mm from the side of the vehicle; the rear (blue) cyclist is positioned at 2592mm from the side of the vehicle.

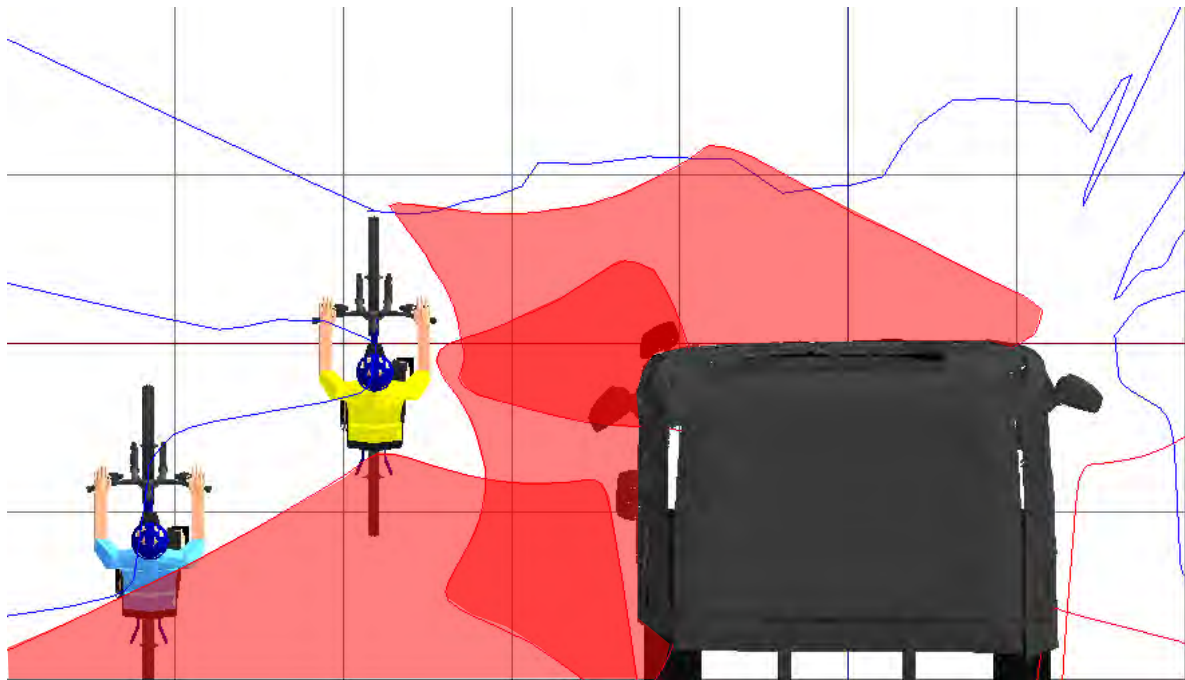


Figure 263. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

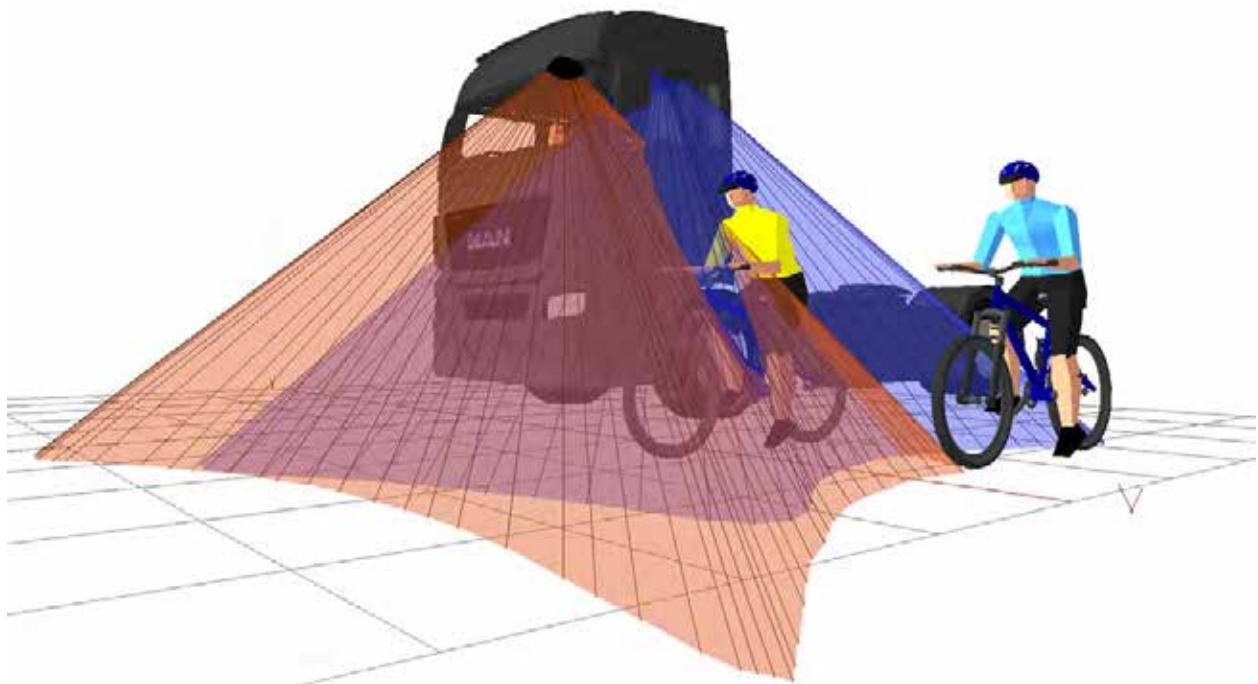


Figure 264. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

The two cyclists can be hidden from direct view to the nearside of the vehicle and Figure 264 shows that the Rear (blue) cyclist is also not visible in class V or Class VI mirrors. The front (yellow) cyclist is visible in both the Class VI and Class V mirrors.



Figure 265. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is visible in the projection of the Class IV mirror

Figure 265 shows that the rear of the two cyclists (blue) is partially visible in the projection of the nearside Class IV mirror. The cyclist would only be partially visible including the right leg and rear wheel. This would appear as a highly distorted image in the bottom left corner of the Class IV mirror.

4.1.1.7.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

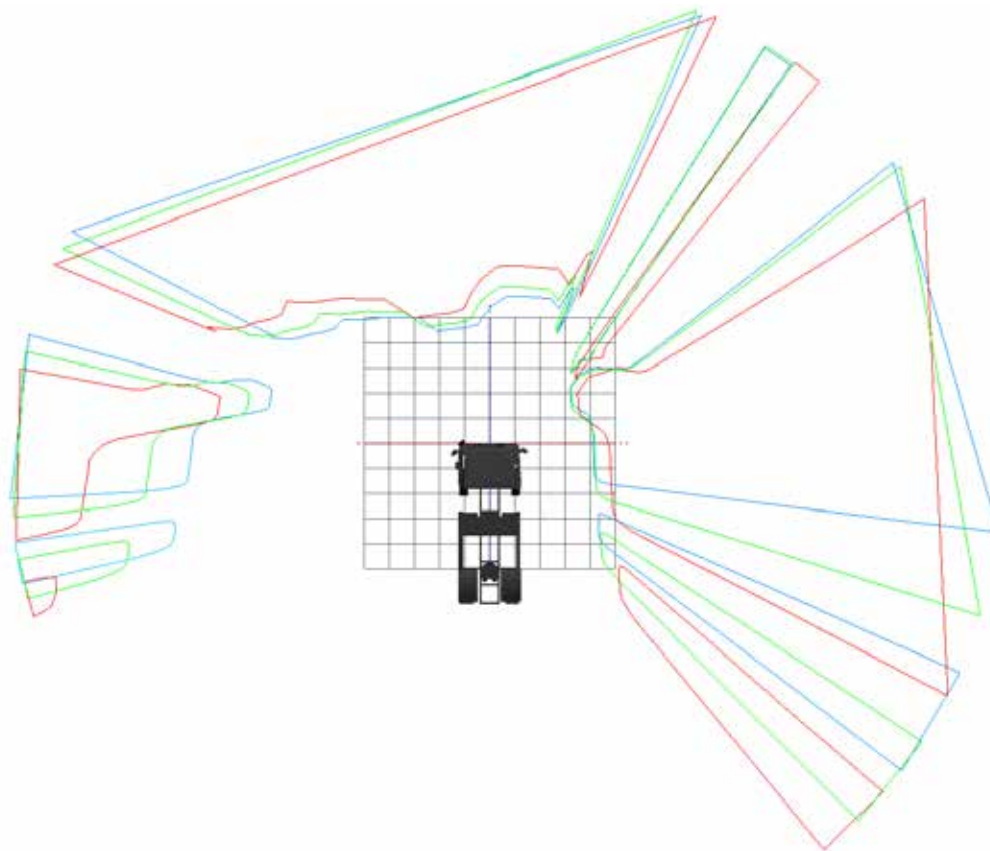


Figure 266. A plan view of the projection of the windscreen and side windows onto the ground plane for the MAN TGX N3 for a range of driver eye positions. Red=smallest driver (5th%ile UK female stature), Green=average sized driver (50th%ile UK male stature), and Blue=tallest driver (95th%ile UK male stature).

4.1.8 MERCEDES ANTOS N3 DISTRIBUTION - 50TH %ILE MALE DRIVER

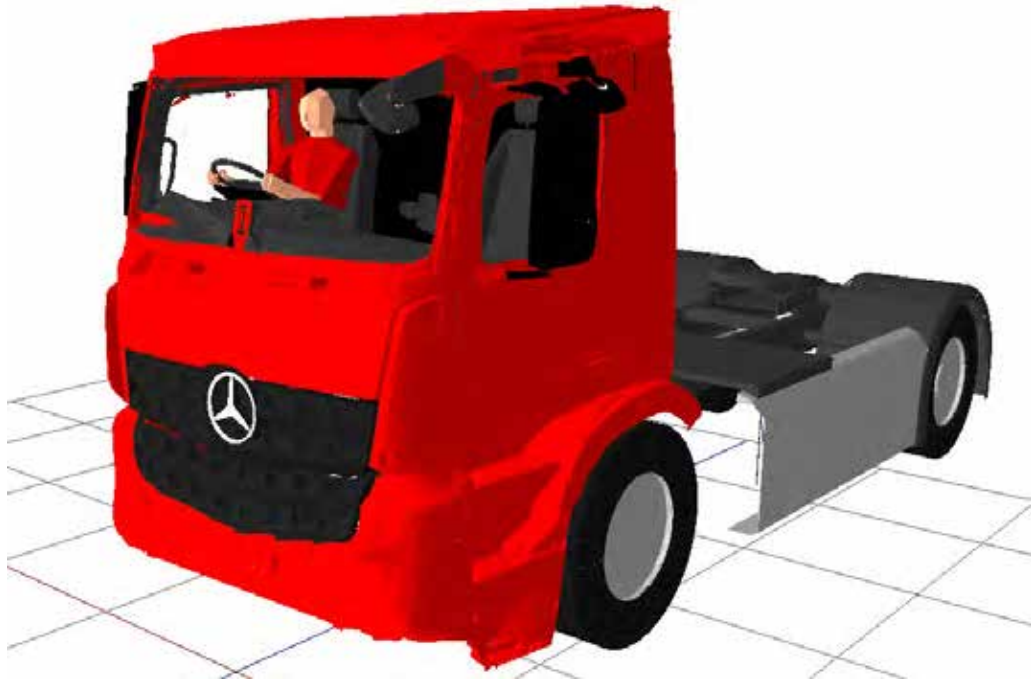


Figure 267. Evaluation model of Mercedes Antos N3G Distribution variant vehicle

4.1.8.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 268 shows a top-down view of all of the window projections for the Mercedes Antos N3 cab with a 50th %ile UK Male Driver. The image on the right of Figure 268 shows the areas of these projections that intersect with the ground. Figure 269 shows the same for the the mirror projections and Figure 270 shows the two combined. Any area outside of the coloured projections is effectively a blind spot at the ground plane.

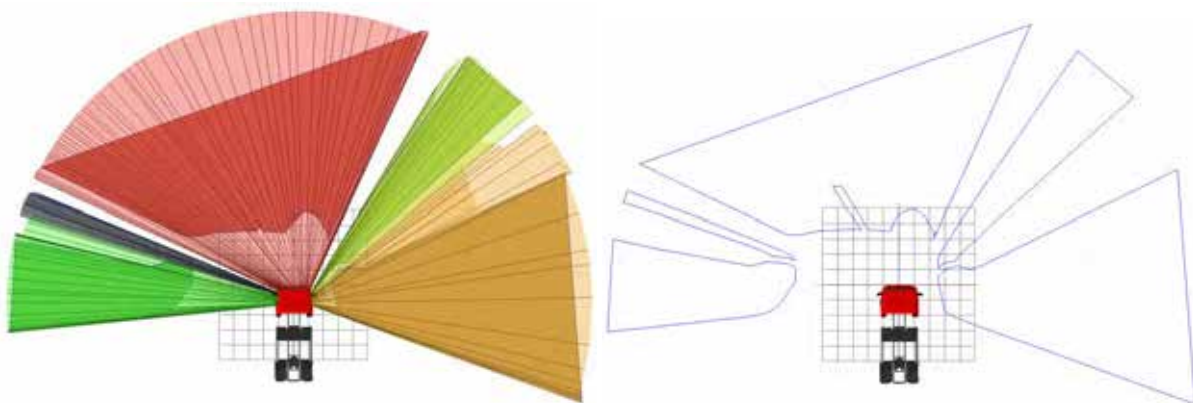


Figure 268. The projection of the windscreen and window apertures at the ground plane for the Mercedes Antos N3

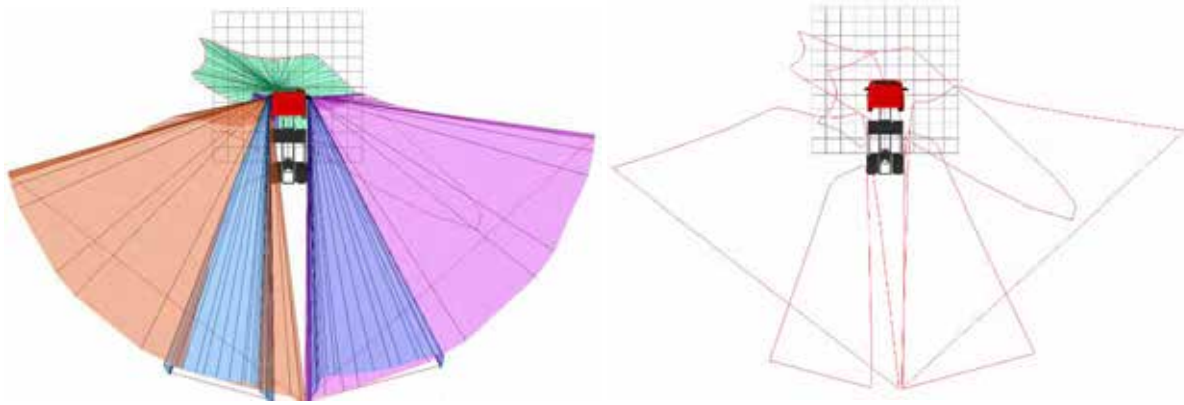


Figure 269. The projection of the mirrors at the ground plane for the Mercedes Antos N3

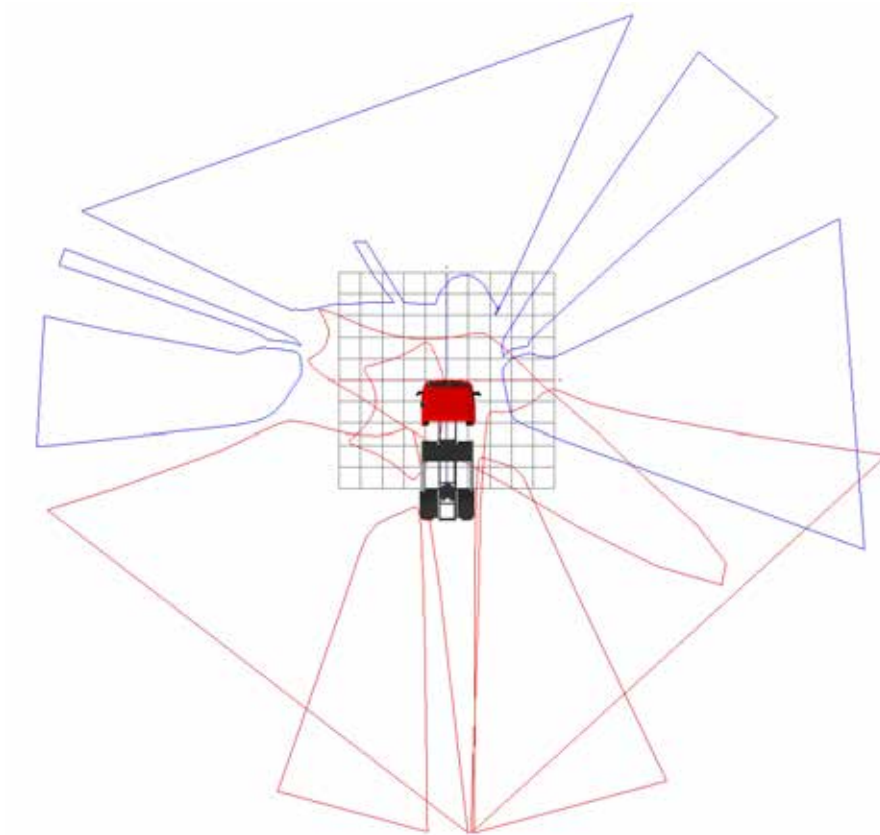


Figure 270. The combined direct and indirect vision projections at the ground plane for the Mercedes Antos N3

Figure 271 through Figure 275 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 276 and Figure 277 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

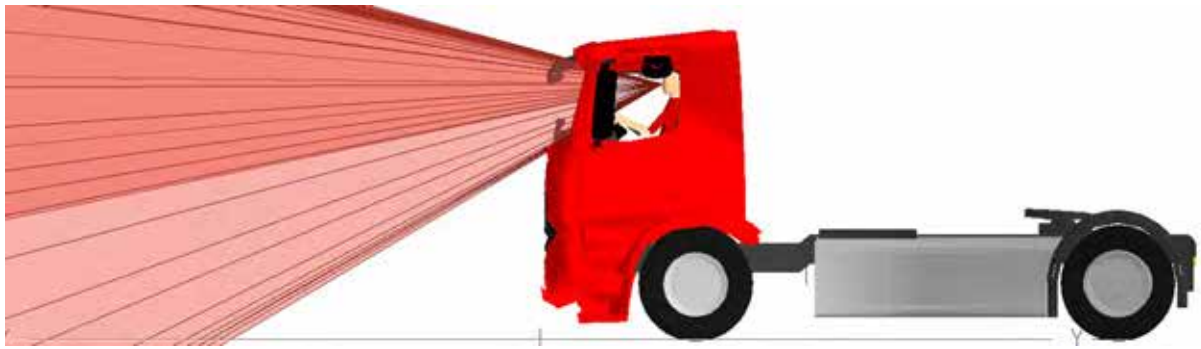


Figure 271. A side view of the windscreen aperture projection for the Mercedes Antos N3

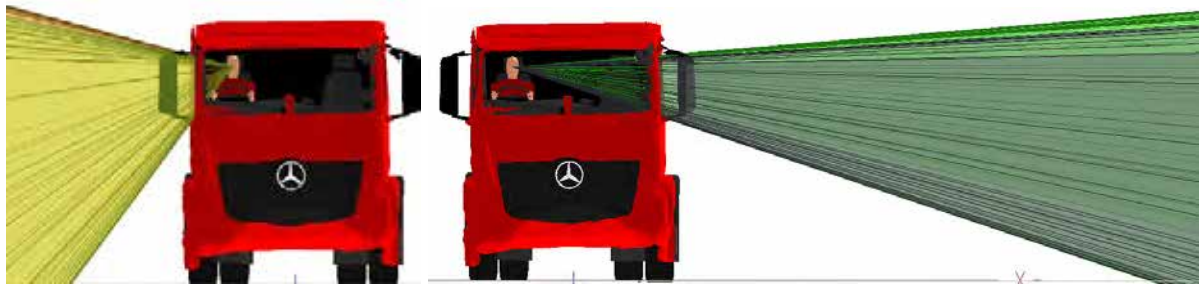


Figure 272. Frontal views of the off side and near side door window projections for the Mercedes Antos N3

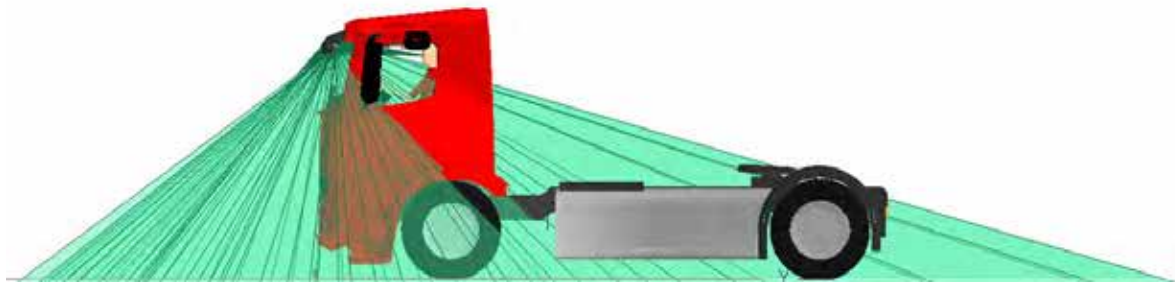


Figure 273. A side view of the Class VI mirror projection for the Mercedes Antos N3



Figure 274. A front view of the Class V mirror projection for the Mercedes Antos N3



Figure 275. Side views of the combined Class II and Class IV mirror projections for the Mercedes Antos N3

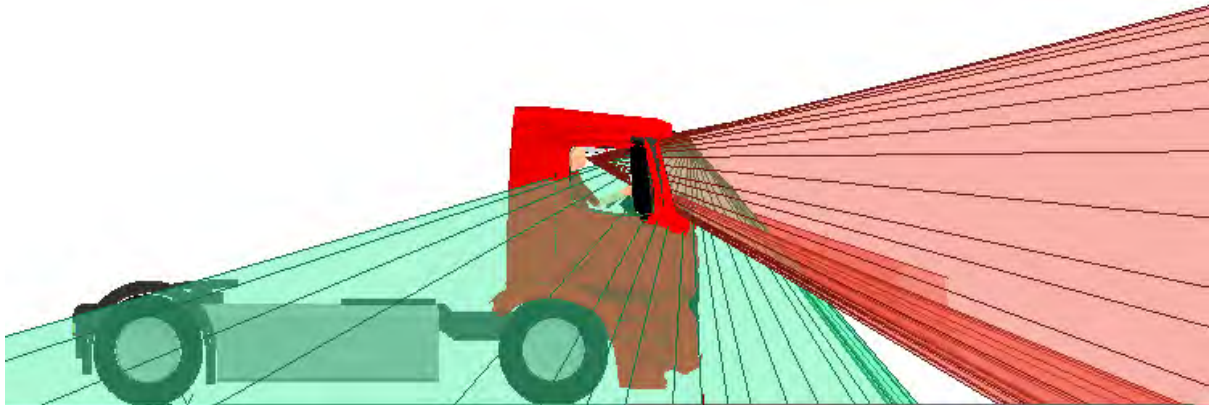


Figure 276. Combined projection of the windscreen and Class VI mirror to the front of the Mercedes Antos N3

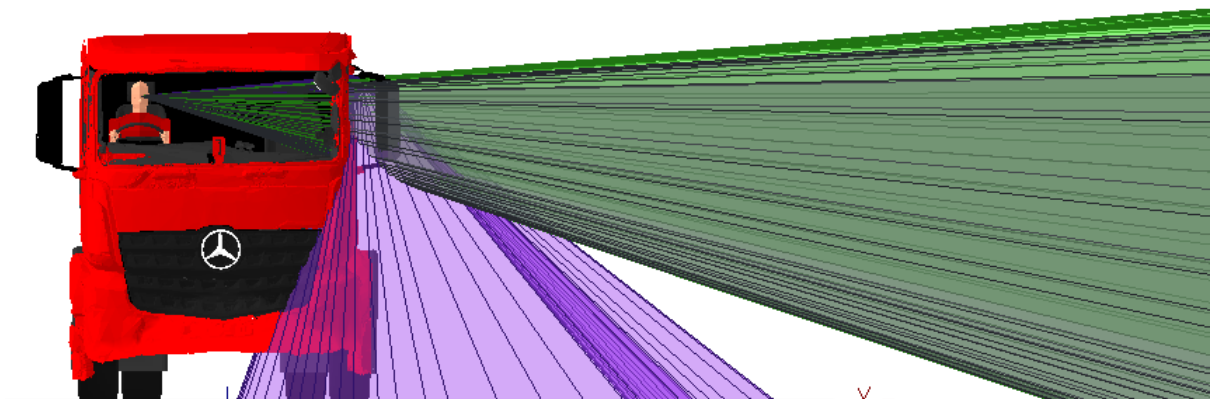


Figure 277. Combined projection of the near side windows and Class V mirror to the side of the Mercedes Antos N3

4.1.8.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 278 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

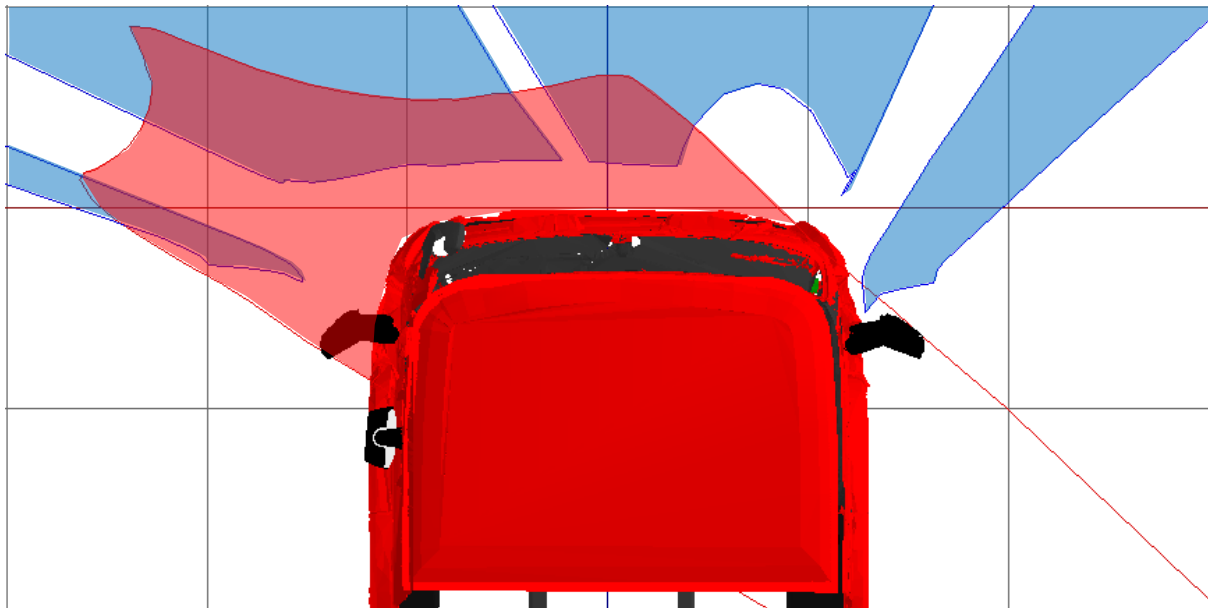


Figure 278. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From Figure 278 it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 270. However Figure 279 and Figure 280 show that there is some space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.

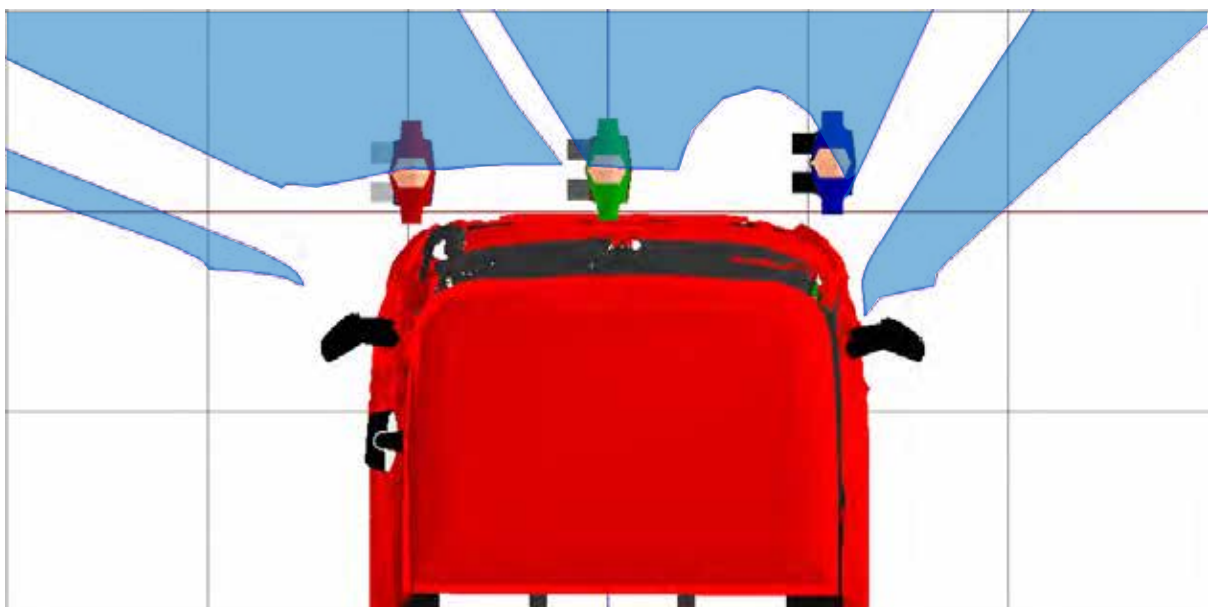


Figure 279. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

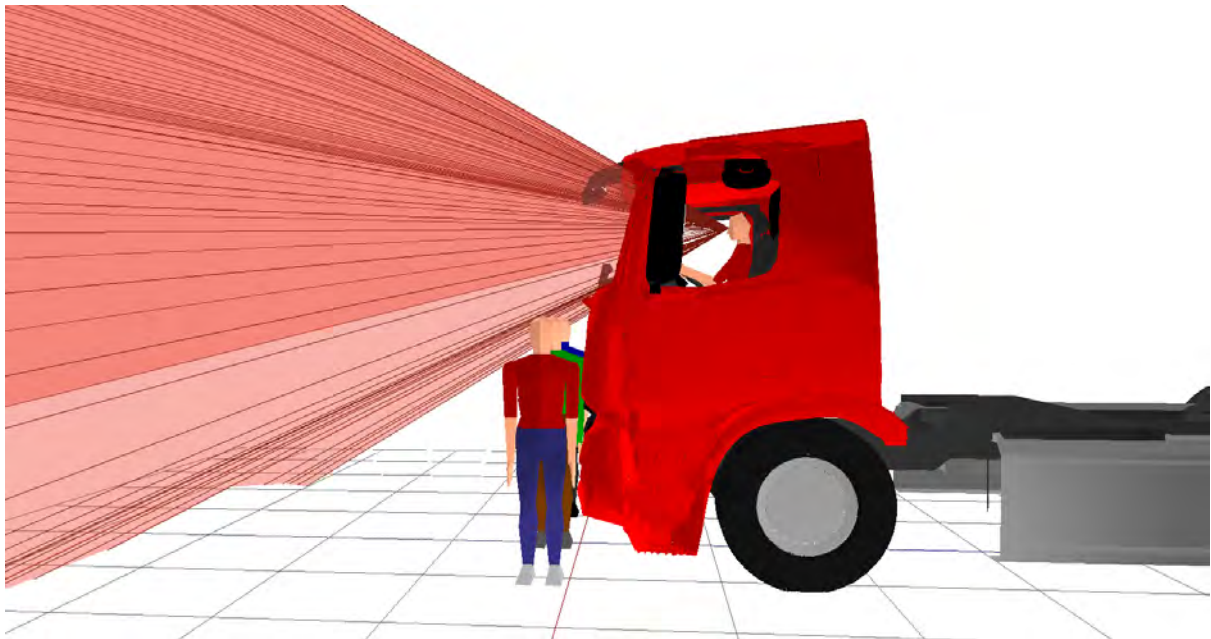


Figure 280. 3D view showing that the three human models can stand 95mm (blue), 0mm (green) and 40mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture

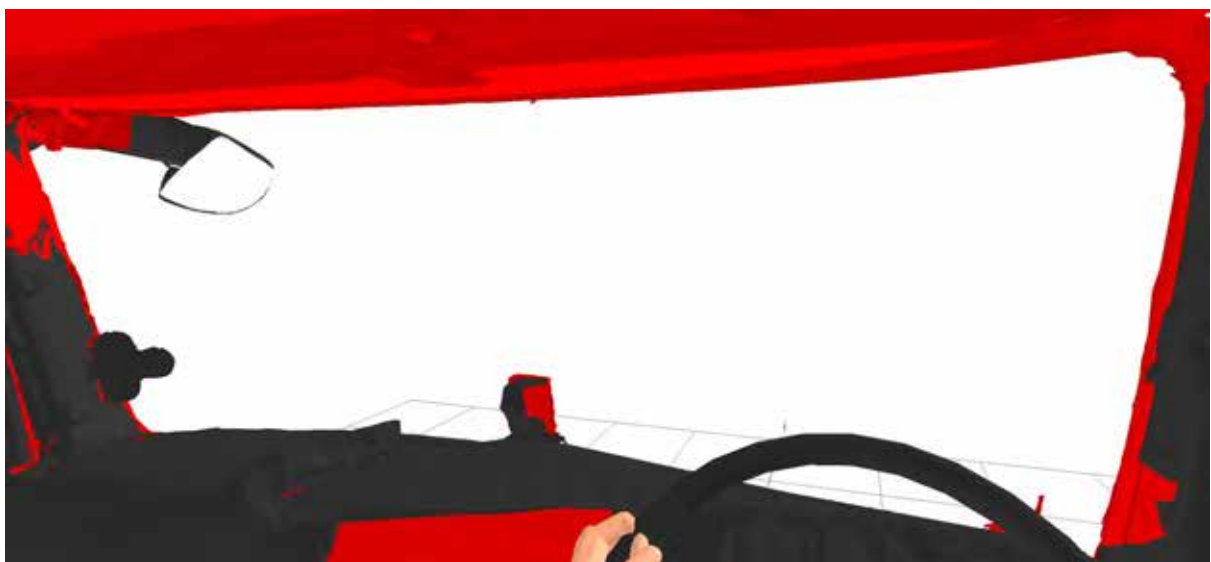


Figure 281. The view from the driver's eyes clearly shows the three pedestrians are hidden from view.

For forwards visibility of the pedestrians all three can just be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 95mm from the front of the vehicle and the left (red) pedestrian is positioned at 40mm from the front of the vehicle. The right pedestrian is obscured by the steering wheel and steering wheel adjustment and the design of the steering wheel itself will impact upon this result. The central (green) pedestrian is hidden from view but is just touching the front of the cab (positioned at 0mm). Thus it is possible for a pedestrian of 50th %ile UK male height or shorter to be hidden from direct vision to the front of the Mercedes Antos N3.

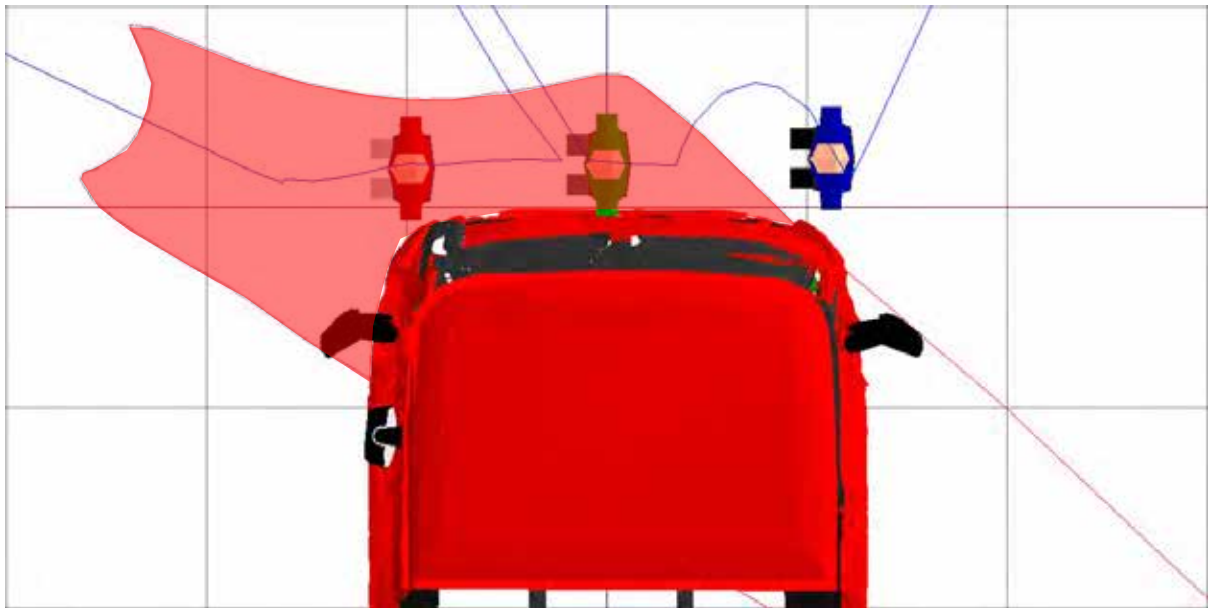


Figure 282. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian



Figure 283. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 283 shows that the pedestrian to the left (red) and centre (green) would be completely visible and the pedestrian to the right (blue) would be visible from the neck down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide a pedestrian to the front of the Mercedes Antos N3.

4.1.8.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

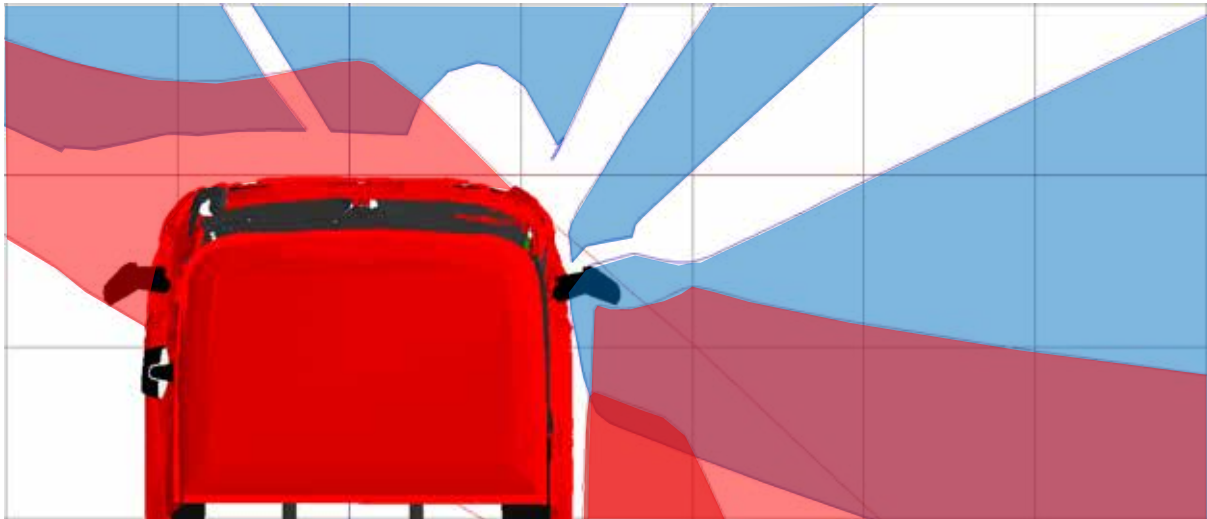


Figure 284. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

From Figure 284 it is clear that the visible areas at a height representative of a cyclist are closer to the vehicle than those taken at ground level shown in Figure 270. Figure 285, Figure 286 and Figure 287 show that whilst there is a small gap between the offside of the vehicle and the near edges of the visible areas, there is insufficient space in which a cyclist could be hidden from direct view.

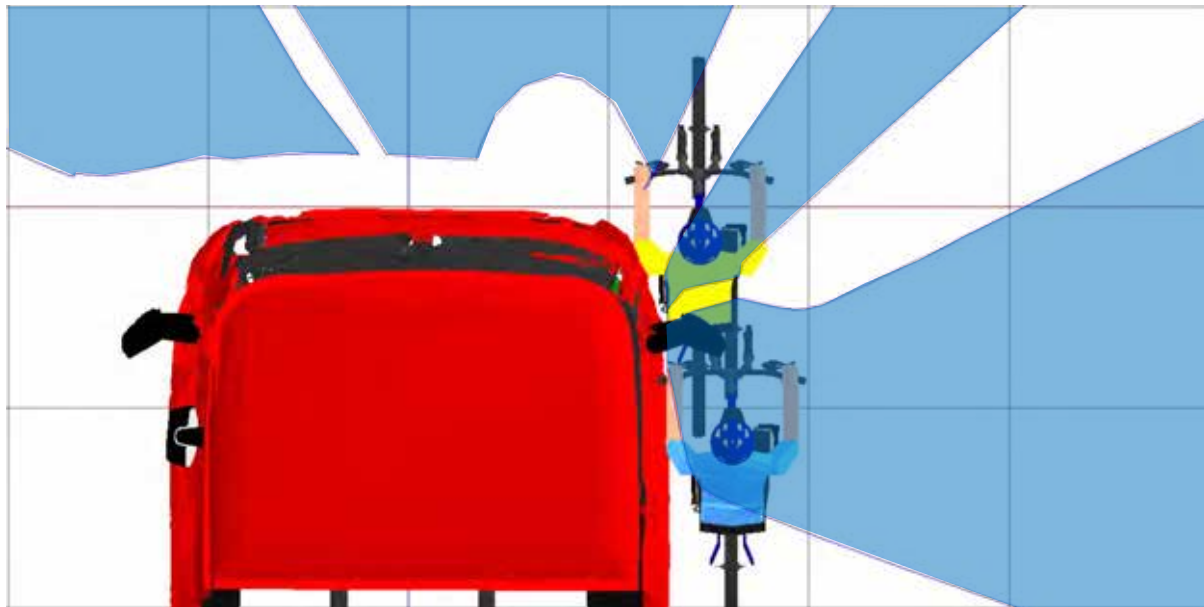


Figure 285. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist

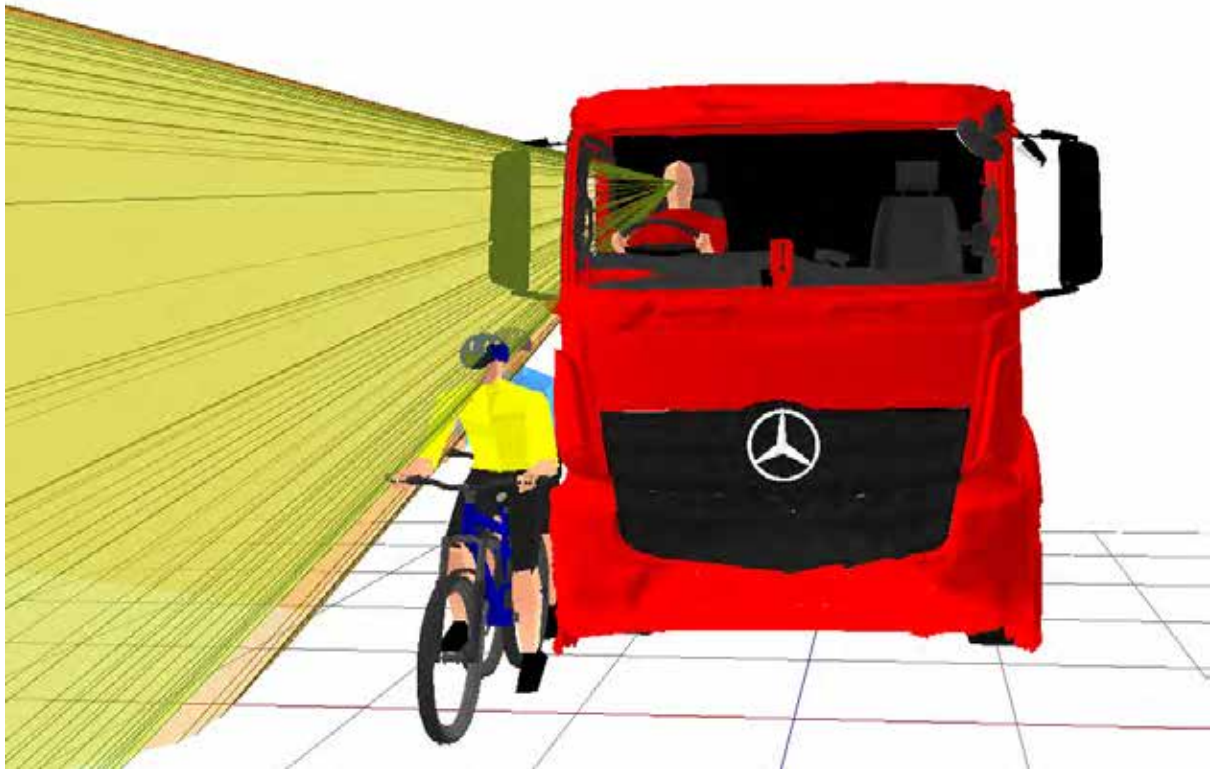


Figure 286. 3D view showing that both cyclists cannot be hidden from direct vision to the offside of the Mercedes Antos N3

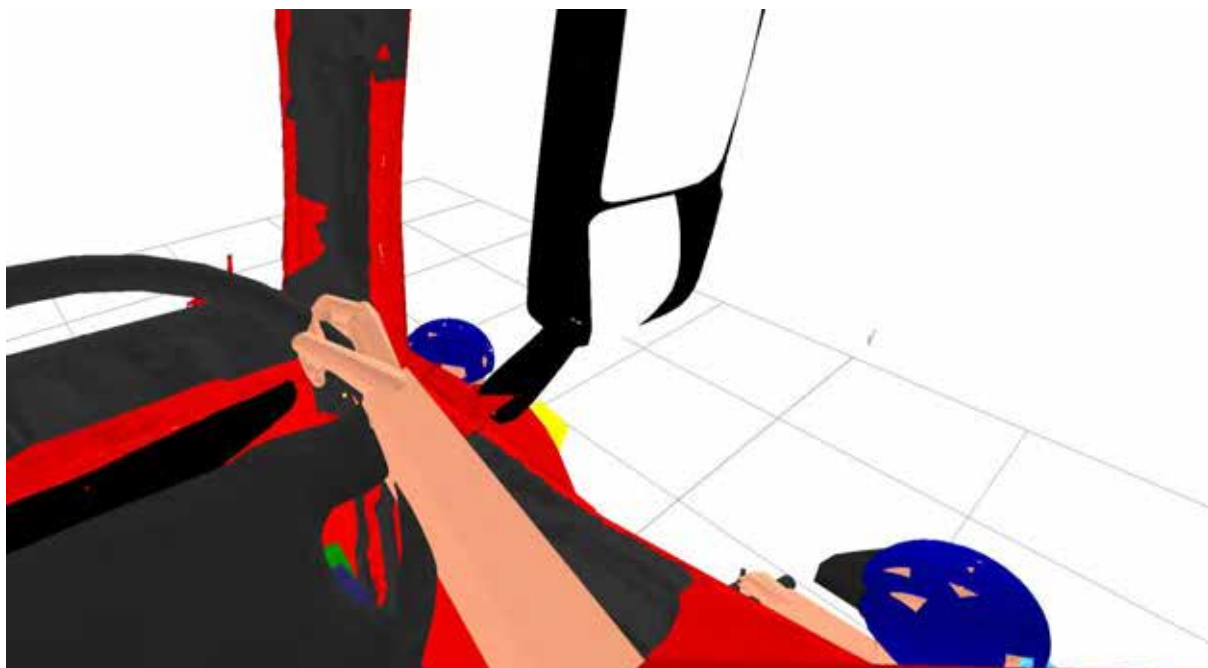


Figure 287. The view from the driver's eyes clearly shows the two cyclists are visible, even when positioned against the side of the vehicle.

For offside visibility of the cyclists there is no blind spot that could obscure a cyclist. Figure 287 shows that even with the cyclists touching the side of the cab they would still be visible to the driver.

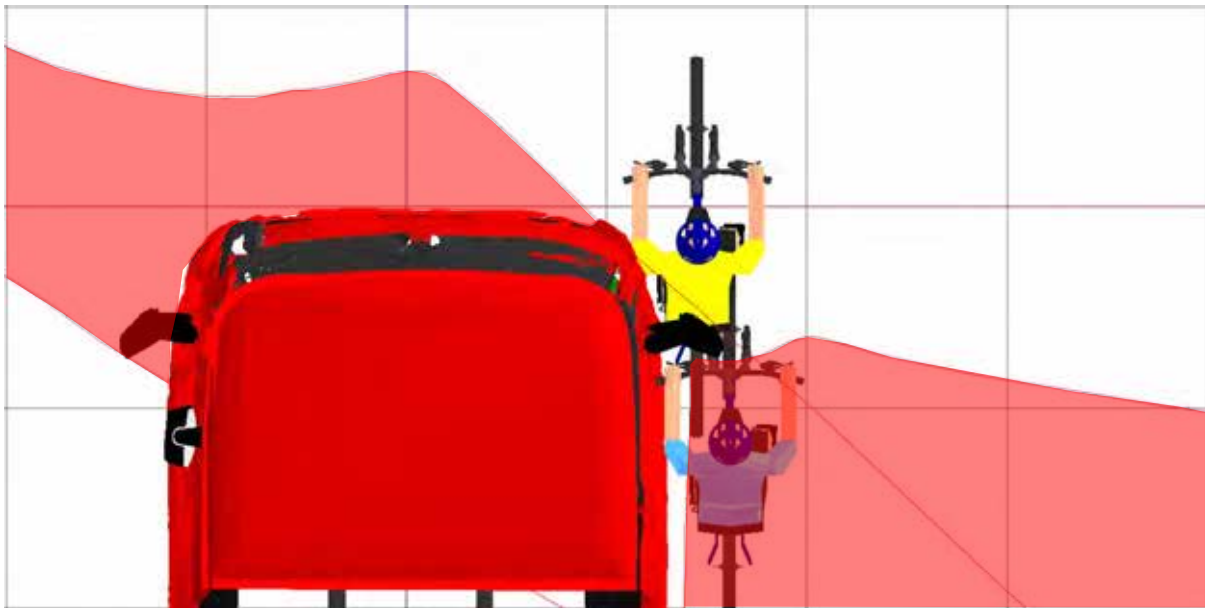


Figure 288. A plan view of the two human models that represent a cyclist moving up the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

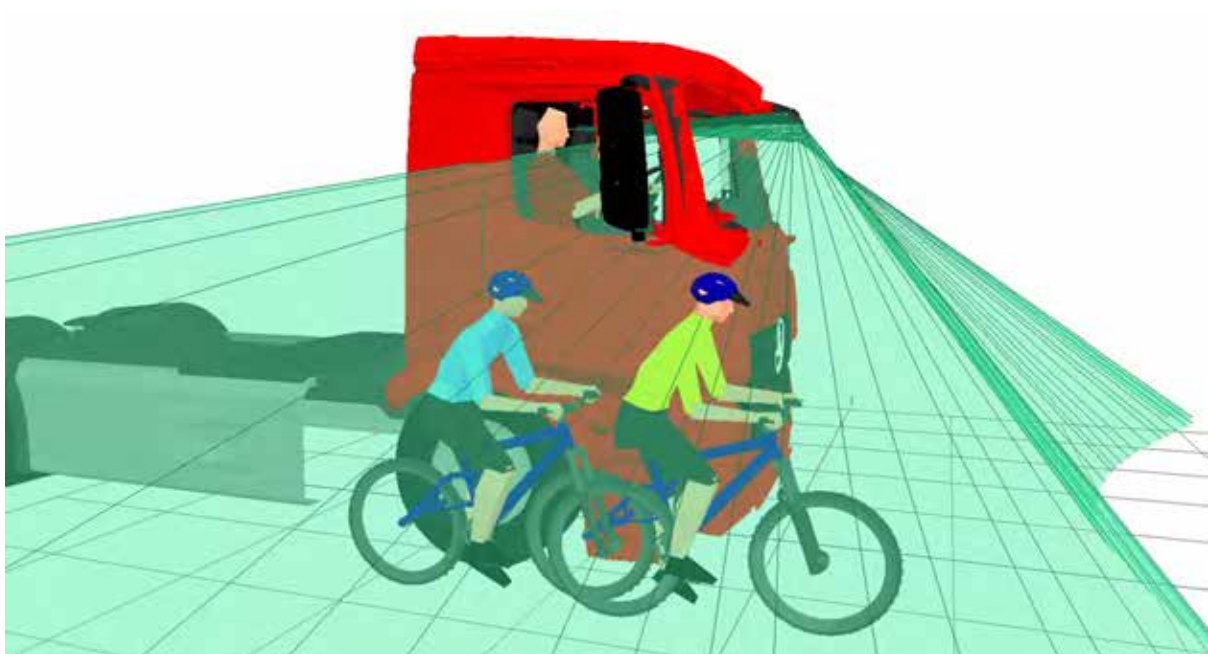


Figure 289. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

In addition to being visible through direct vision to the offside of the vehicle both cyclists are visible in the Class IV and Class VI mirrors. Figure 289 shows that theoretically both cyclists are visible in the Class VI mirror. However, due to limitations of the projection technique, the rear cyclist (blue) would actually be hidden from view by the cab of the vehicle. Part of the front (yellow) cyclist would be visible in the Class VI mirror including their arms and the front of the bicycle.

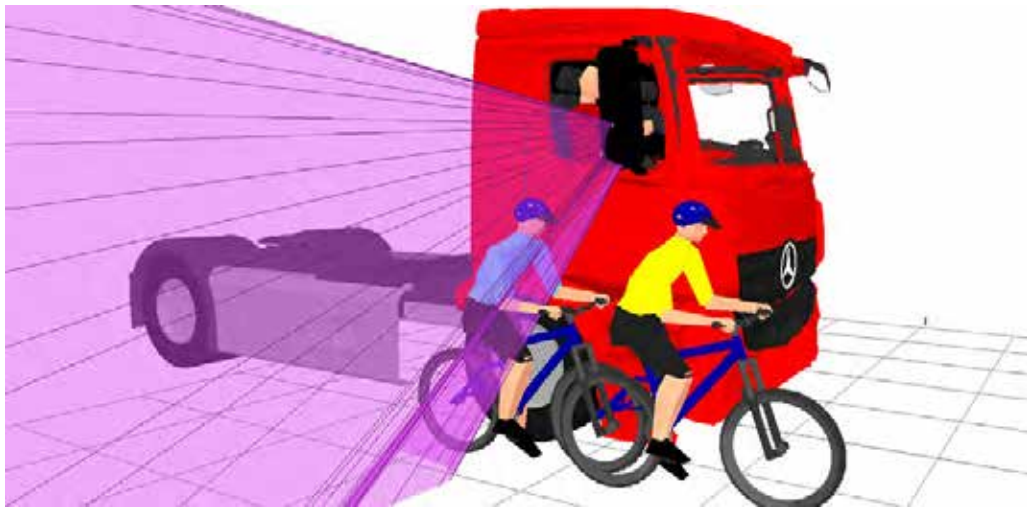


Figure 290. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 290 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and torso, upper arms and right thigh. The projections show that for a driver using their mirrors, it is not possible to hide a cyclist as defined in the positions shown to the offside of the Mercedes Antos N3.

4.1.8.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

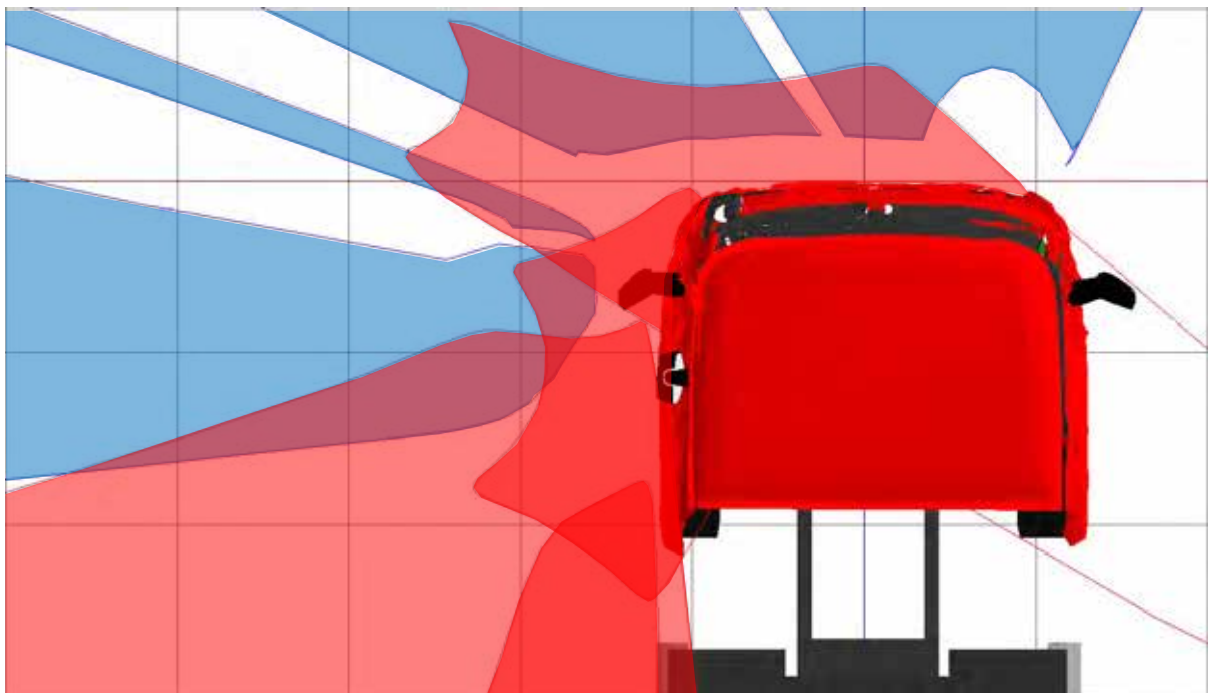


Figure 291. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 292 and Figure 293 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

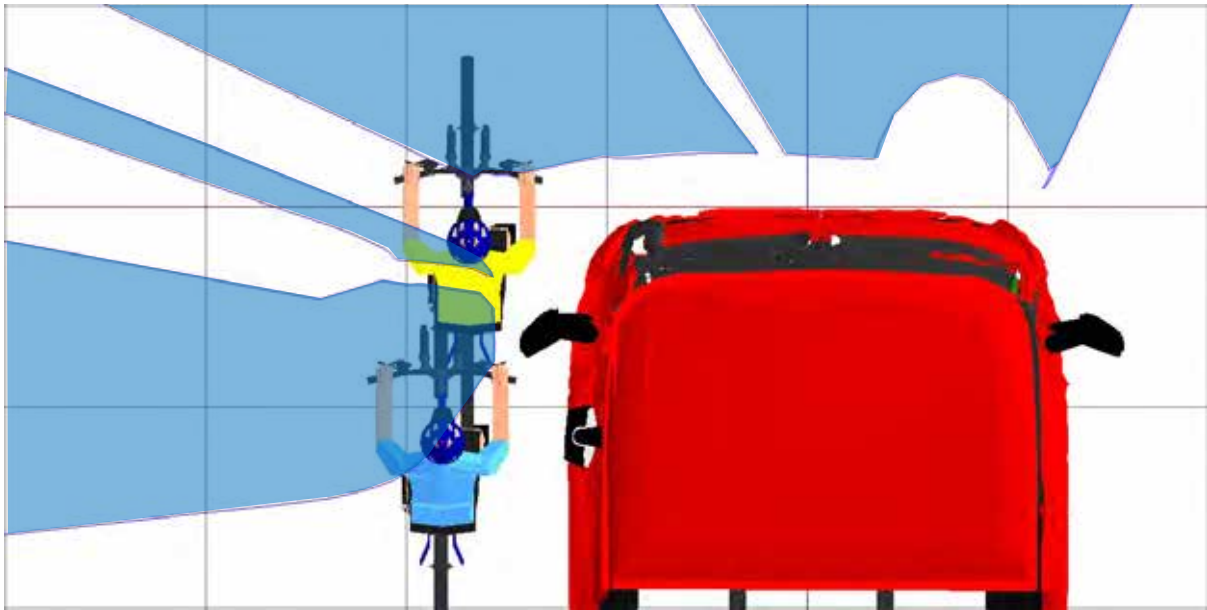


Figure 292. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

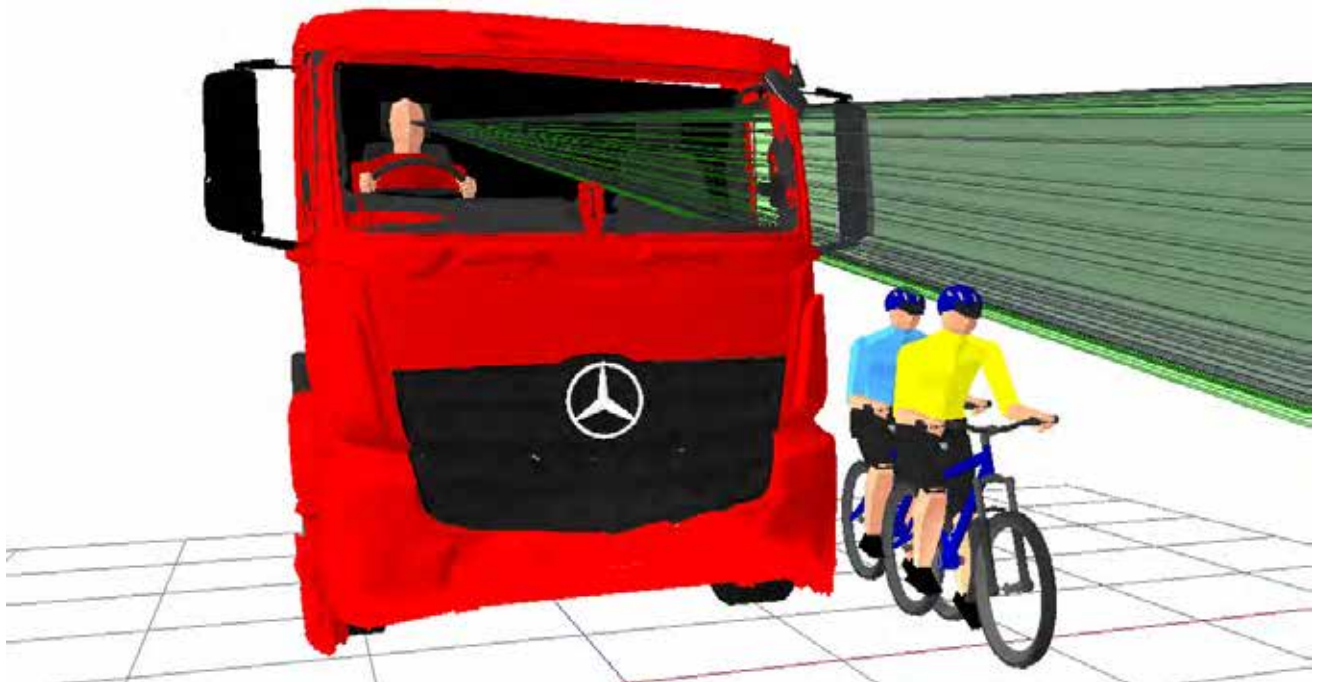


Figure 293. 3D view showing that the two human models can be positioned 359mm (yellow) and 300mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 294. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 359mm from the side of the vehicle, the rear (blue) cyclist is positioned at 300mm from the side of the vehicle.

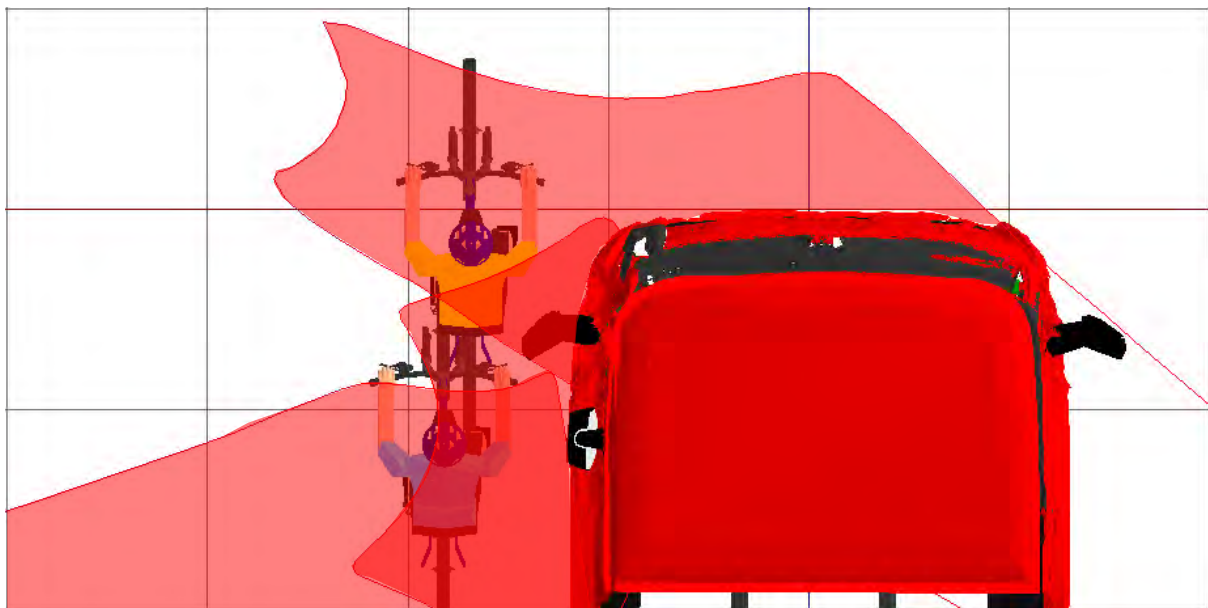


Figure 295. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

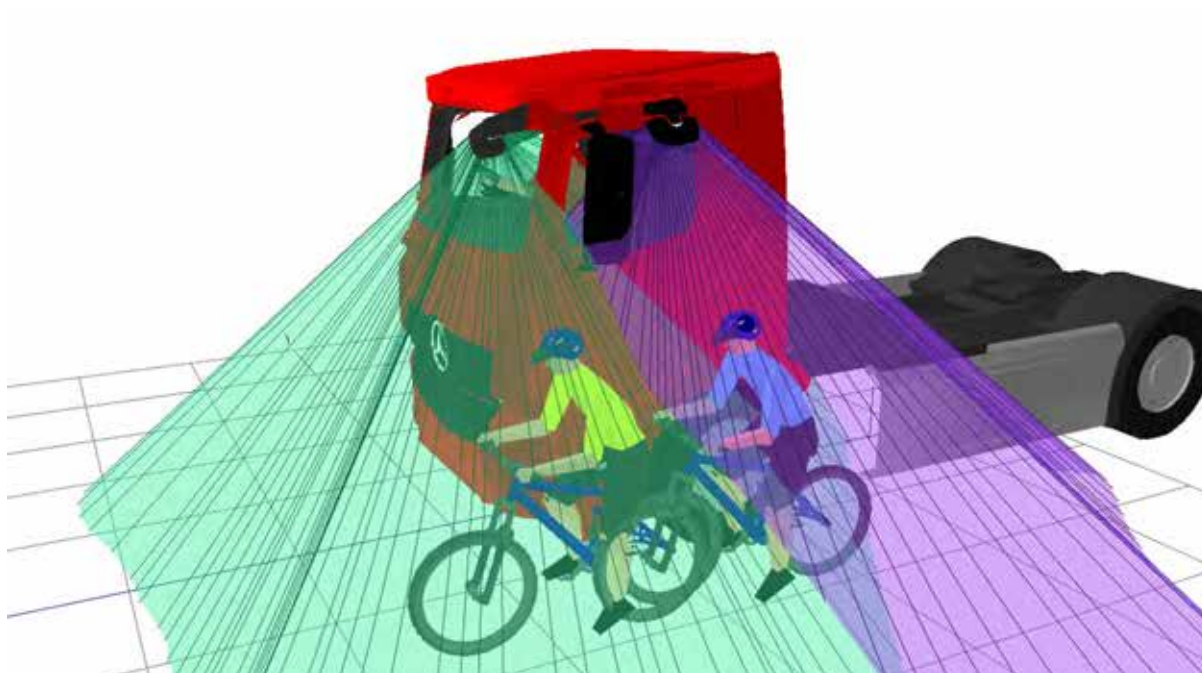


Figure 296. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 296 shows that the front (yellow) cyclist is visible in the Class V and Class VI mirrors. The front (yellow) cyclist is completely visible in the Class VI mirror and from the neck down in the Class V mirror. The rear (blue) cyclist's arms, legs and front of their bike are visible in the Class VI and completely visible in the Class V mirror.



Figure 297. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is visible in the projection of the Class IV mirror

Figure 297 shows that the rear of the two cyclists (blue) is also visible in the projection of the nearside Class IV mirror. The cyclist would only be partially visible including the head and back of the torso of the rider. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the nearside of the Mercedes Antos N3.

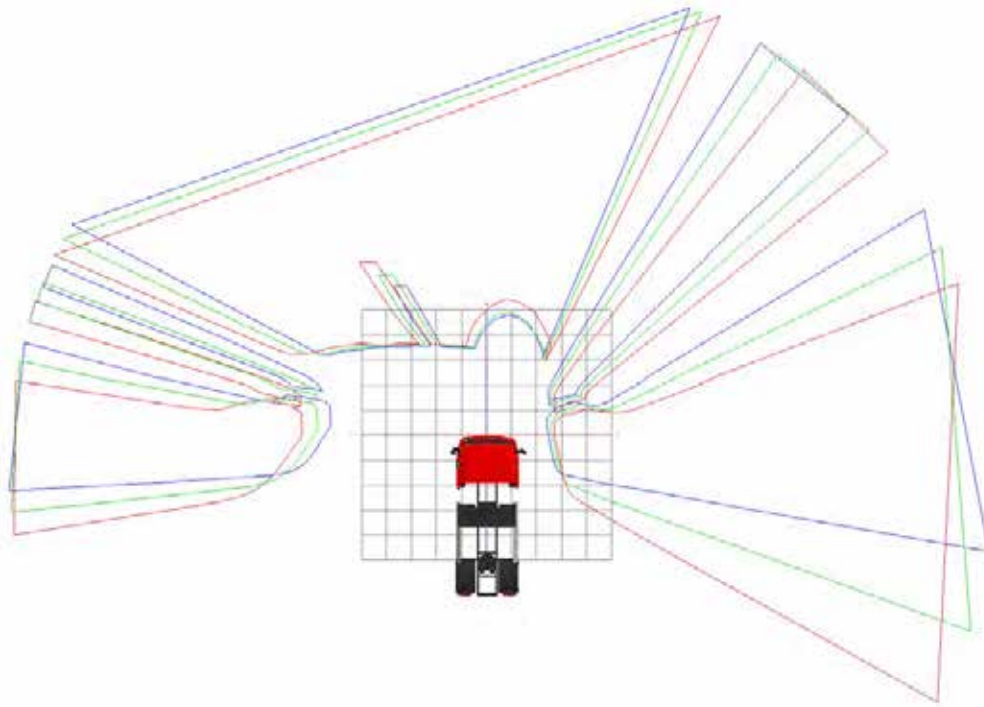
4.1.8.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

Figure 298. A plan view of the projection of the windscreen and side windows onto the ground plane for the Mercedes Antos N3 for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.1.9 MERCEDES AROCS N3G CONSTRUCTION - 50TH %ILE MALE DRIVER



Figure 299. Evaluation model of Mercedes Arocs N3G Construction variant vehicle

4.1.9.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 300 shows a top-down view of all of the window projections for the Mercedes Arocs N3G cab with a 50th %ile UK Male Driver. The image on the right of Figure 300 shows the areas of these projections that intersect with the ground. Figure 301 shows the same for the the mirror projections and Figure 302 shows the two combined. Any area outside of the coloured projections is effectively a blind spot at the ground plane.

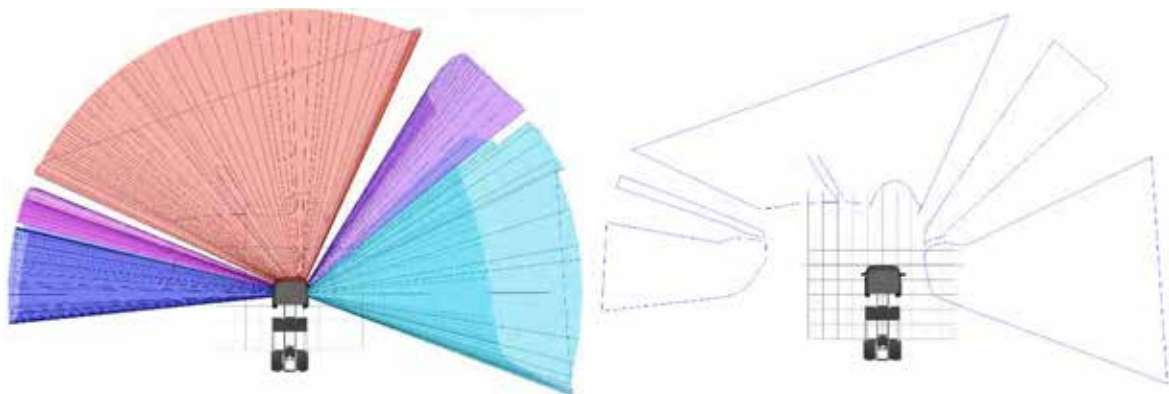


Figure 300. The projection of the windscreen and window apertures at the ground plane for the Mercedes Arocs N3G

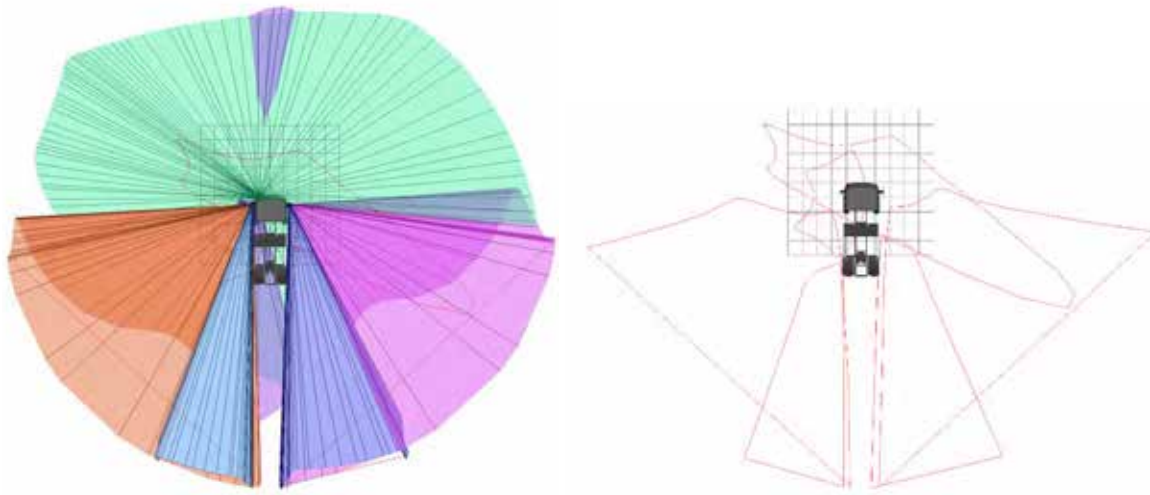


Figure 301. The projection of the mirrors at the ground plane for the Mercedes Arocs N3G

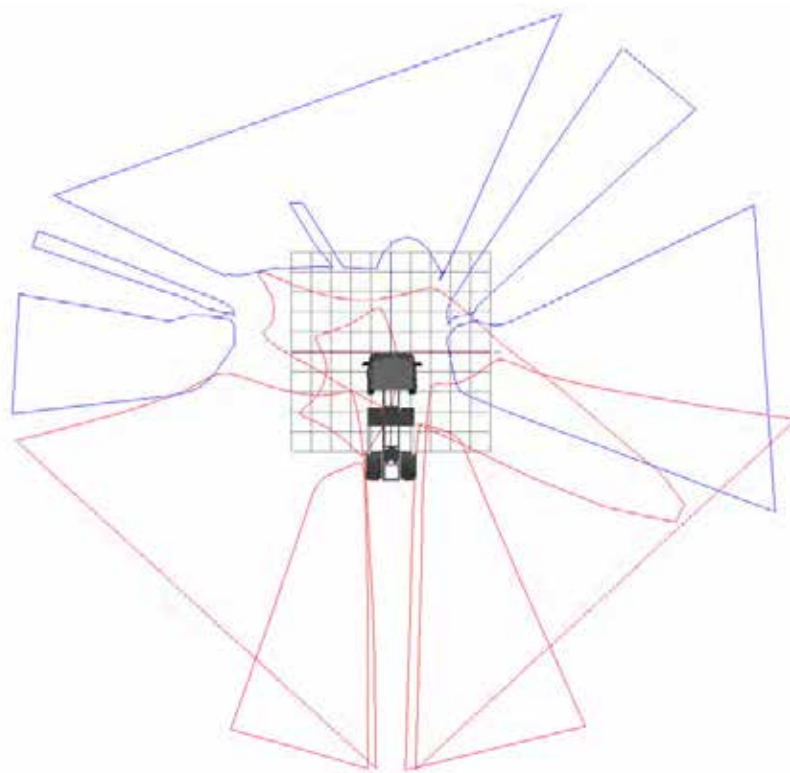


Figure 302. The combined direct and indirect vision projections at the ground plane for the Mercedes Arocs N3G

Figure 303 through Figure 307 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 308 and Figure 309 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.



Figure 303. A side view of the windscreen aperture projection for the Mercedes Arocs N3G



Figure 304. Frontal views of the off side and near side door window projections for the Mercedes Arocs N3G



Figure 305. A side view of the Class VI mirror projection for the Mercedes Arocs N3G



Figure 306. A front view of the Class V mirror projection for the Mercedes Arocs N3G

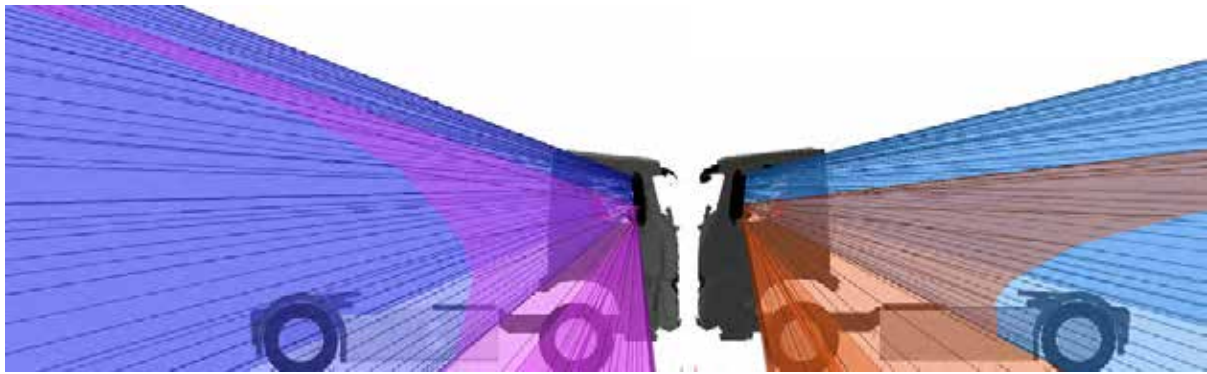


Figure 307. Side views of the combined Class II and Class IV mirror projections for the Mercedes Arocs N3G

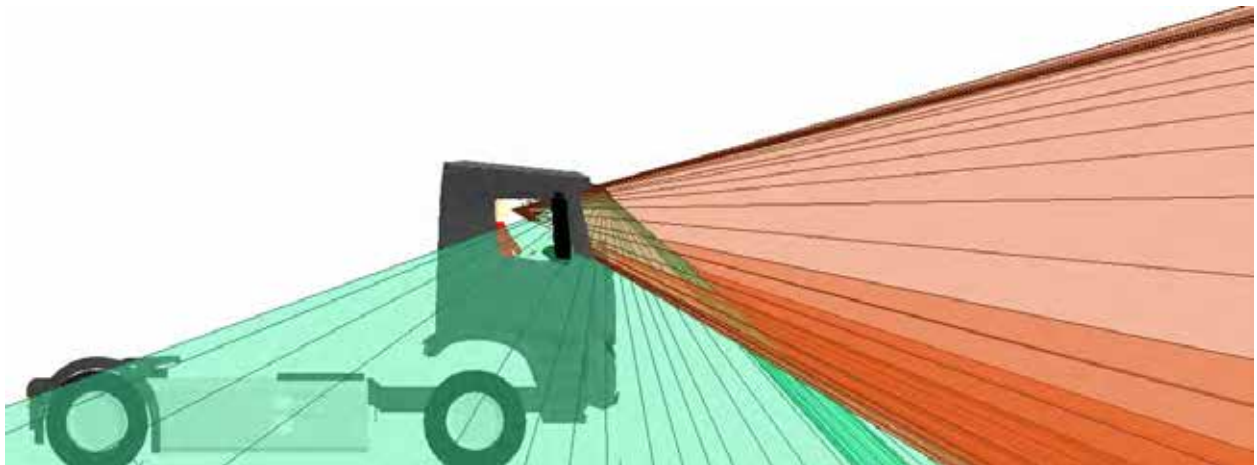


Figure 308. Combined projection of the windscreen and Class VI mirror to the front of the Mercedes Arocs N3G

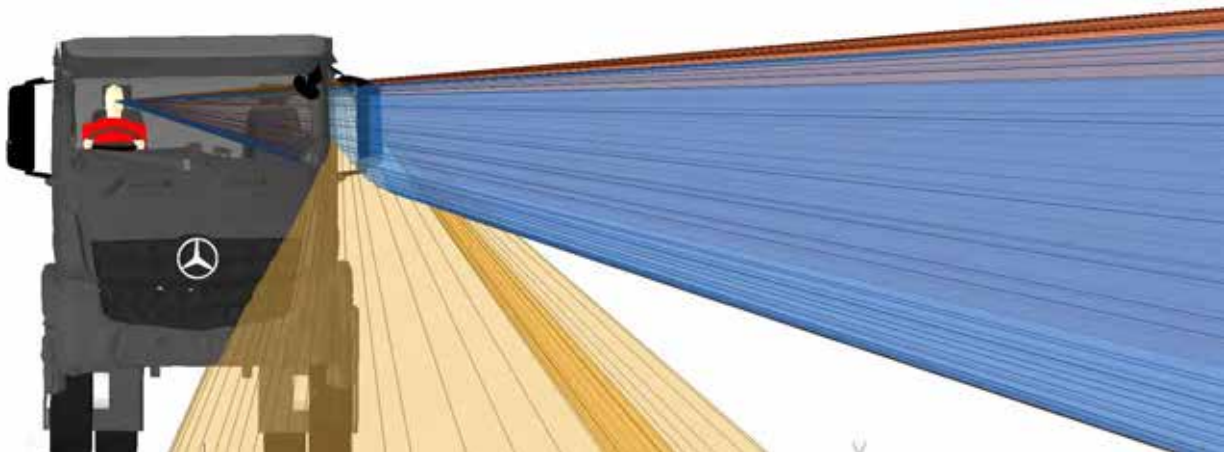


Figure 309. Combined projection of the near side windows and Class V mirror to the side of the Mercedes Arocs N3G

4.1.9.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 310 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

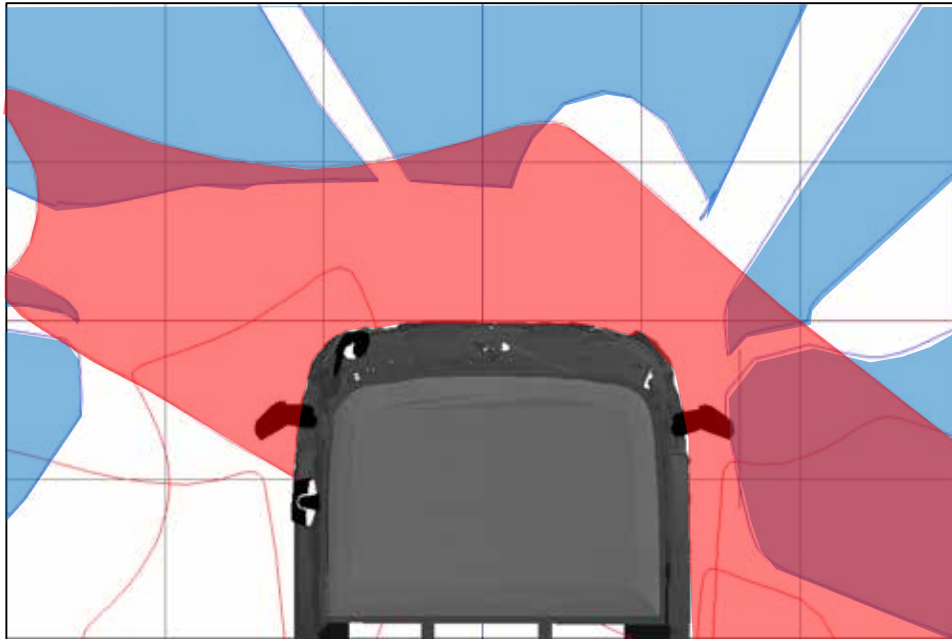


Figure 310. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From Figure 310 it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 302. However Figure 311 and Figure 312 show that there is a clear space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.

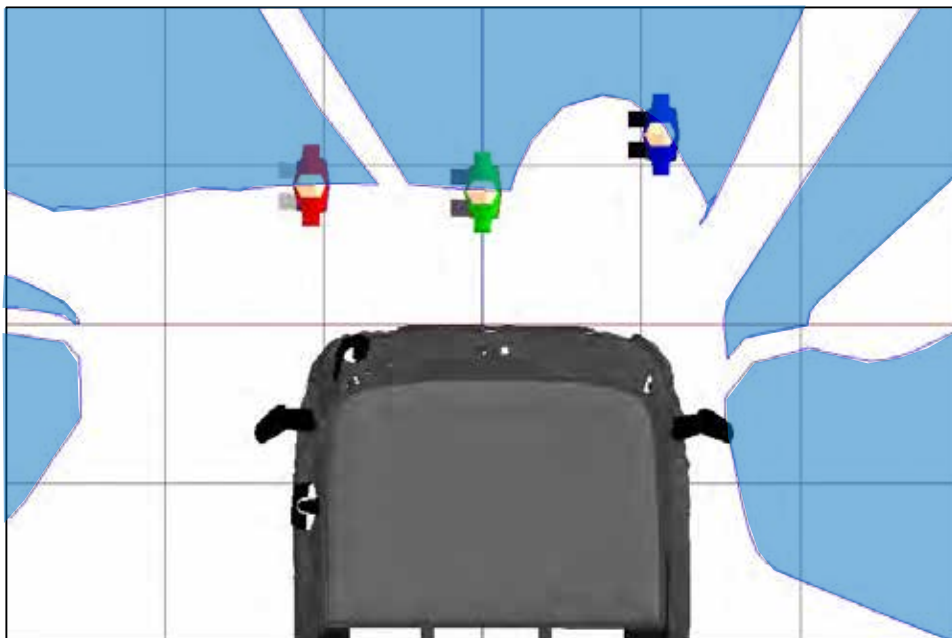


Figure 311. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

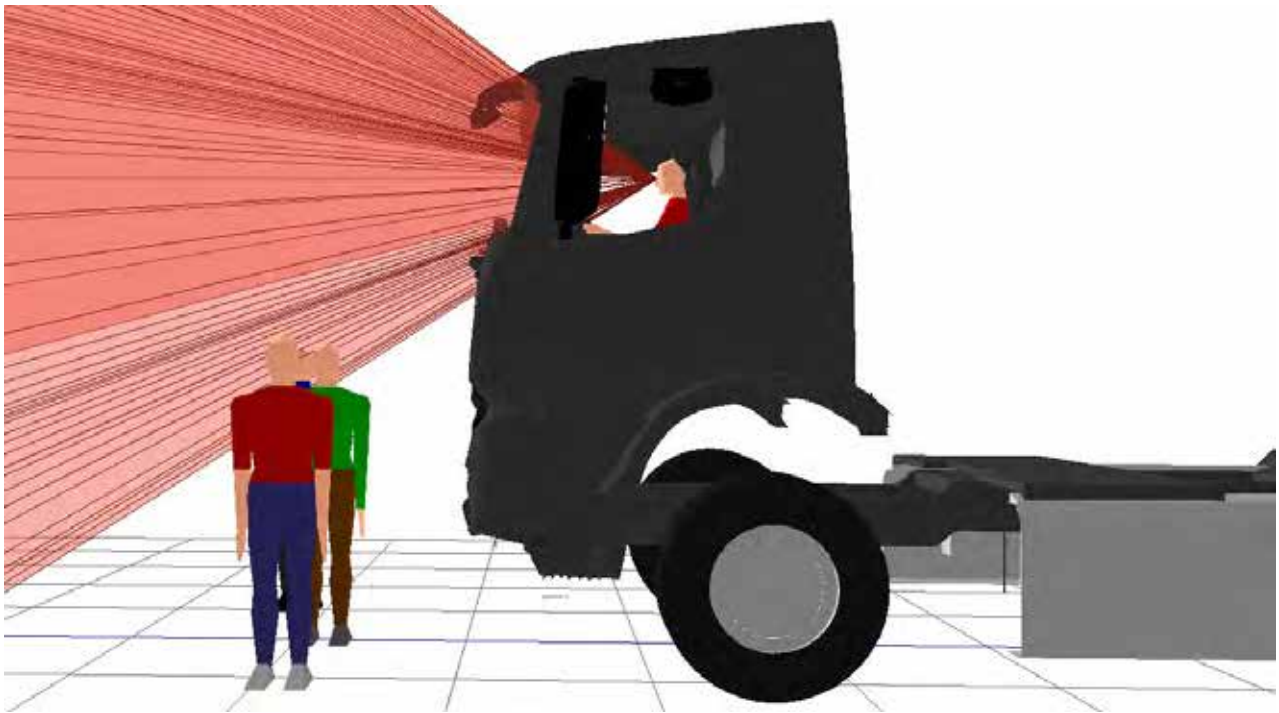


Figure 312. 3D view showing that the three human models can stand 1034mm (blue), 623mm (green) and 751mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 313. The view from the driver's eyes clearly shows the three pedestrians are hidden from view.

For forwards visibility of the pedestrians all three can be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 1034mm from the front of the vehicle, the left (red) pedestrian is positioned at 751mm from the front of the vehicle and the central (green) pedestrian is positioned at 623mm from the front of the vehicle. These figures represent a considerable distance between the pedestrians and the front of the vehicle in which pedestrians would presumably be comfortable to walk, with the potential of being unseen. It is also important to note the significant increase in the blind spot to direct vision due to the increased height of the cab of the Mercedes Arcos N3G over the Antos N3. The maximum distance has increased from 95mm (see Figure 280) to 1034mm from the front of the cab in which a pedestrian can be hidden.

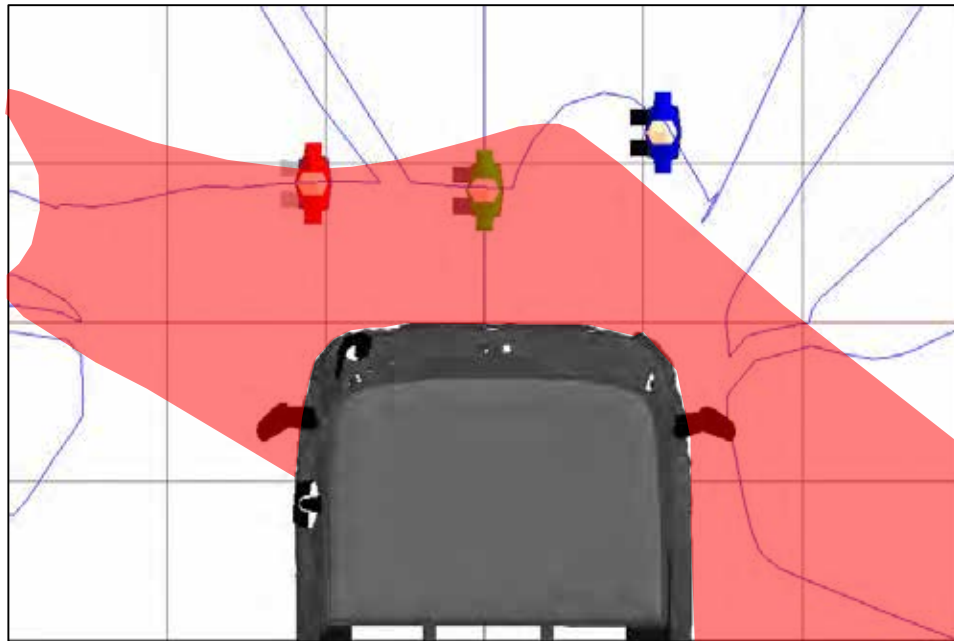


Figure 314. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian



Figure 315. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 315 shows that the pedestrian to the left (red) and centre (green) would be completely visible and the pedestrian to the right (blue) would be visible from the neck down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide a pedestrian as defined to the front of the Mercedes Arocs N3G.

4.1.9.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

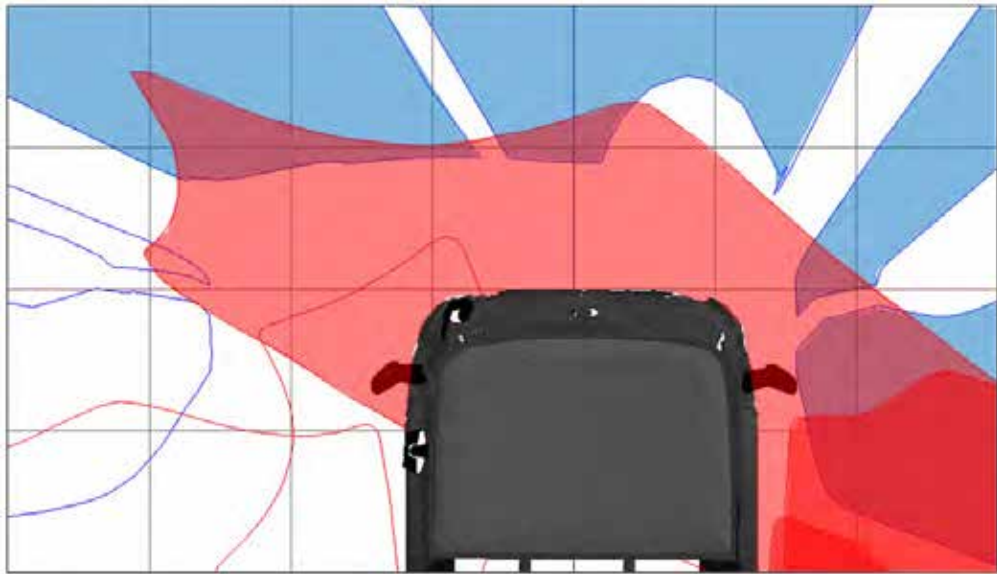


Figure 316. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 317 and Figure 318 show that a both cyclists can be obscured from the direct vision of the driver, with the front (yellow) cyclist being directly 120mm from the vehicle and the rear (blue) cyclist being directly adjacent to the vehicle.

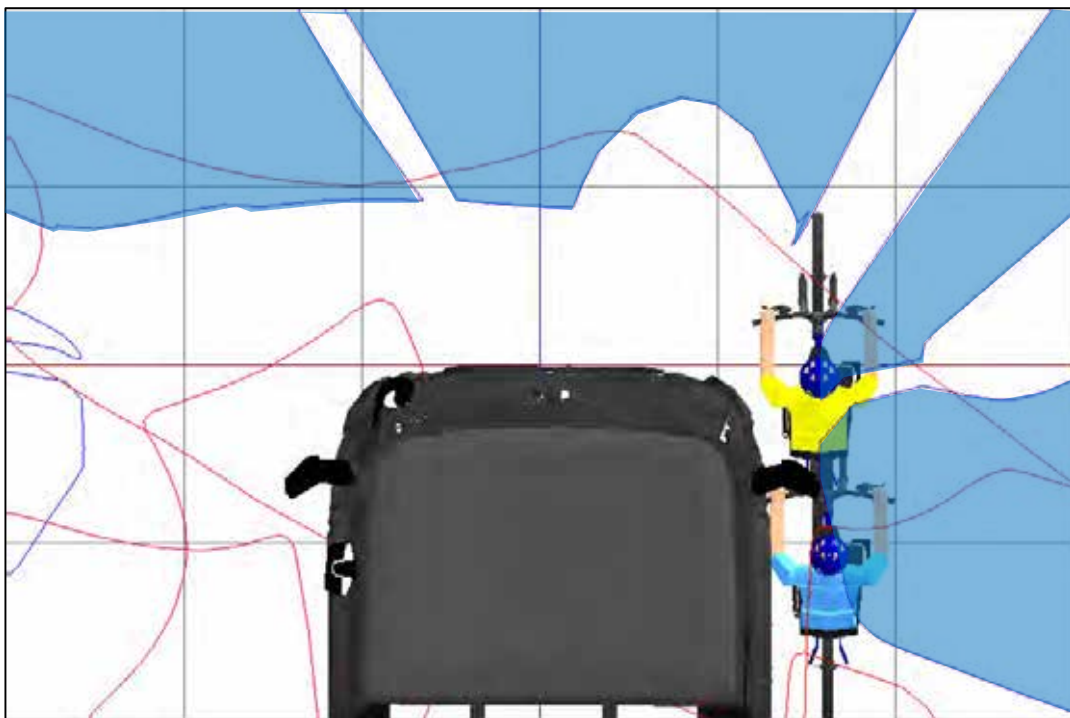


Figure 317. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist

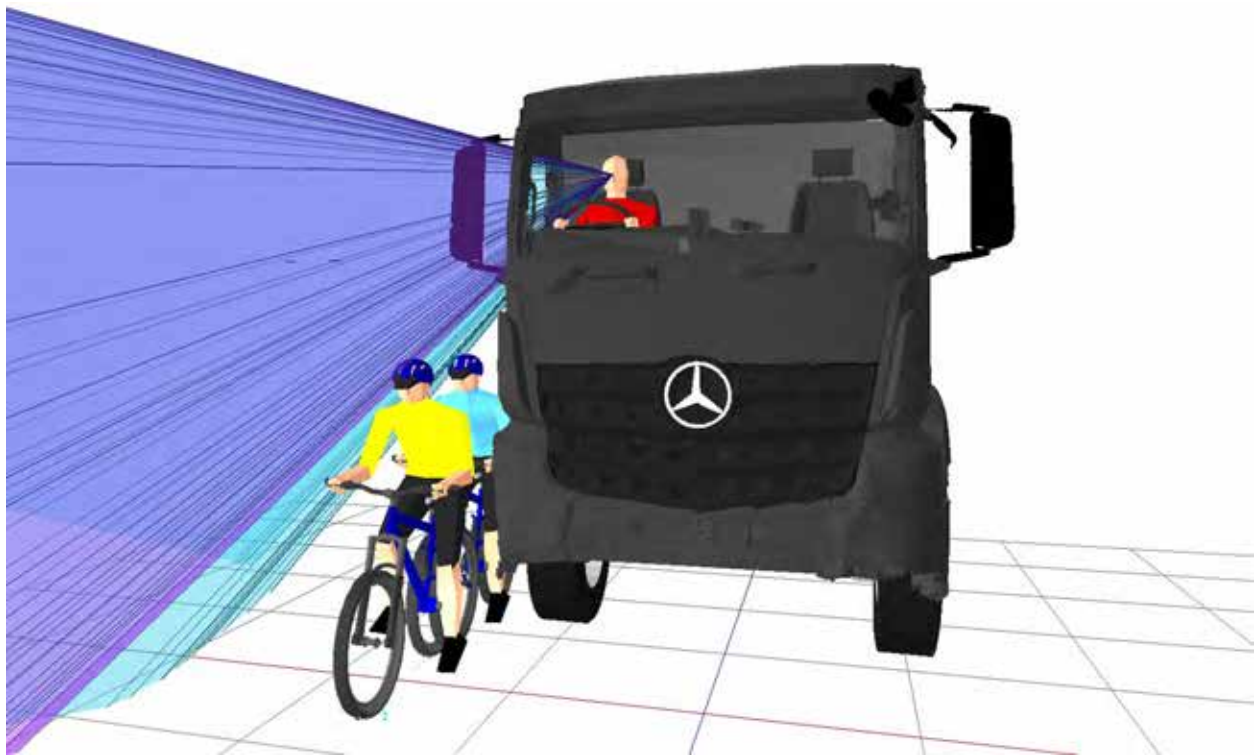


Figure 318. 3D view showing that both cyclists can be hidden from direct vision to the offside of the Mercedes Arocs N3G

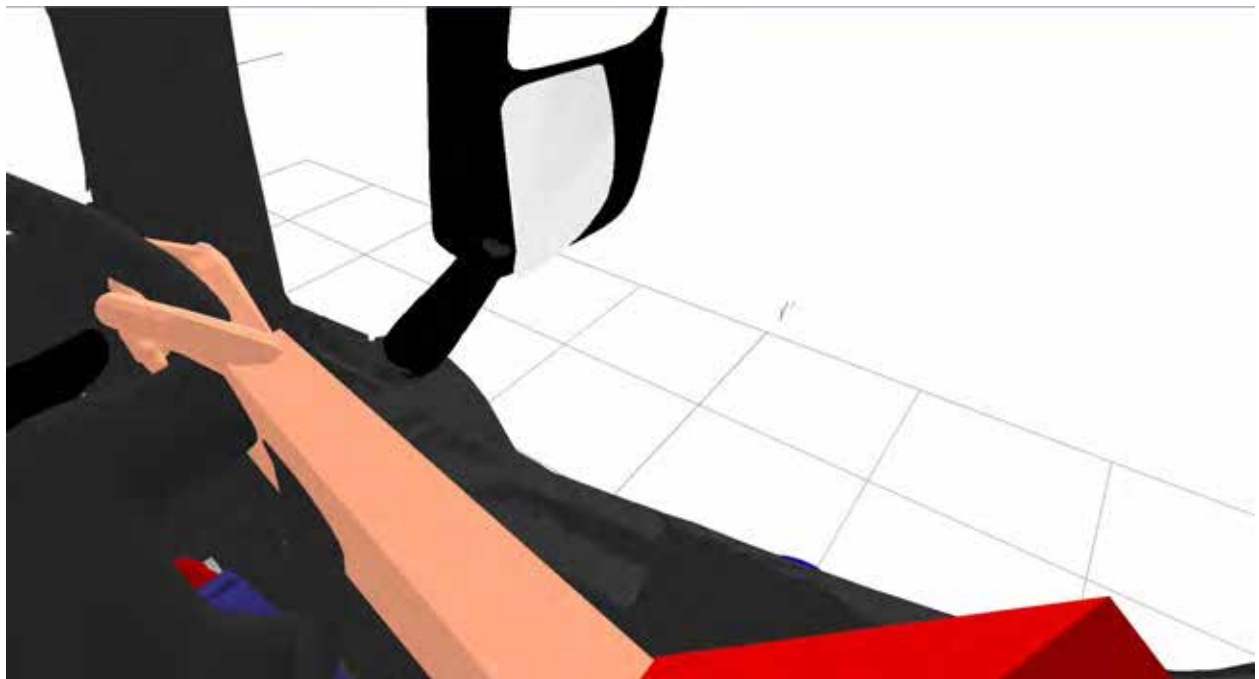


Figure 319. The view from the driver's eyes clearly shows the two cyclists are not visible

For offside direct visibility of the cyclists there is a blind spot that can obscure both cyclists but both cyclists need to be directly adjacent to, or very close to the side of the cab. Figure 319 shows that the cyclists can be obscured from the driver when using direct vision.

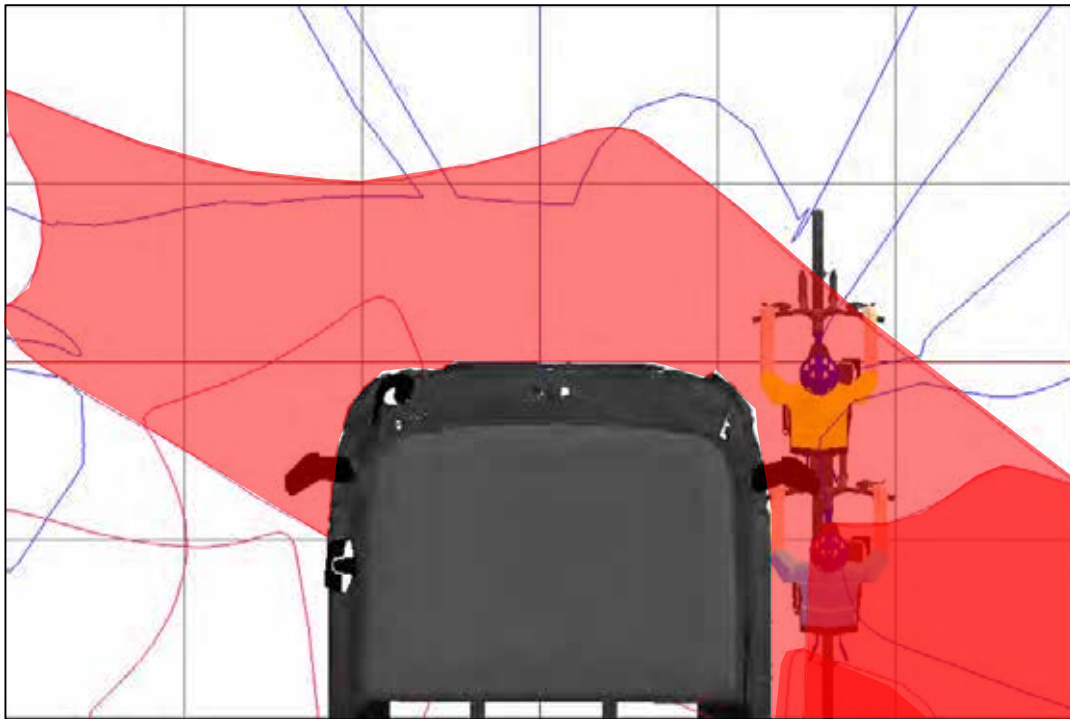


Figure 320. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist



Figure 321. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

The cyclists are visible to the driver through the use of the mirrors. Figure 321 shows that theoretically both cyclists are visible in the Class VI mirror. However, due to limitations of the projection technique, the rear cyclist (blue) would actually be hidden from view by the cab of the vehicle. However, part of the front (yellow) cyclist would be visible in the Class VI mirror including their arms and the front of the bicycle.

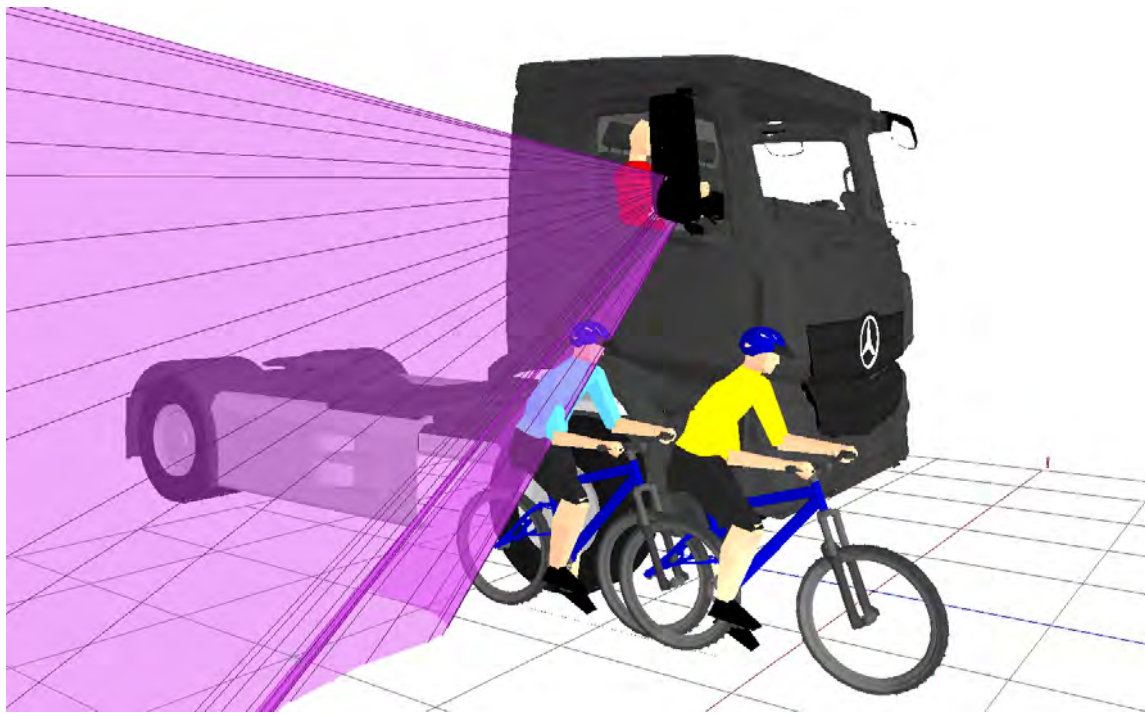


Figure 322. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 322 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and shoulders. The projections show that for a driver using their mirrors, it is not possible to hide a cyclist in the positions shown to the offside of the Mercedes Arocs N3G.

4.1.9.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

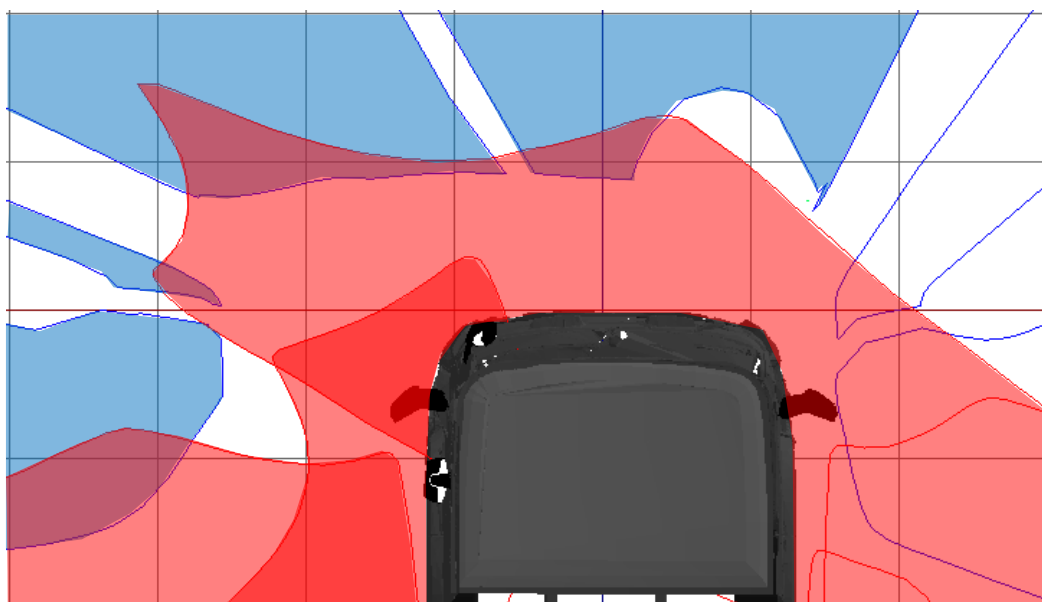


Figure 323. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 324 and Figure 325 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

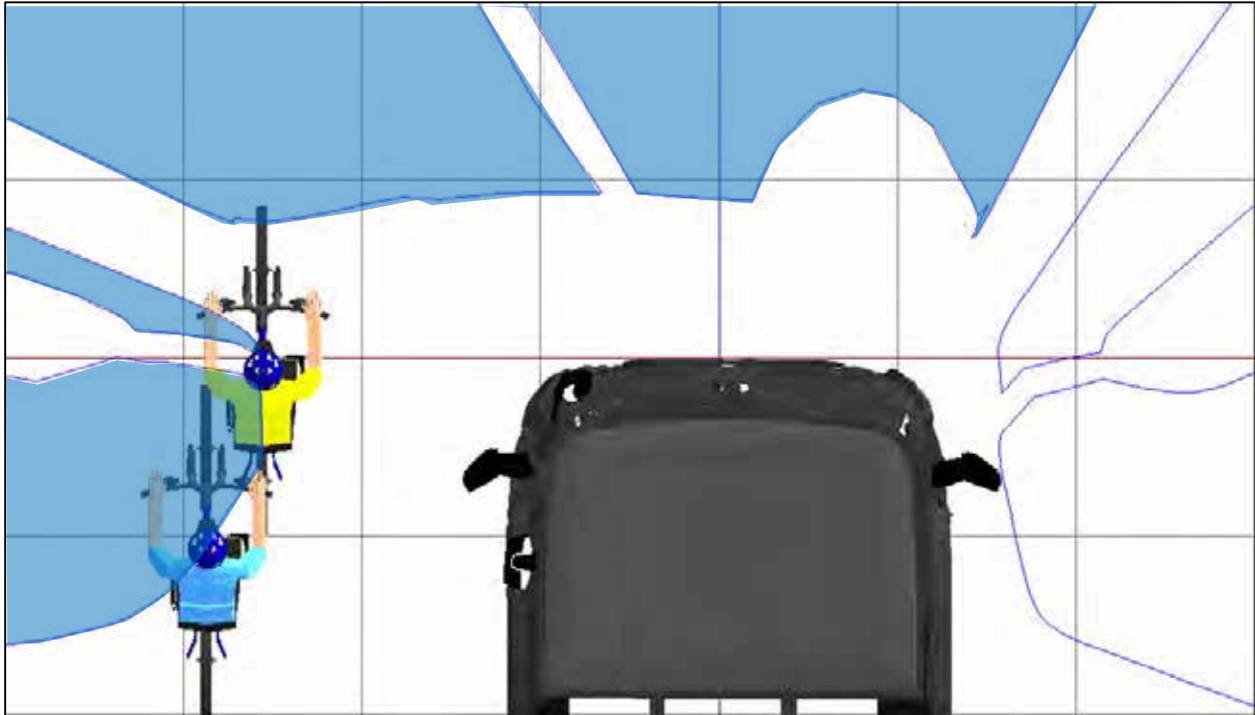


Figure 324. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

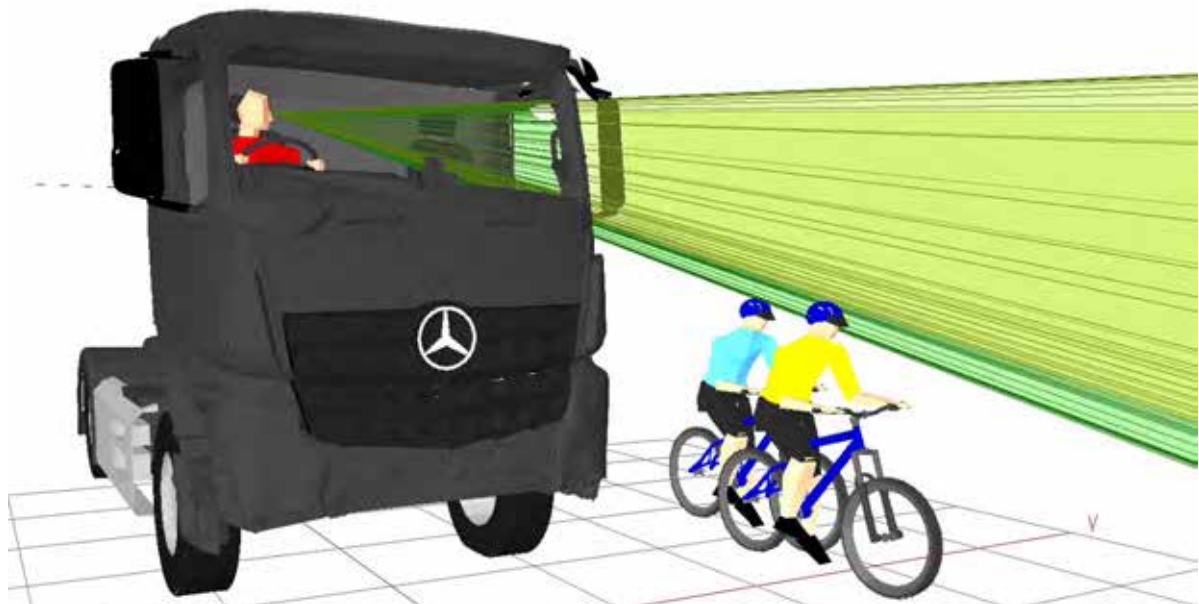


Figure 325. 3D view showing that the two human models can be positioned 1115mm (yellow) and 1356mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture

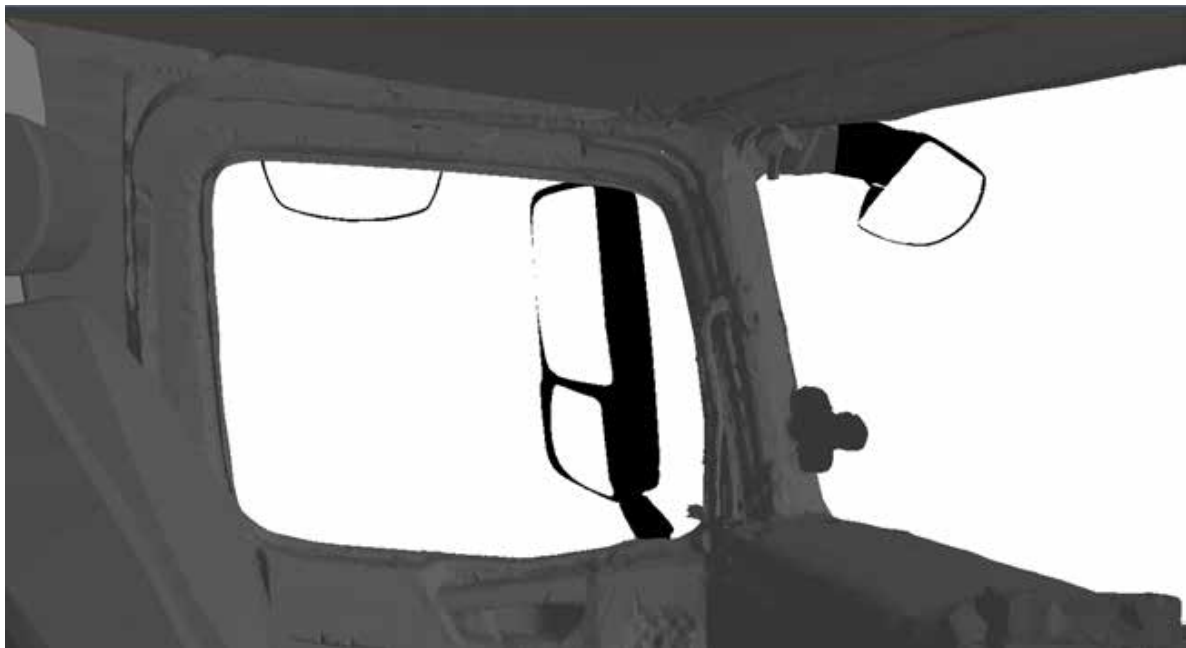


Figure 326. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 1115mm from the side of the vehicle, the rear (blue) cyclist is positioned at 1356mm from the side of the vehicle. As seen in the forward vision assessment there is a significant increase in the blind spot to direct vision due to the increased height of the cab of the Mercedes Arocs N3G over the Antos N3. The maximum distance has increased from 359mm (see Figure 293) to 1356mm from the side of the cab in which a cyclist can be hidden.

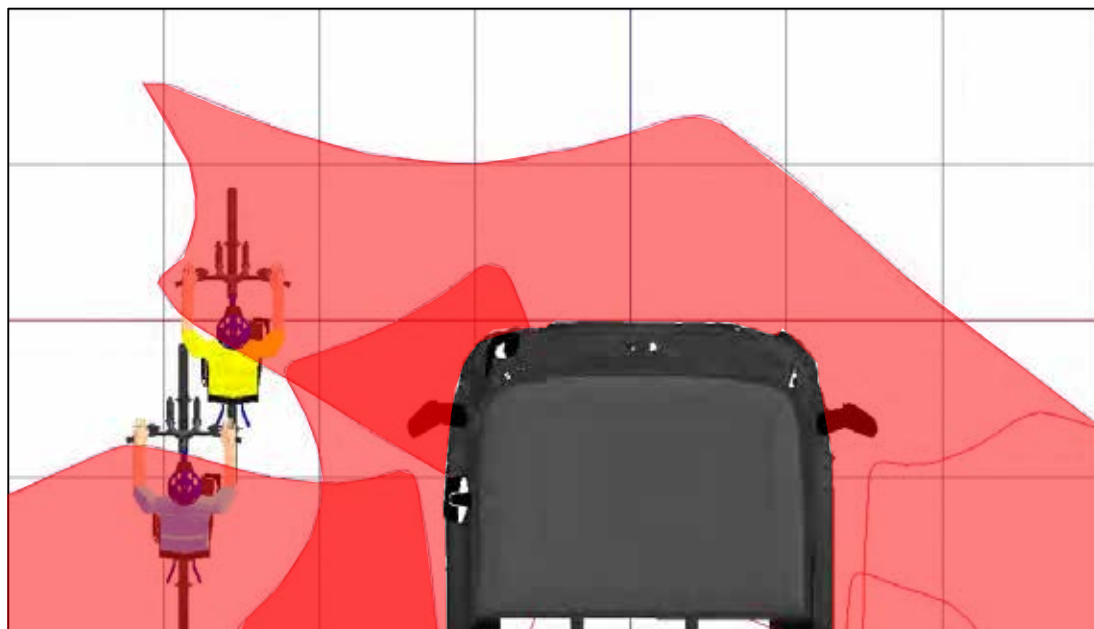


Figure 327. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

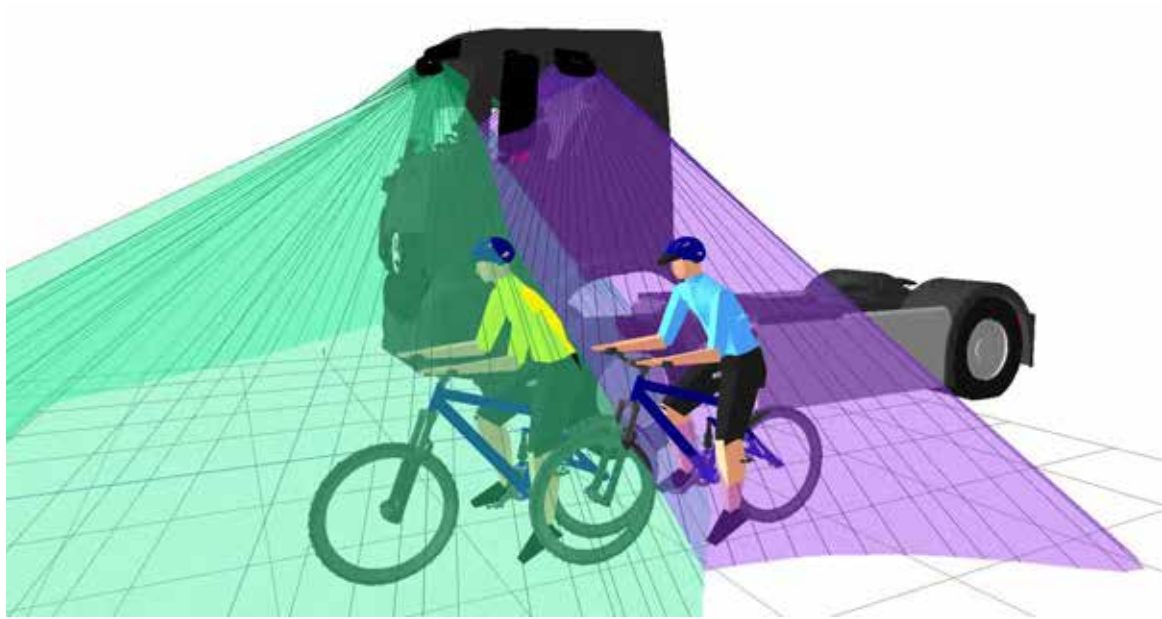


Figure 328. 3D view showing that the Front (yellow) cyclists positioned to the nearside of the vehicle is visible in the projection of the Class V and / or Class VI mirrors, and the rearmost Cyclist is partially visible in the Class V

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 328 shows that the front (yellow) cyclist is visible in the in the Class VI mirror and from the waist down in the Class V mirror. The rear (blue) cyclist would have the front half of their cycle visible in the Class VI and only the lower half of their wheels in the Class V. Figure 329 shows that the rear (blue) cyclist would also be partially visible in the Class IV mirror.



Figure 329. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is partially visible in the Class IV mirror

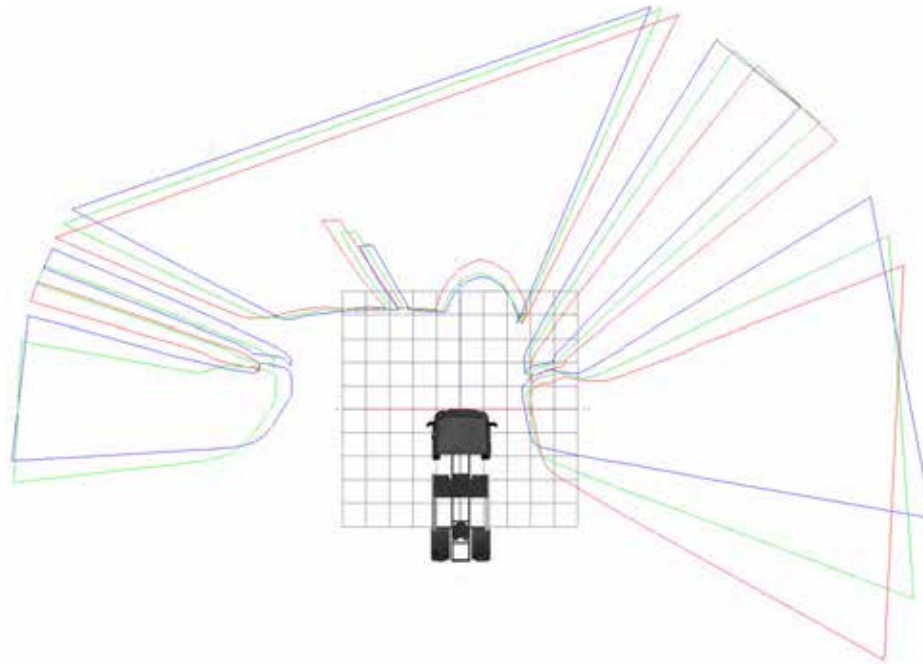
4.1.9.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

Figure 330. A plan view of the projection of the windscreen and side windows onto the ground plane for the Mercedes Arocs N3G for a range of driver eye positions. Red=smallest driver (5th%ile UK female stature), Green=average sized driver (50th%ile UK male stature), and Blue=tallest driver (95th%ile UK male stature).

4.1.10 MERCEDES ACTROS N3 - 50TH %ILE MALE DRIVER

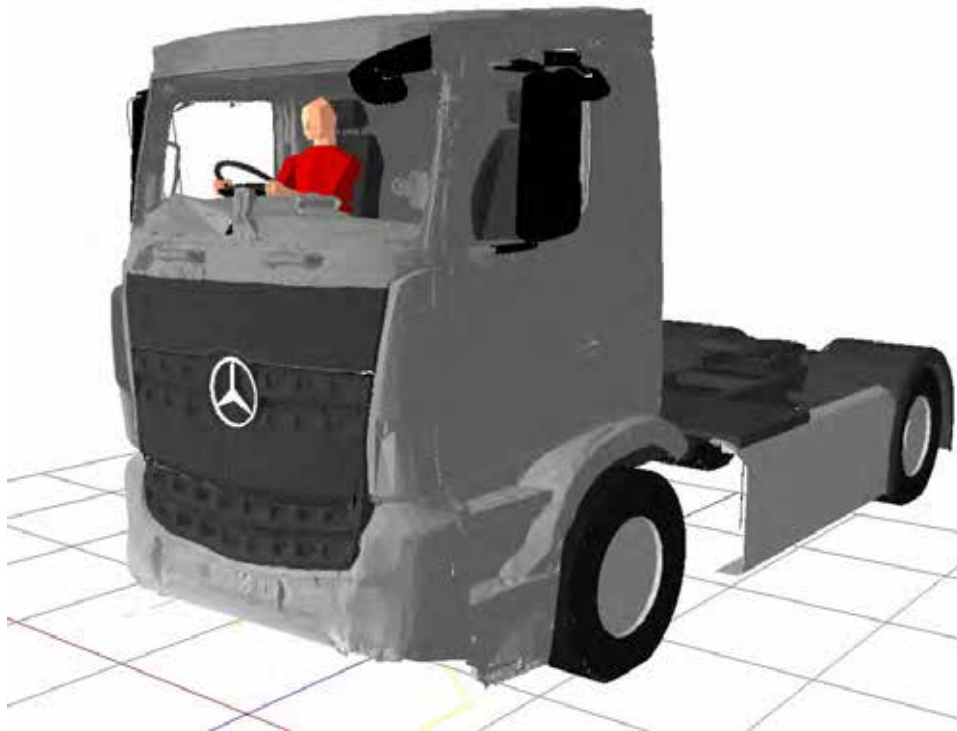


Figure 331. Evaluation model of Mercedes Actros N3 Distribution variant vehicle

4.1.10.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 332 shows a top-down view of all of the window projections for the Mercedes Actros N3 cab with a 50th %ile UK Male Driver. The image on the right of Figure 332 shows the areas of these projections that intersect with the ground. Figure 333 shows the same for the the mirror projections and Figure 334 shows the two combined. Any area outside of the coloured projections is effectively a blind spot at the ground plane.

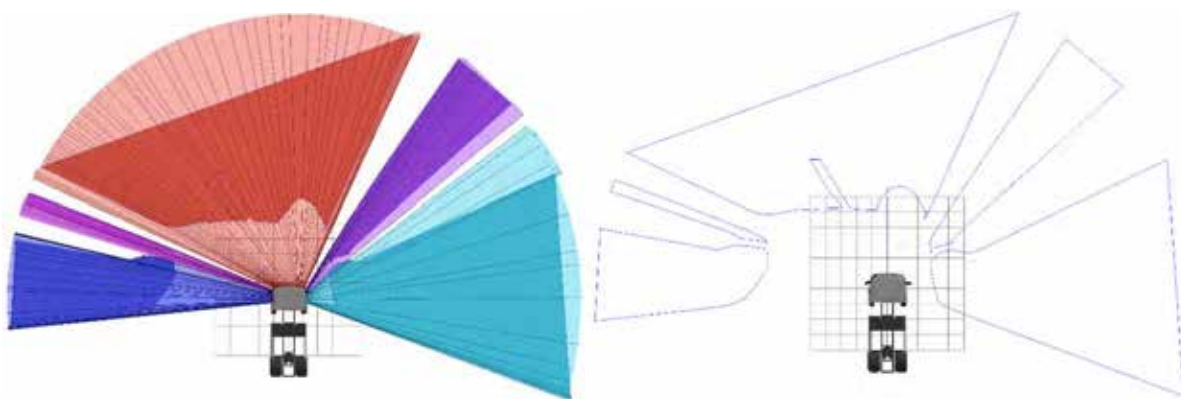


Figure 332. The projection of the windscreen and window apertures at the ground plane for the Mercedes Actros N3

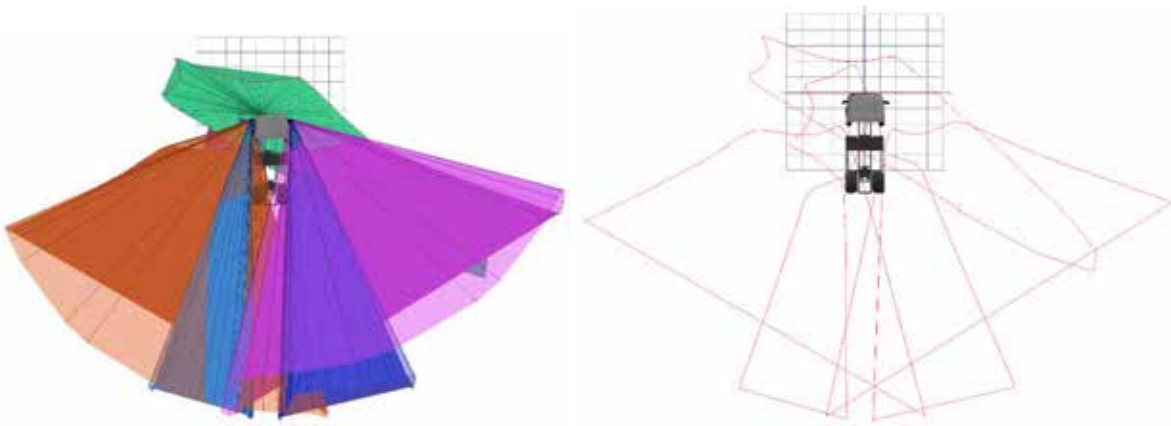


Figure 333. The projection of the mirrors at the ground plane for the Mercedes Actros N3

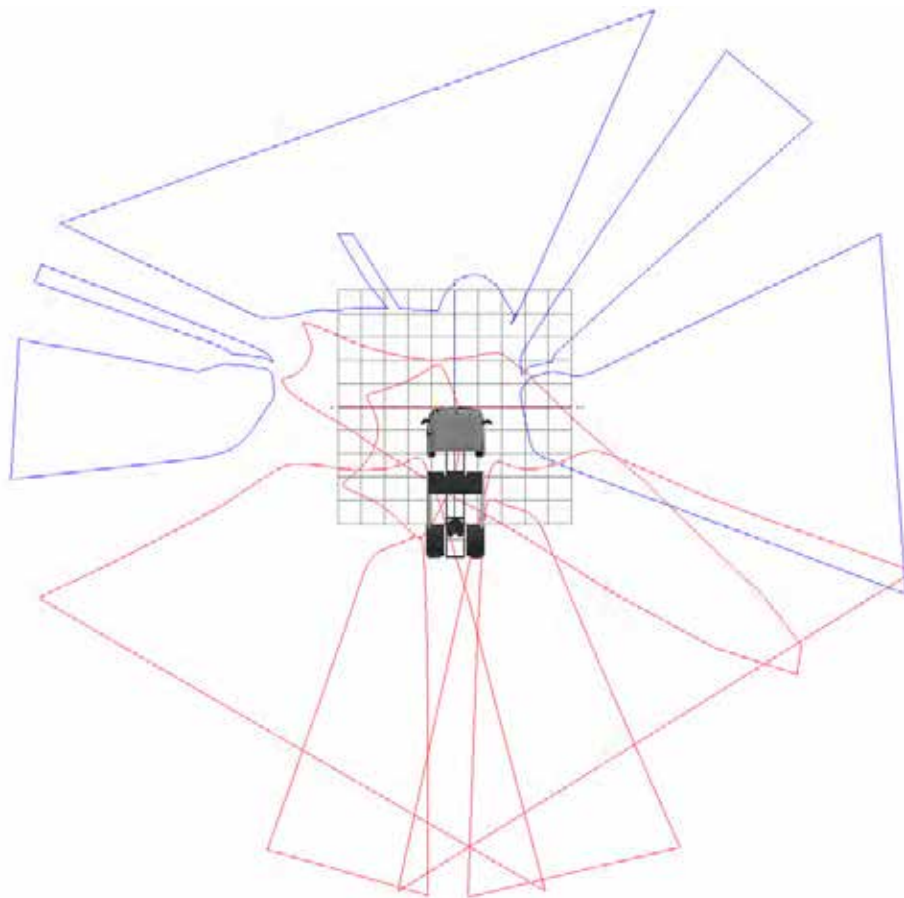


Figure 334. The combined direct and indirect vision projections at the ground plane for the Mercedes Actros N3

Figure 335 through Figure 339 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 340 and Figure 341 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

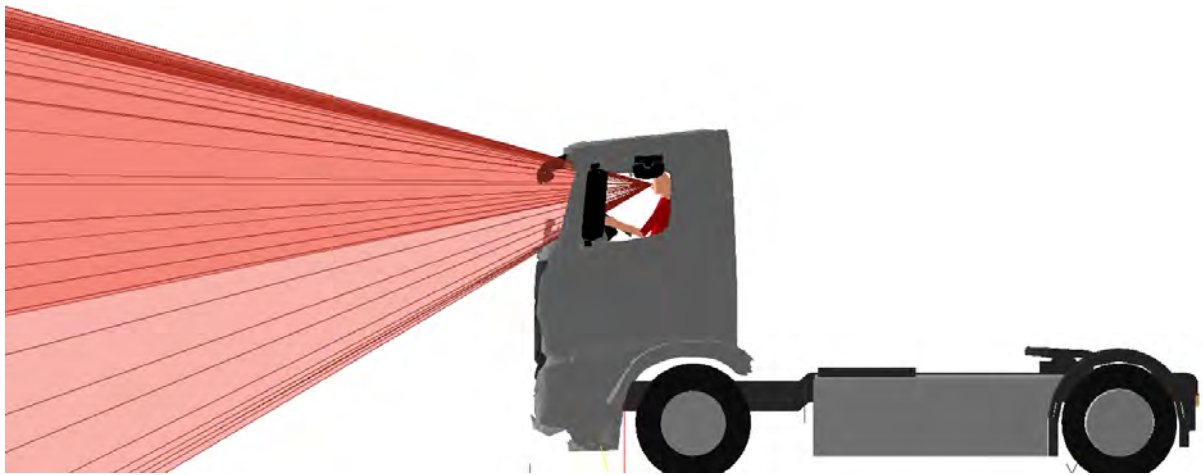


Figure 335. A side view of the windscreen aperture projection for the Mercedes Actros N3

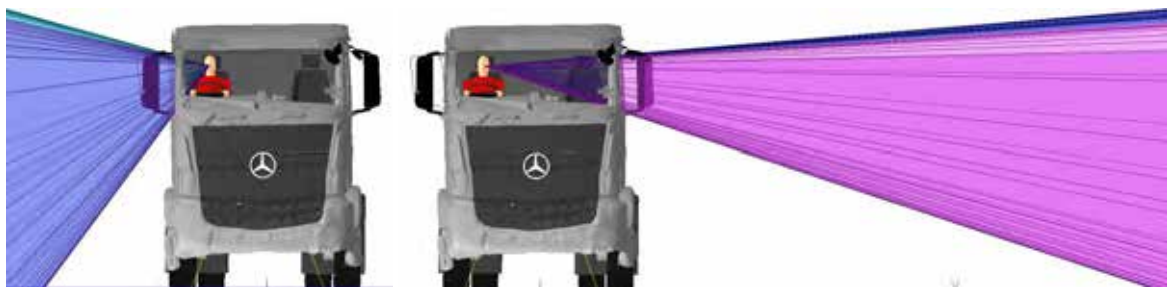


Figure 336. Frontal views of the off side and near side door window projections for the Mercedes Actros N3

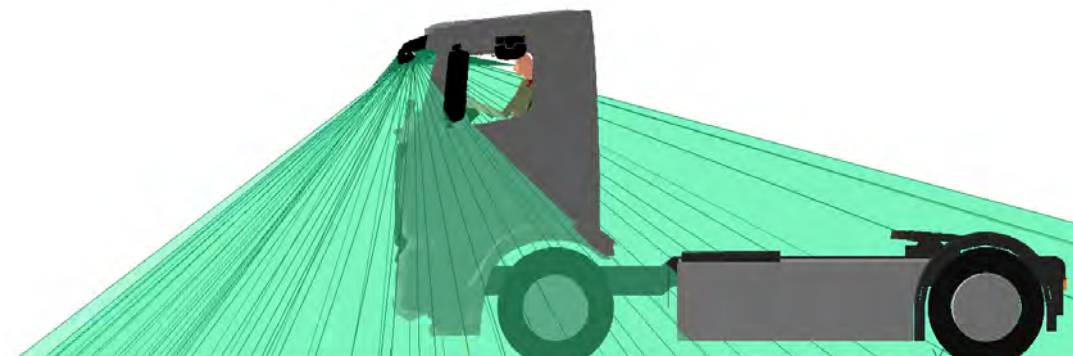


Figure 337. A side view of the Class VI mirror projection for the Mercedes Actros N3



Figure 338. A front view of the Class V mirror projection for the Mercedes Actros N3

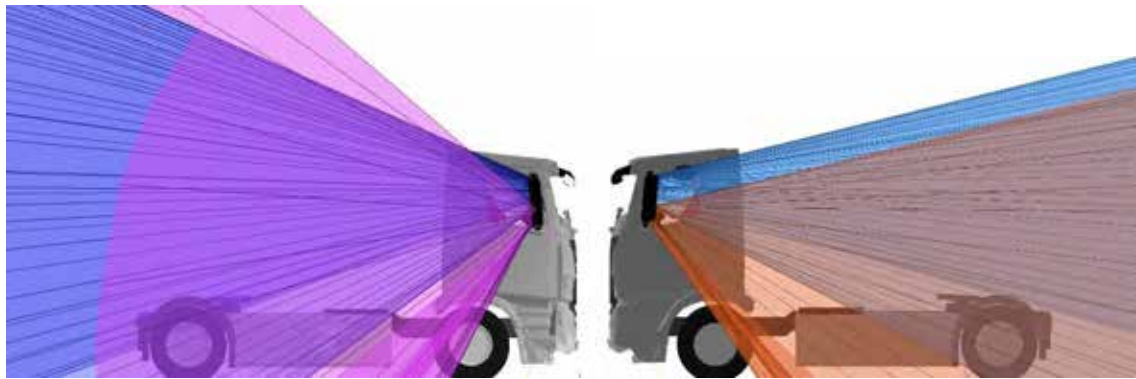


Figure 339. Side views of the combined Class II and Class IV mirror projections for the Mercedes Actros N3

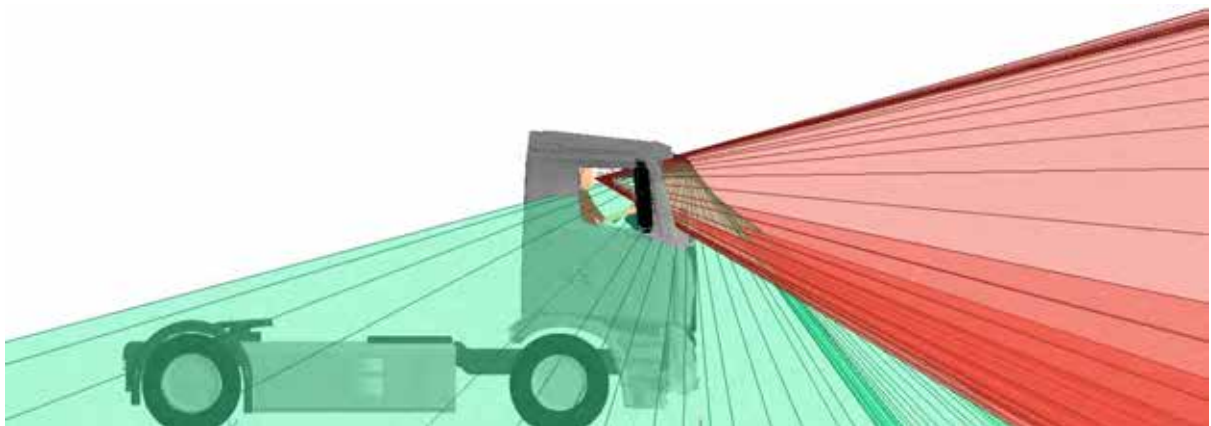


Figure 340. Combined projection of the windscreen and Class VI mirror to the front of the Mercedes Actros N3

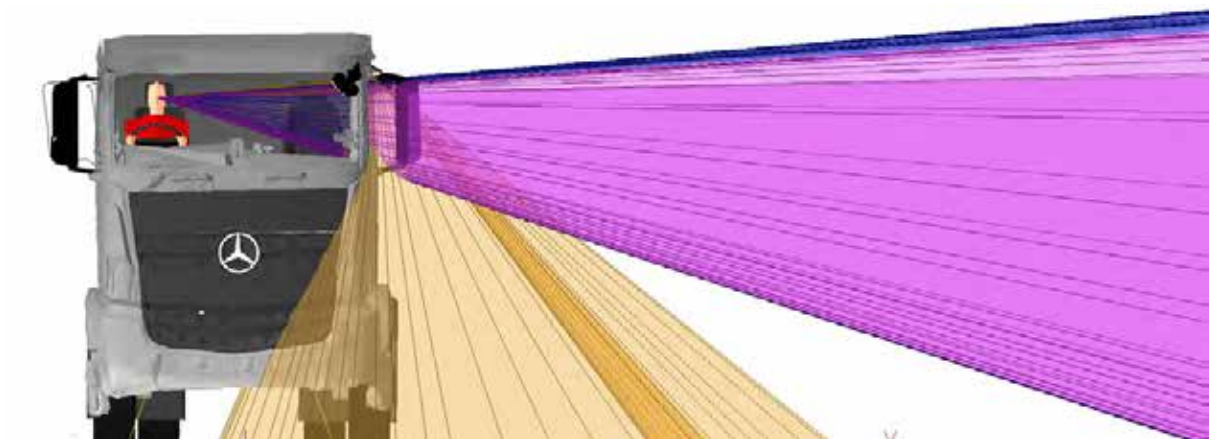


Figure 341. Combined projection of the near side windows and Class V mirror to the side of the Mercedes Actros N3

4.1.10.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 342 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

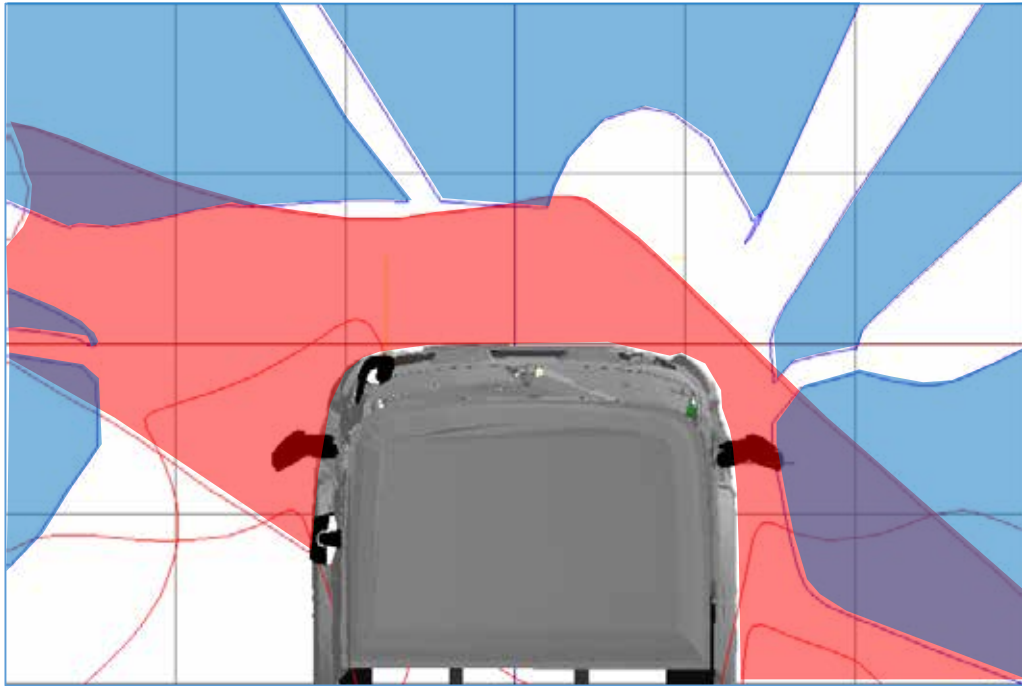


Figure 342. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From Figure 342 it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 334. Figure 343 and Figure 344 show that there is a clear space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.

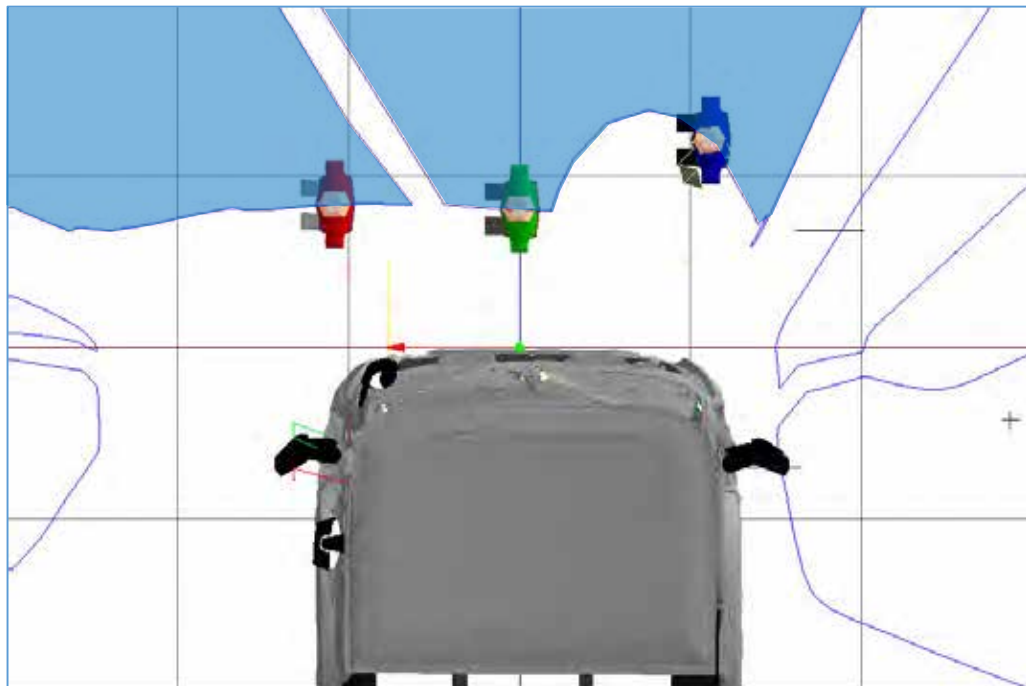


Figure 343. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

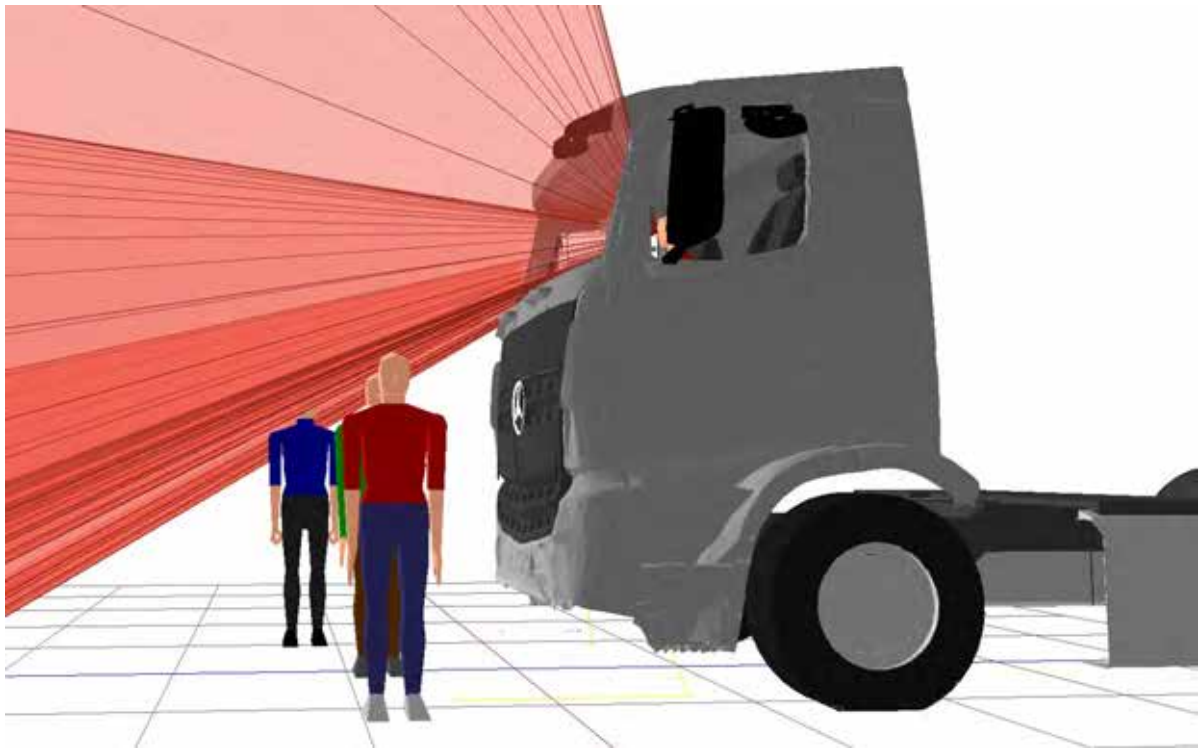


Figure 344. 3D view showing that the three human models can stand 1084mm (blue), 624mm (green) and 749mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture

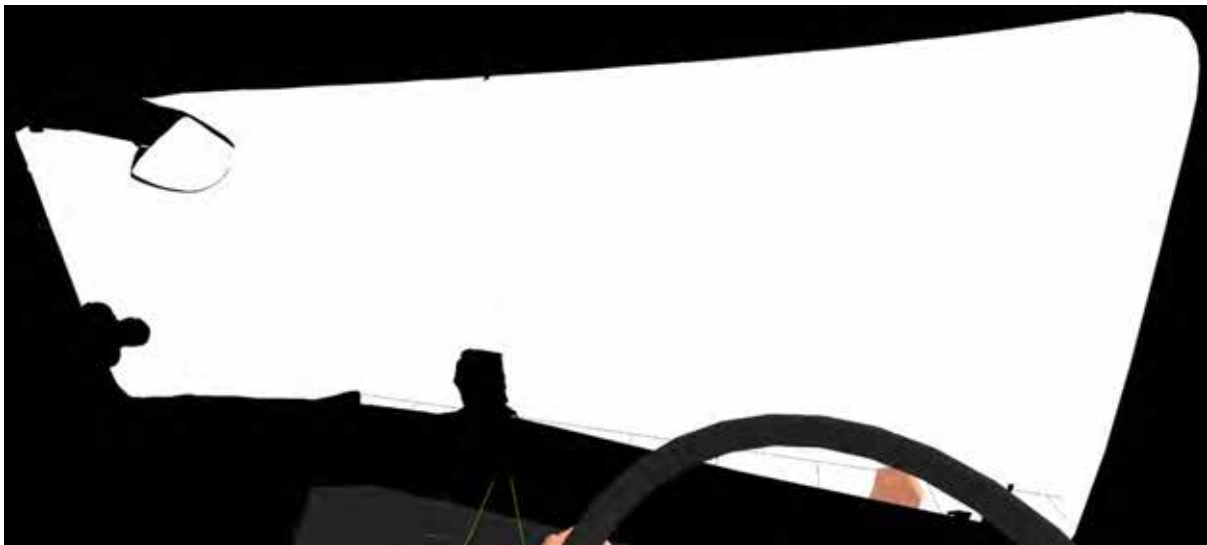


Figure 345. The view from the driver's eyes clearly shows the three pedestrians are hidden from view.

For forwards visibility of the pedestrians all three can be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 1084mm from the front of the vehicle, the left (red) pedestrian is positioned at 749mm from the front of the vehicle and the central (green) pedestrian is positioned at 624mm from the front of the vehicle. These figures represent a considerable distance between the pedestrians and the front of the vehicle in which pedestrians would presumably be comfortable to walk, with the potential of being unseen.

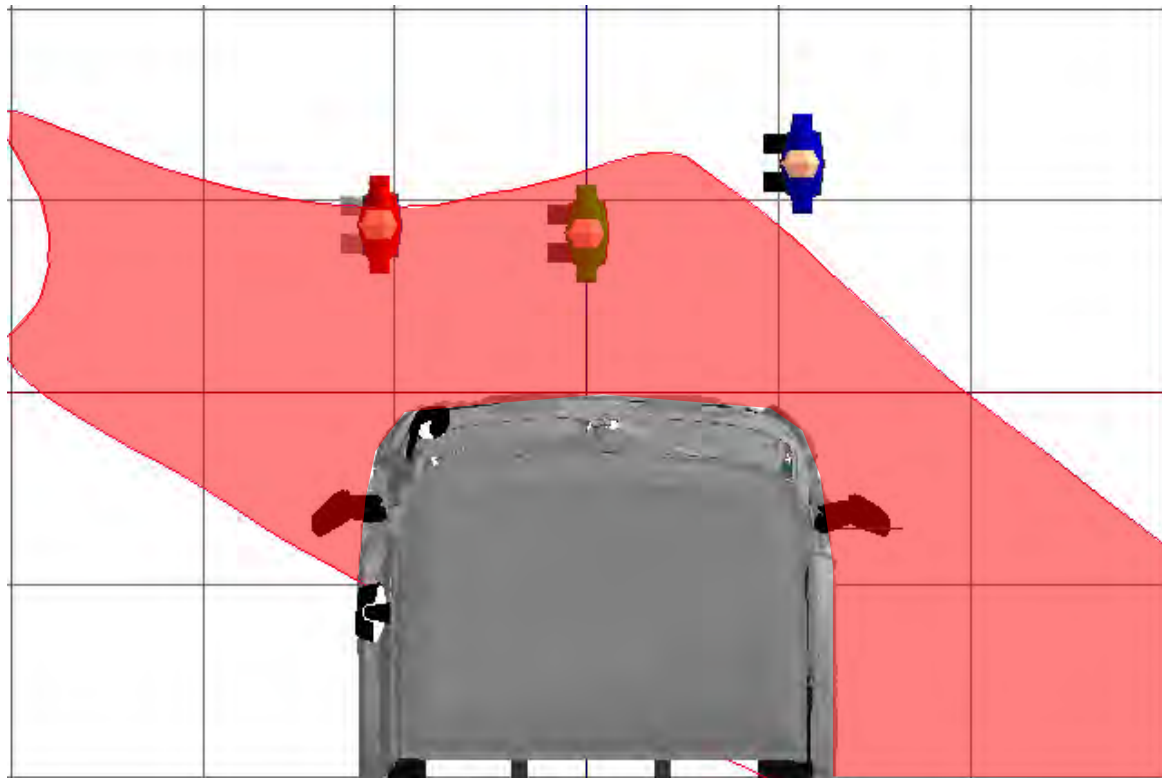


Figure 346. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

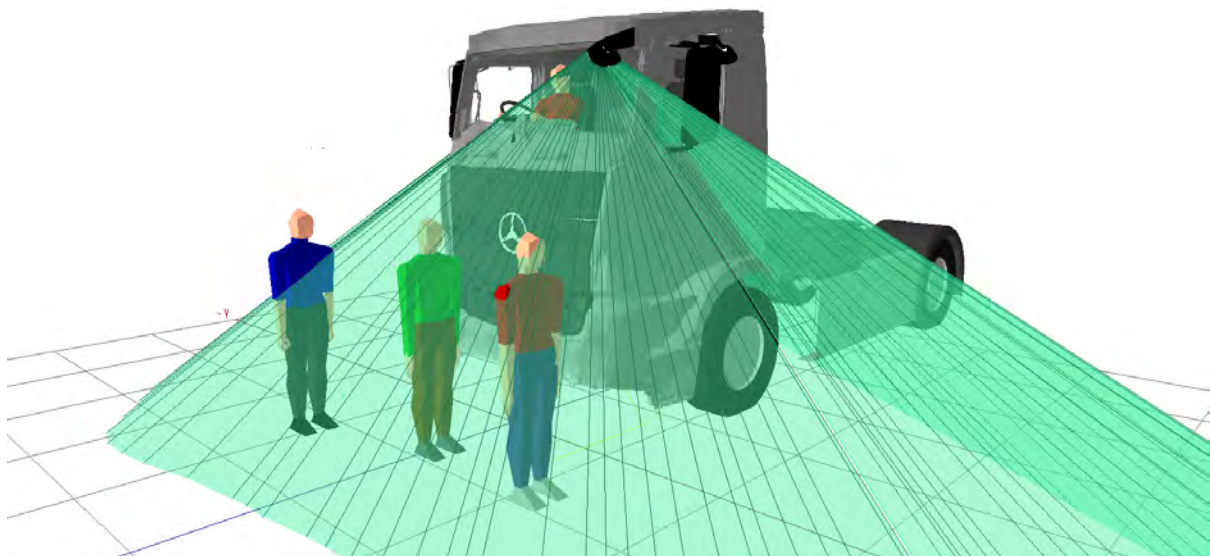


Figure 347. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 347 shows that the pedestrian to the left (red) and centre (green) would be completely visible and the pedestrian to the right (blue) would be visible from the neck down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide a pedestrian to the front of the Mercedes Actros N3.

4.1.10.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

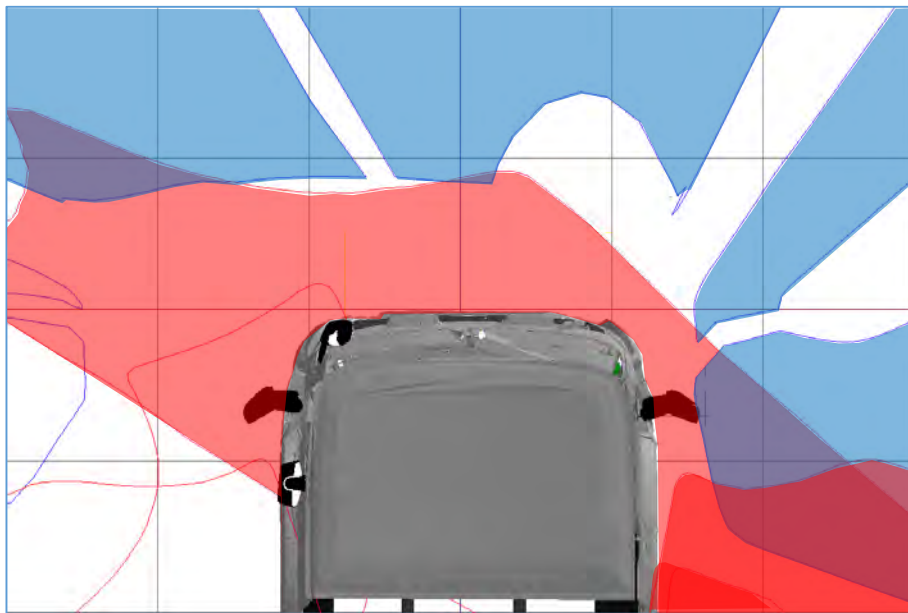


Figure 348. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 349 shows that a both cyclists can be obscured from the direct vision of the driver, with the front (yellow) cyclist being 120mm from the vehicle and the rear (blue) cyclist being directly adjacent to the vehicle.

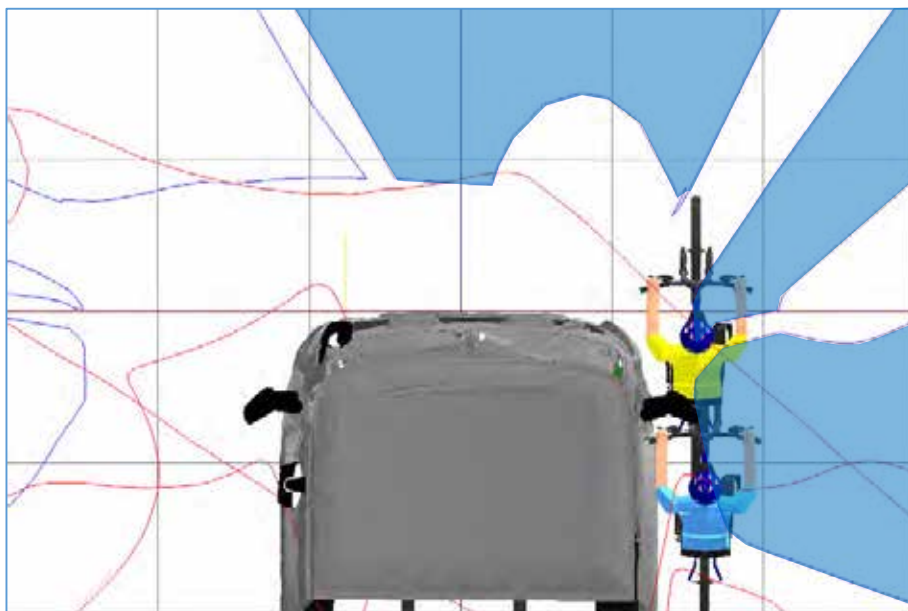


Figure 349. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist

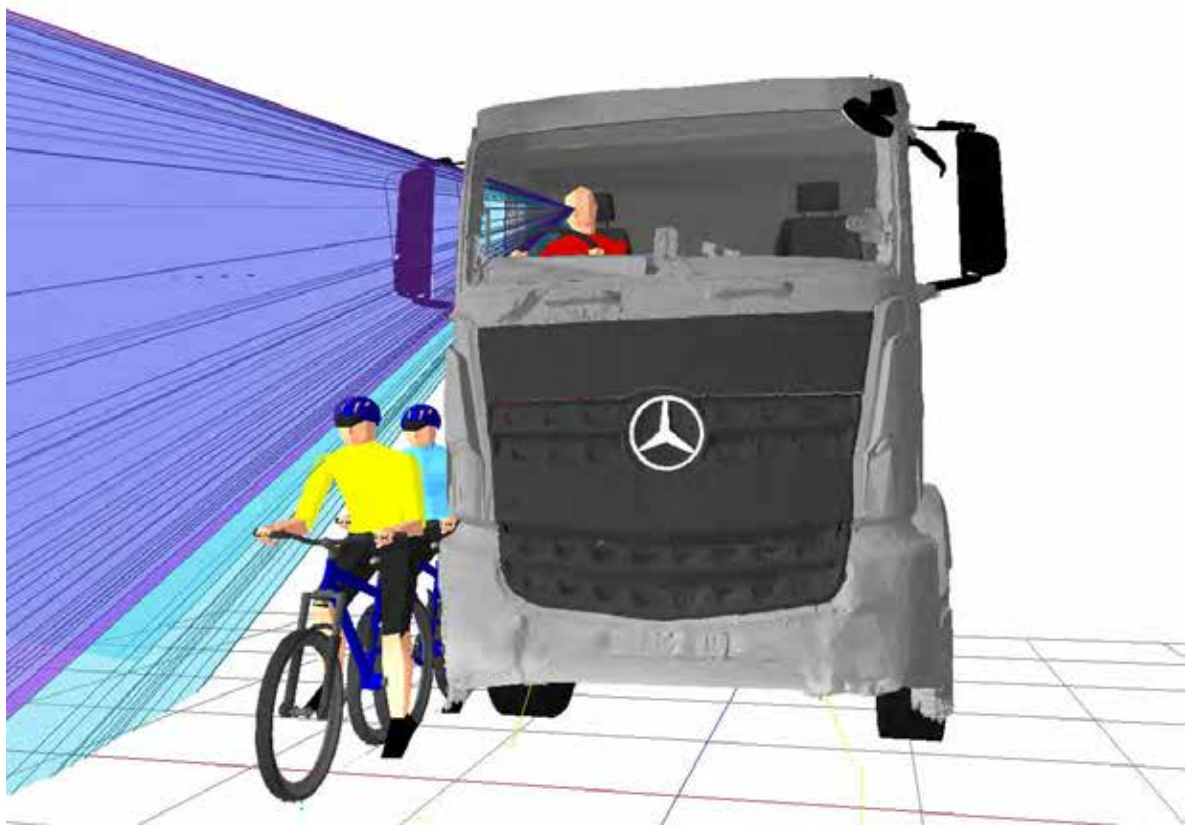


Figure 350. 3D view showing that both cyclists can be hidden from direct vision to the offside of the Mercedes Actros N3

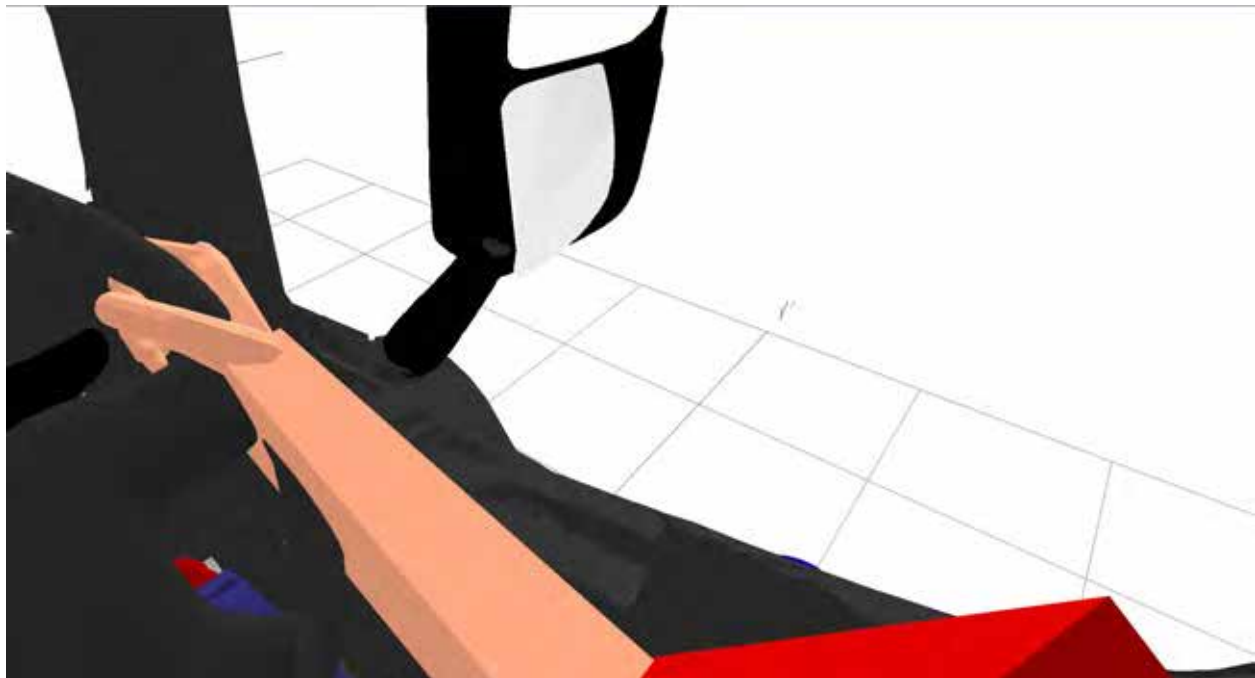


Figure 351. The view from the driver's eyes clearly shows the two cyclists are not visible

For offside direct visibility of the cyclists there is a blind spot that can obscure both cyclists but both cyclists need to be directly adjacent to, or very close to the side of the cab. Figure 351 shows that the cyclists can be obscured from the driver when using direct vision.

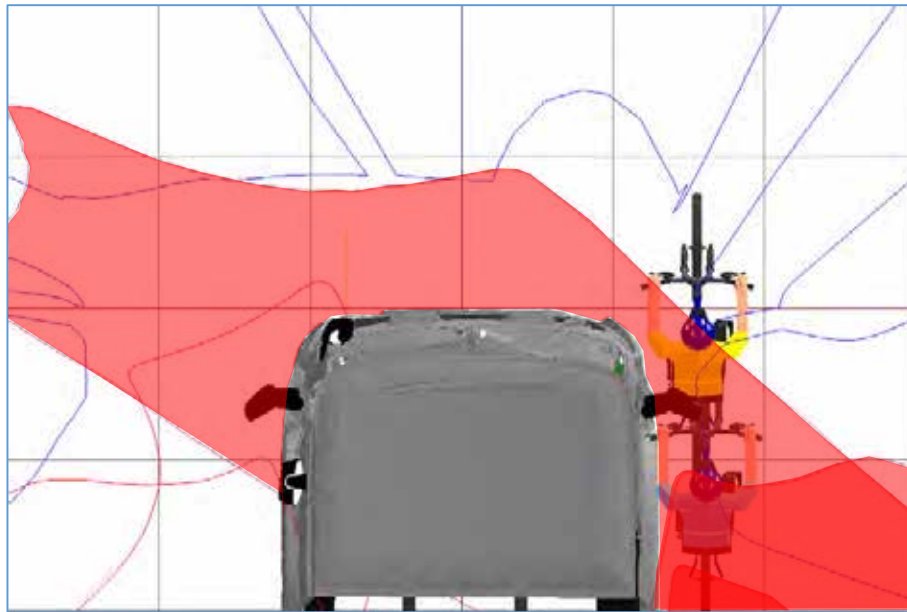


Figure 352. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

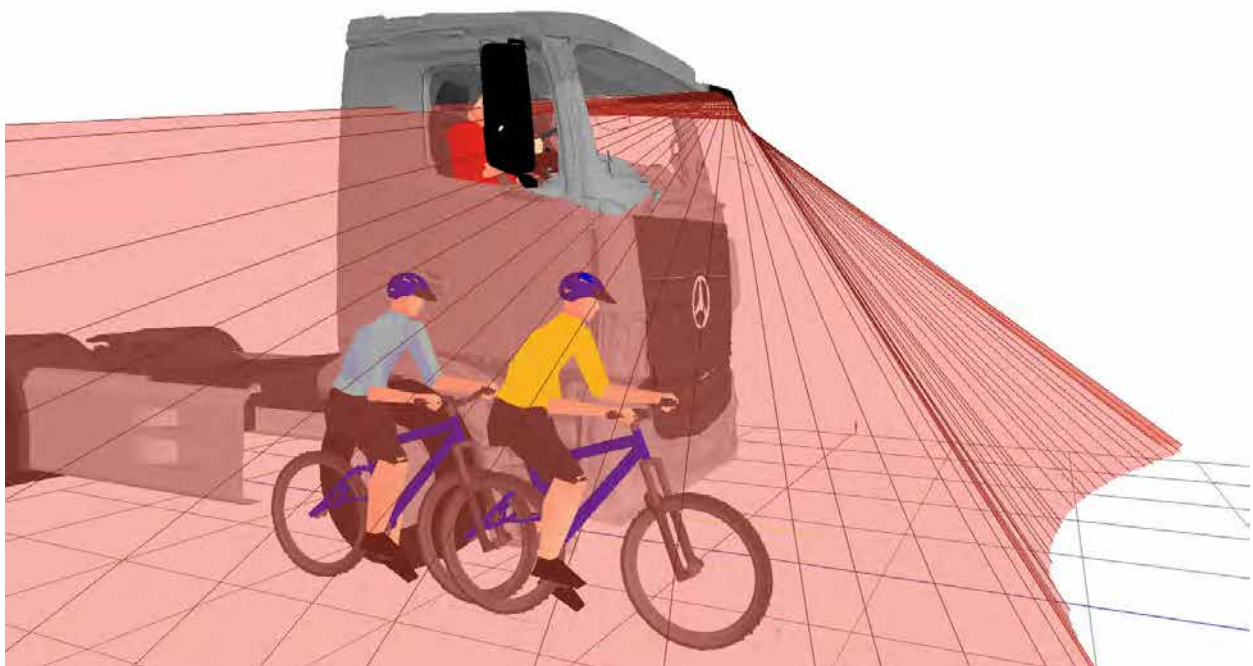


Figure 353. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

The cyclists are visible to the driver through the use of the mirrors. Figure 353 shows that theoretically both cyclists are visible in the Class VI mirror. However, due to limitations of the projection technique, the rear cyclist (blue) would actually be hidden from view by the cab of the vehicle. However, part of the front (yellow) cyclist would be visible in the Class VI mirror including their arms and the front of the bicycle.

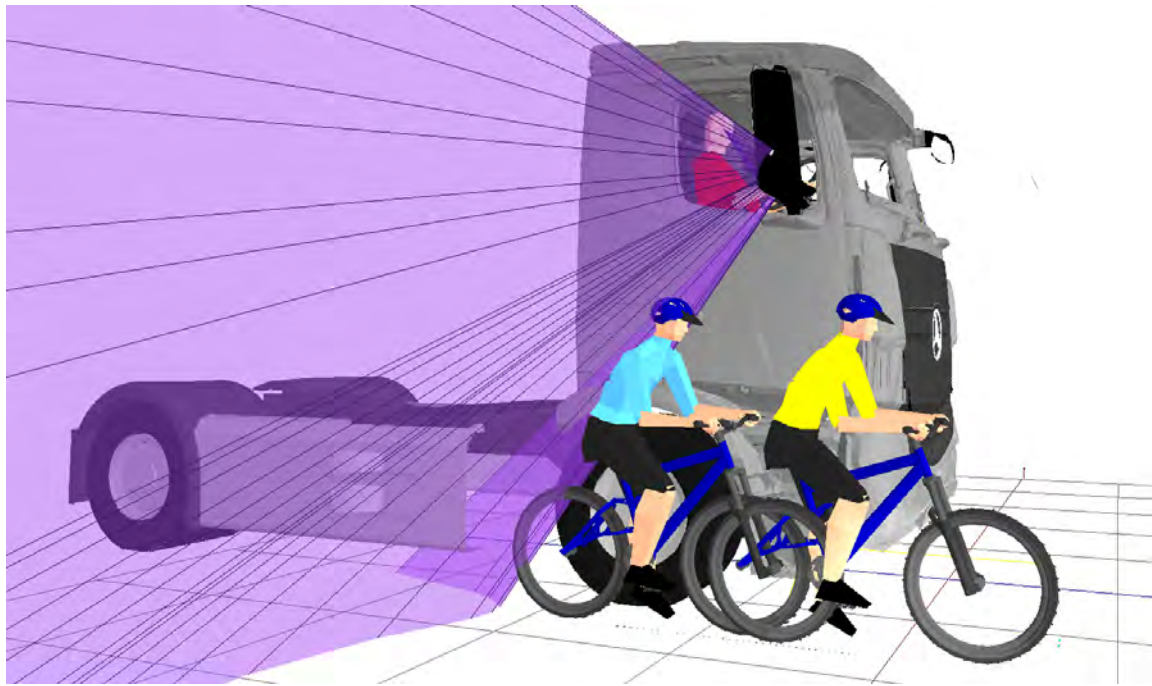


Figure 354. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 354 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their back and rear wheel. The projections show that for a driver using their mirrors, it is not possible to hide a cyclist in the positions shown to the offside of the Mercedes Actros N3.

4.1.10.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

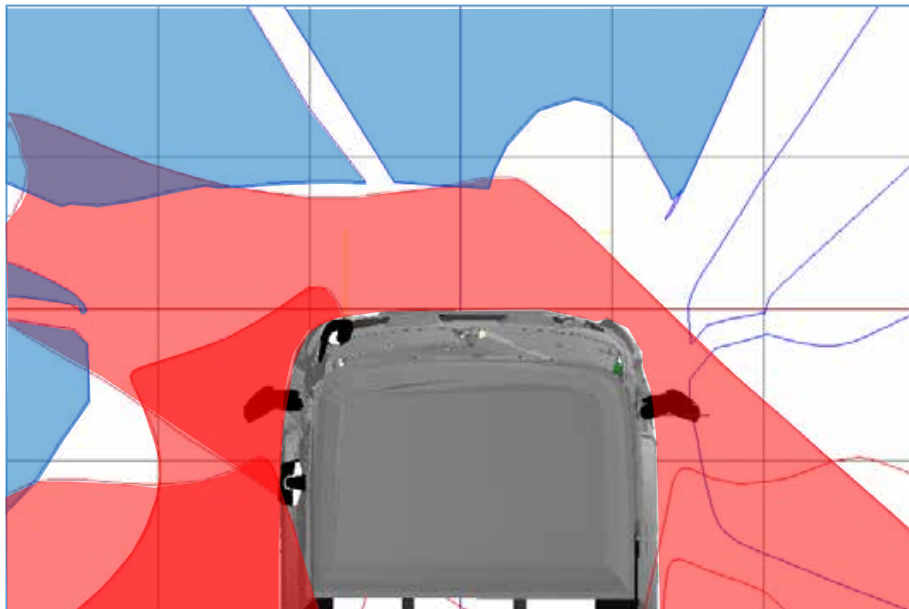


Figure 355. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 356 and Figure 357 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

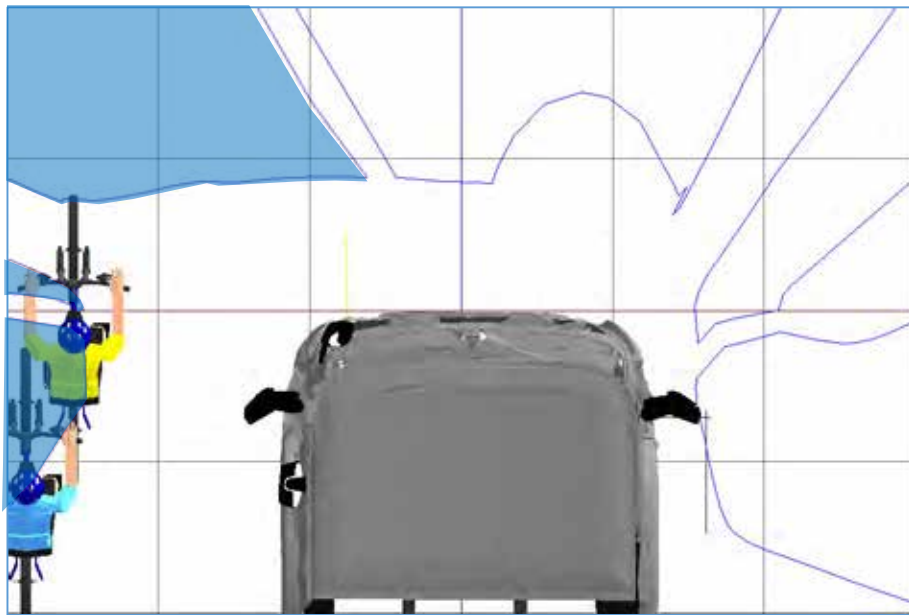


Figure 356. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

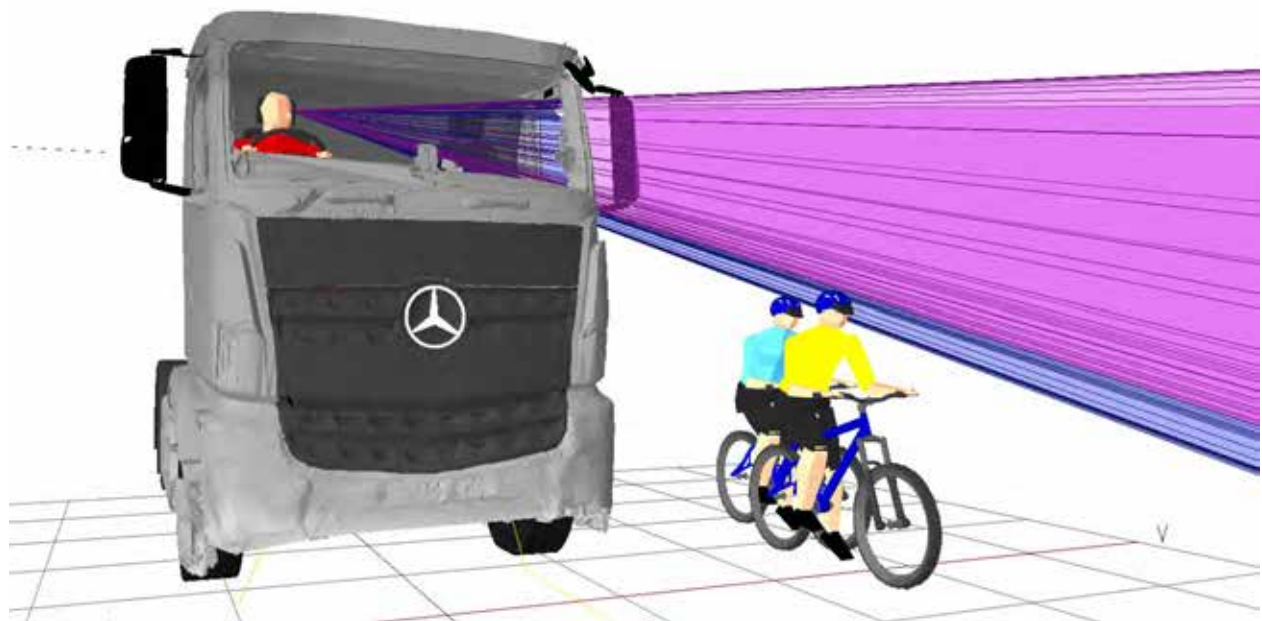


Figure 357. 3D view showing that the two human models can be positioned 1114mm (yellow) and 1316mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 358. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 1114mm from the side of the vehicle, the rear (blue) cyclist is positioned at 1316mm from the side of the vehicle.

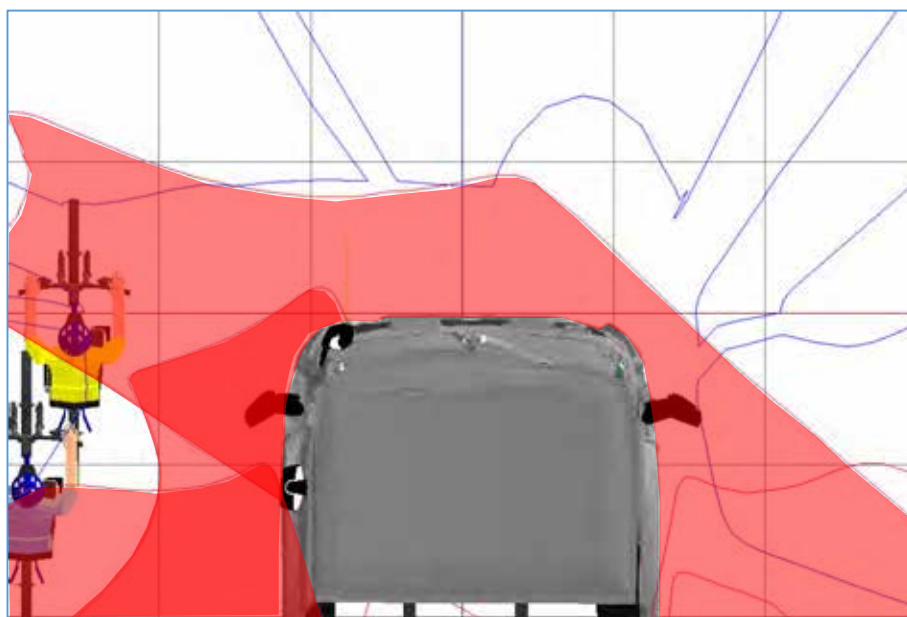


Figure 359. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

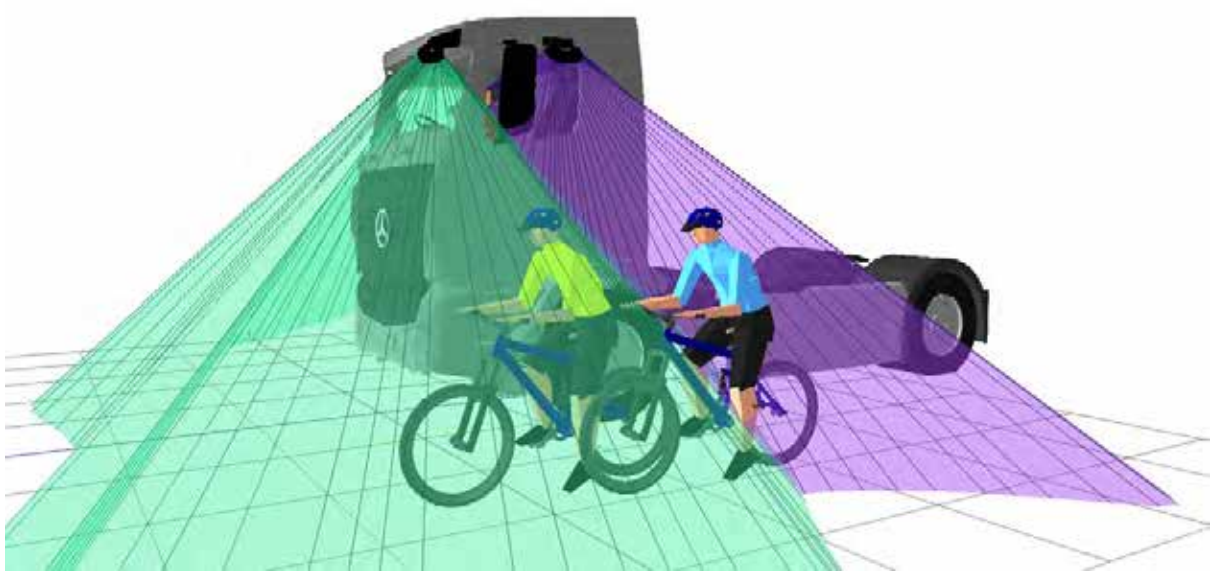


Figure 360. 3D view showing that the Front (yellow) cyclists positioned to the nearside of the vehicle is visible in the projection of the Class V and / or Class VI mirrors, but that the rearmost Cyclist is not visible in either mirror

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 360 shows that the front (yellow) cyclist is visible in the Class V and Class VI mirrors. The rear (blue) cyclist is not visible in the Class VI mirror but is partially visible in the Class V mirror with the rear wheel and front wheel being visible. Figure 361 shows that the both cyclists are not visible in the Class IV mirror.

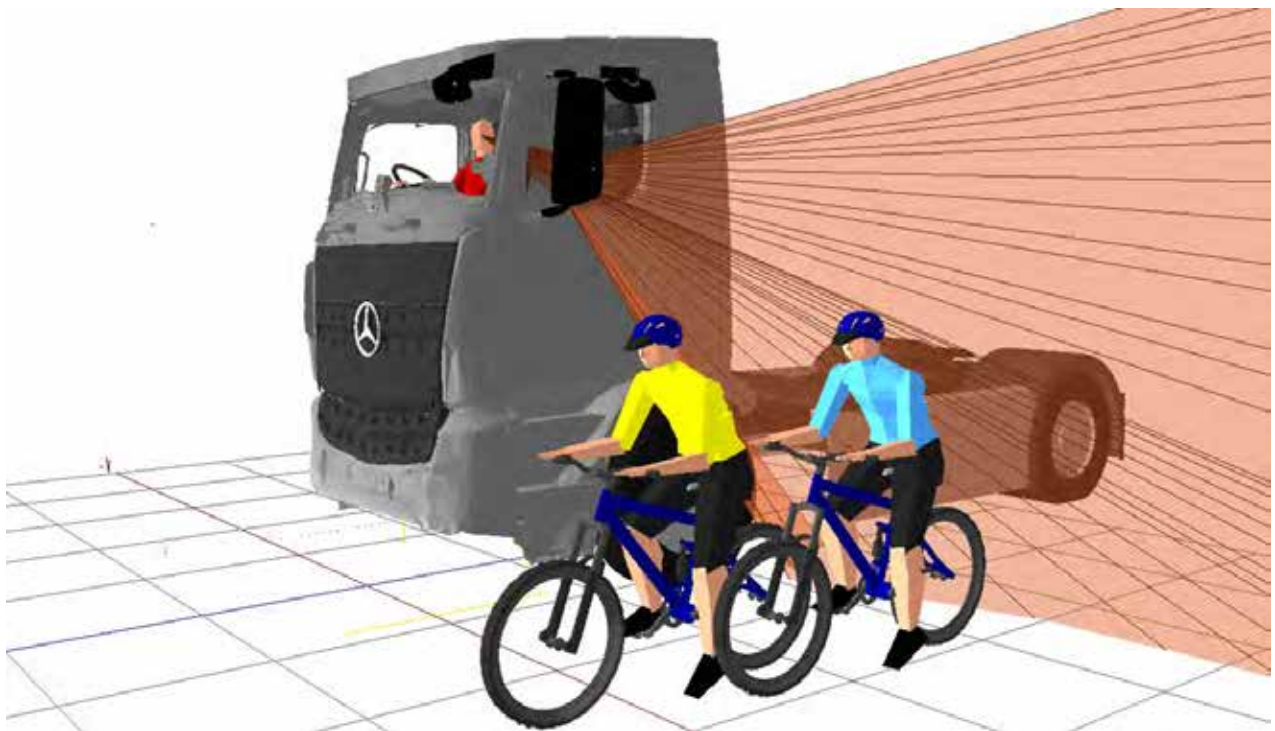


Figure 361. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is not visible in the projection of the Class IV or Class II mirror

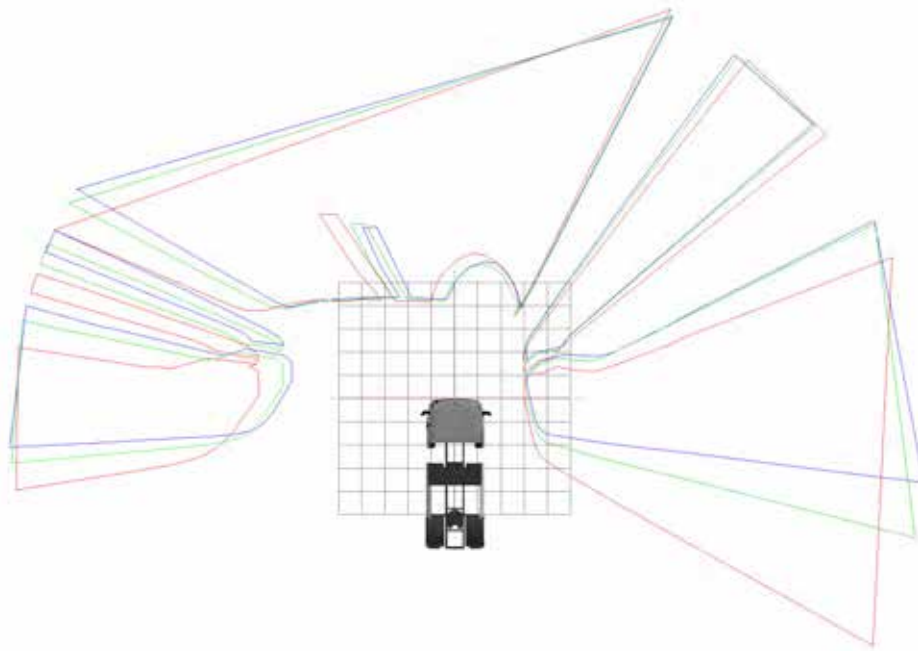
4.1.10.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

Figure 362. A plan view of the projection of the windscreen and side windows onto the ground plane for the Mercedes Actros N3 for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.1.11 MERCEDES ECONIC LOW ENTRY CAB - 50TH %ILE MALE DRIVER



Figure 363. Evaluation model of Mercedes Econic LEC vehicle

4.1.11.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 364 shows a top-down view of all of the window projections for the Mercedes Econic LEC cab with a 50th %ile UK Male Driver. The image on the right of Figure 364 shows the areas of these projections that intersect with the ground. Figure 365 shows the same for the the mirror projections and Figure 366 shows the two combined. Any area outside of the coloured projections is effectively a blind spot at the ground plane.

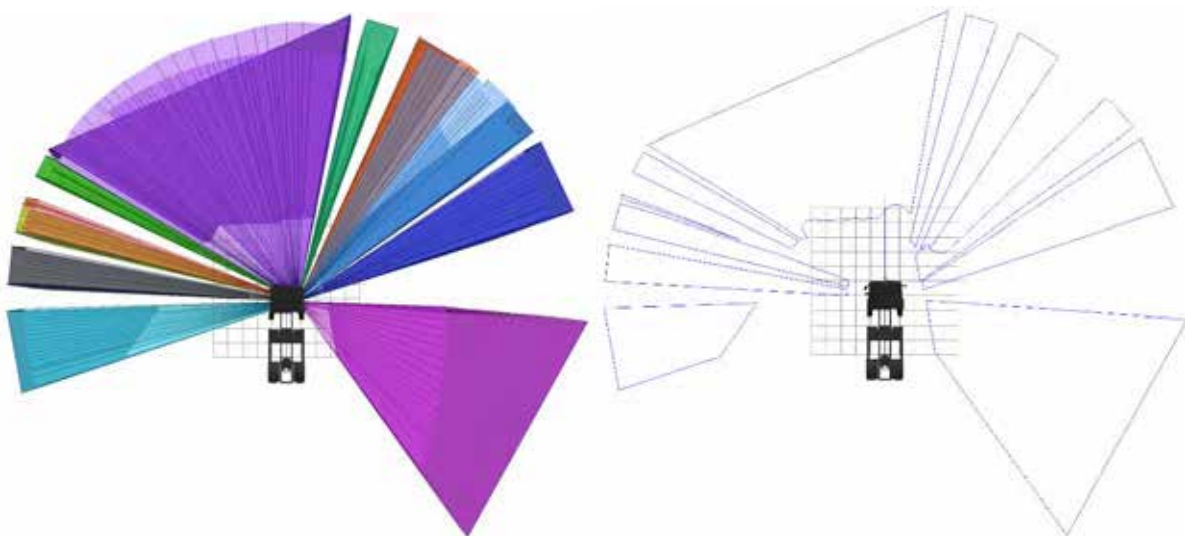


Figure 364. The projection of the windscreen and window apertures at the ground plane for the Mercedes Econic LEC

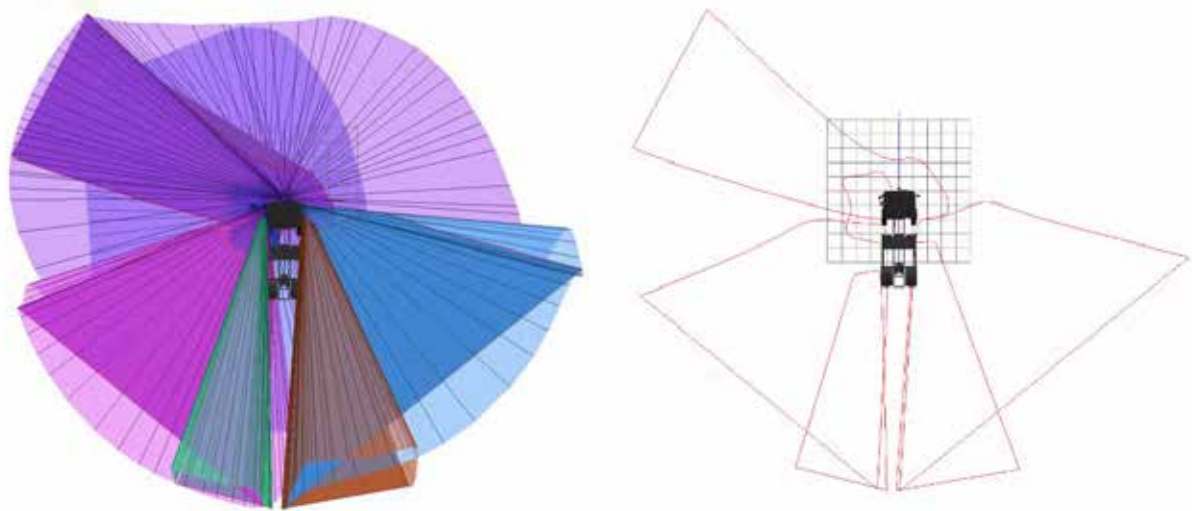


Figure 365. The projection of the mirrors at the ground plane for the Mercedes Econic LEC

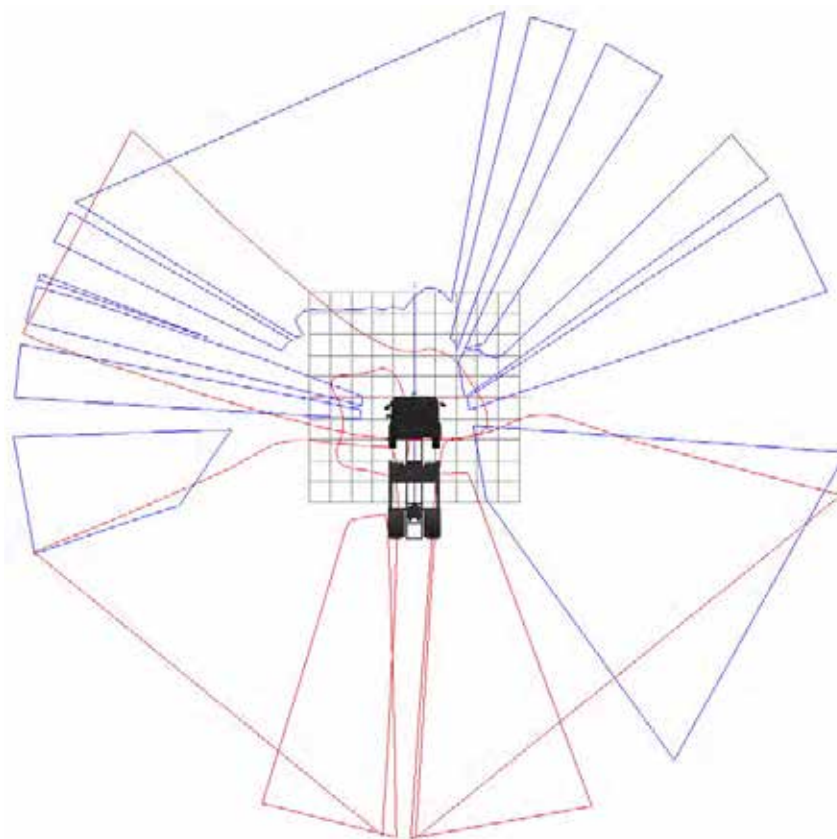


Figure 366. The combined direct and indirect vision projections at the ground plane for the Mercedes Econic LEC

Figure 367 through Figure 371 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 372 and Figure 373 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.



Figure 367. A side view of the windscreen aperture projection for the Mercedes Econic LEC

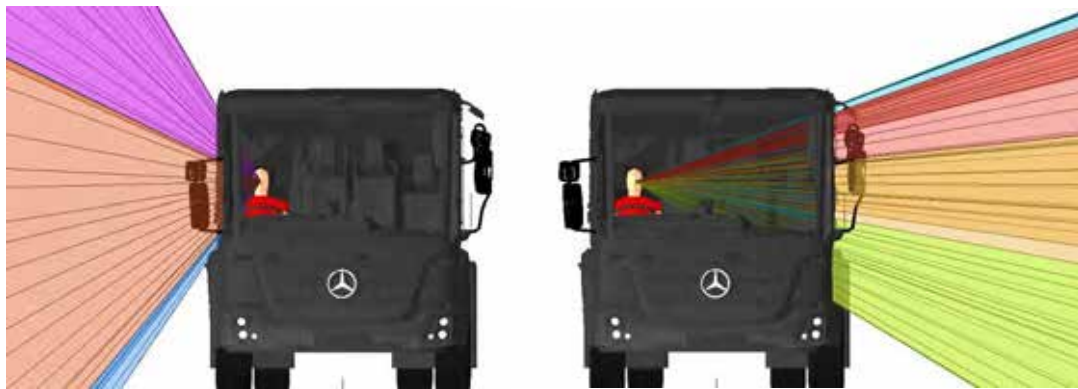


Figure 368. Frontal views of the off side and near side door window projections for the Mercedes Econic LEC



Figure 369. A side view of the Class VI mirror projection for the Mercedes Econic LEC



Figure 370. A front view of the Class V mirror projection for the Mercedes Econic LEC



Figure 371. Side views of the combined Class II and Class IV mirror projections for the Mercedes Econic LEC

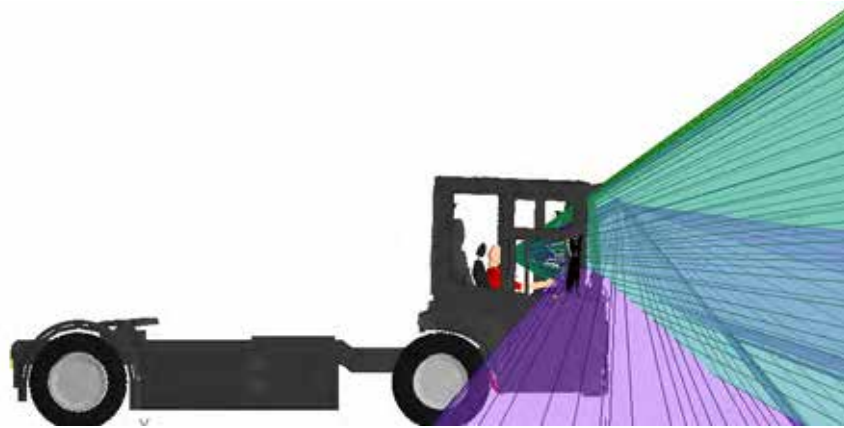


Figure 372. Combined projection of the windscreen and Class VI mirror to the front of the Mercedes Econic LEC

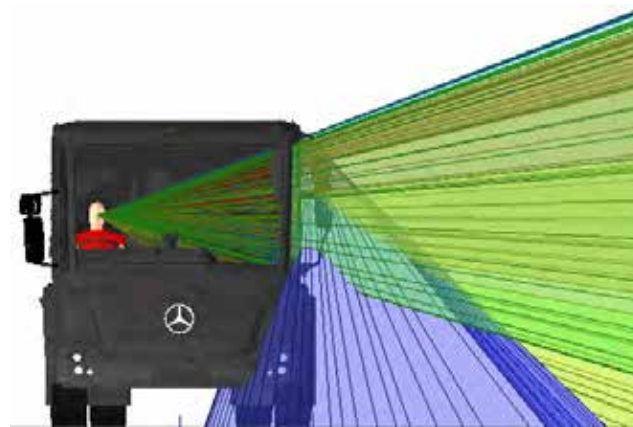


Figure 373. Combined projection of the near side windows and Class V mirror to the side of the Mercedes Econic LEC

4.1.11.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 374 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

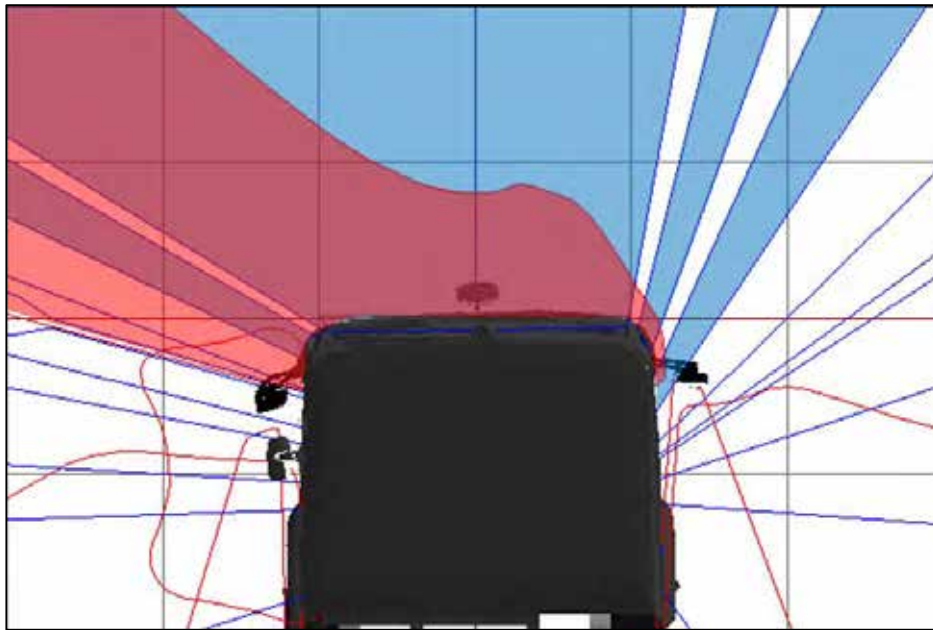


Figure 374. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are adjacent to the vehicle side, i.e. there is no gap in which a pedestrian human model with a stature that represents an average UK male can be hidden from the driver’s view.

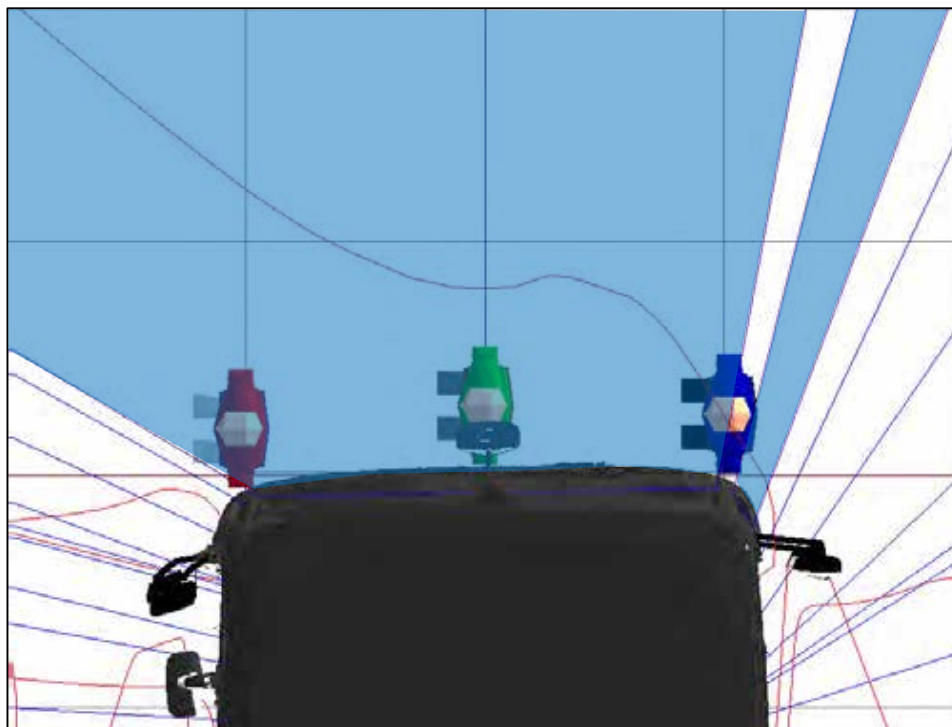


Figure 375. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

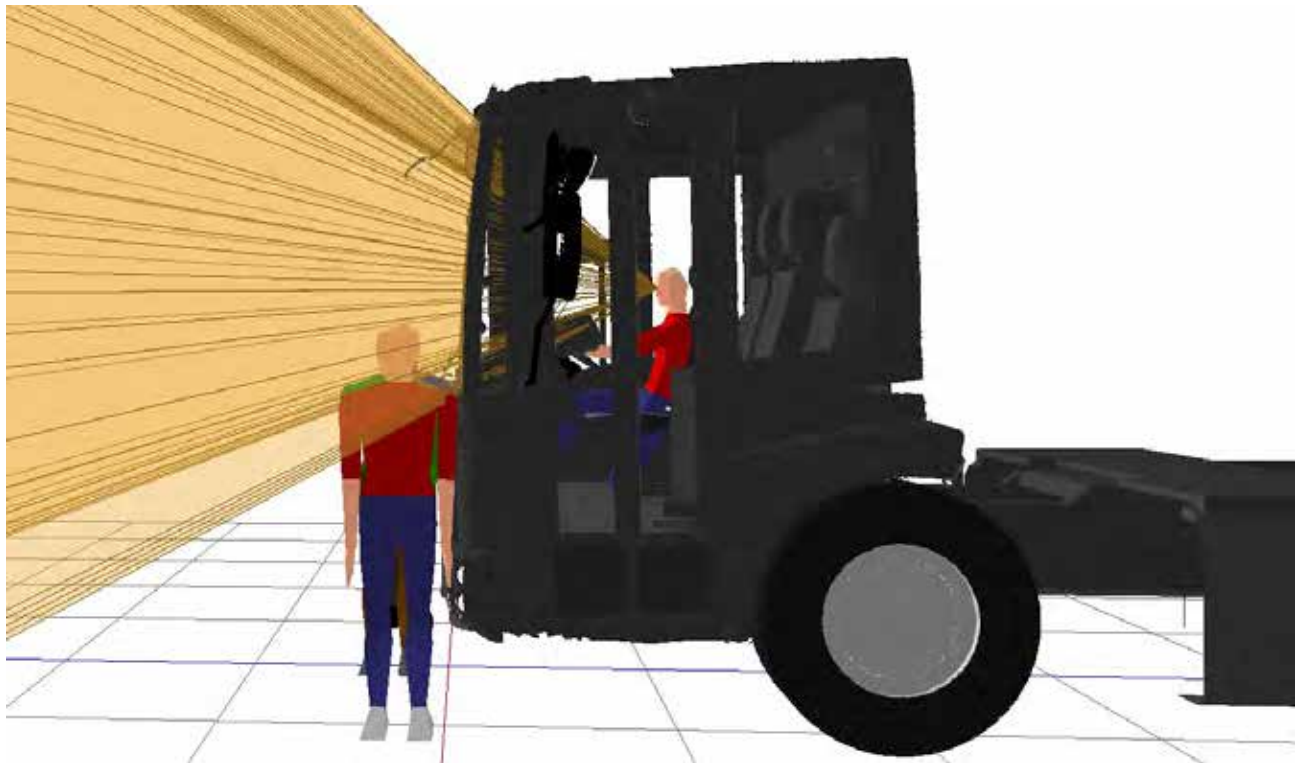


Figure 376. 3D view showing that none of the pedestrians cannot be hidden from the drivers view



Figure 377. The view from the driver's eyes shows that none of the pedestrians can be hidden from the drivers view

For forwards visibility of the pedestrians it is not possible to hide the three human models from the direct vision of the driver of the Mercedes Econic.

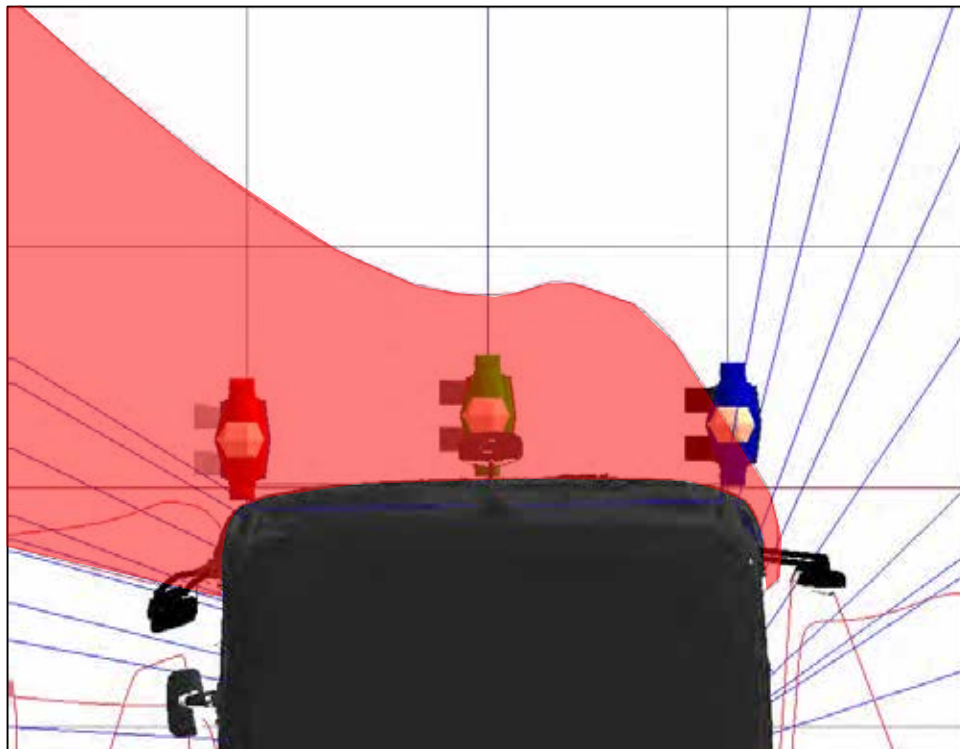


Figure 378. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

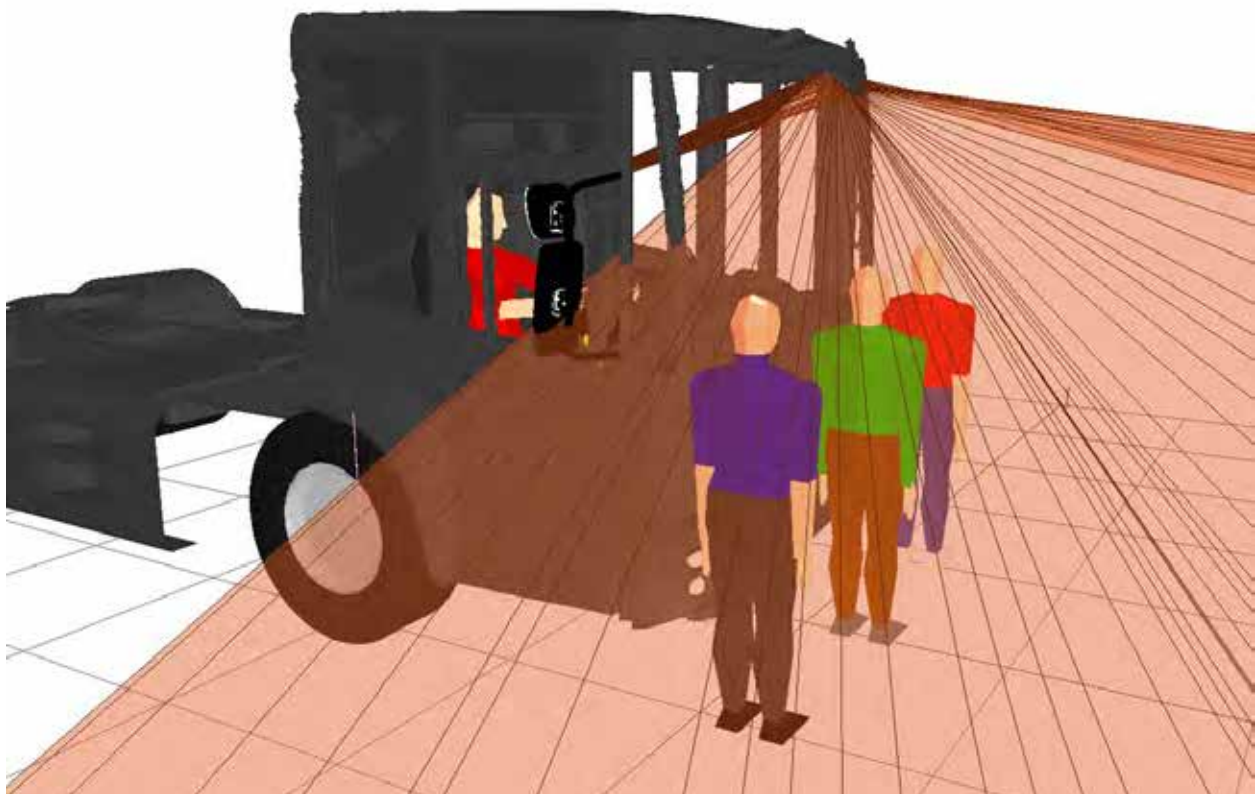


Figure 379. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

The three pedestrians cannot be hidden from direct view to the front of the vehicle and all three are visible in the Class VI mirror. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide a pedestrian as defined to the front of the Mercedes Econic.

4.1.11.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

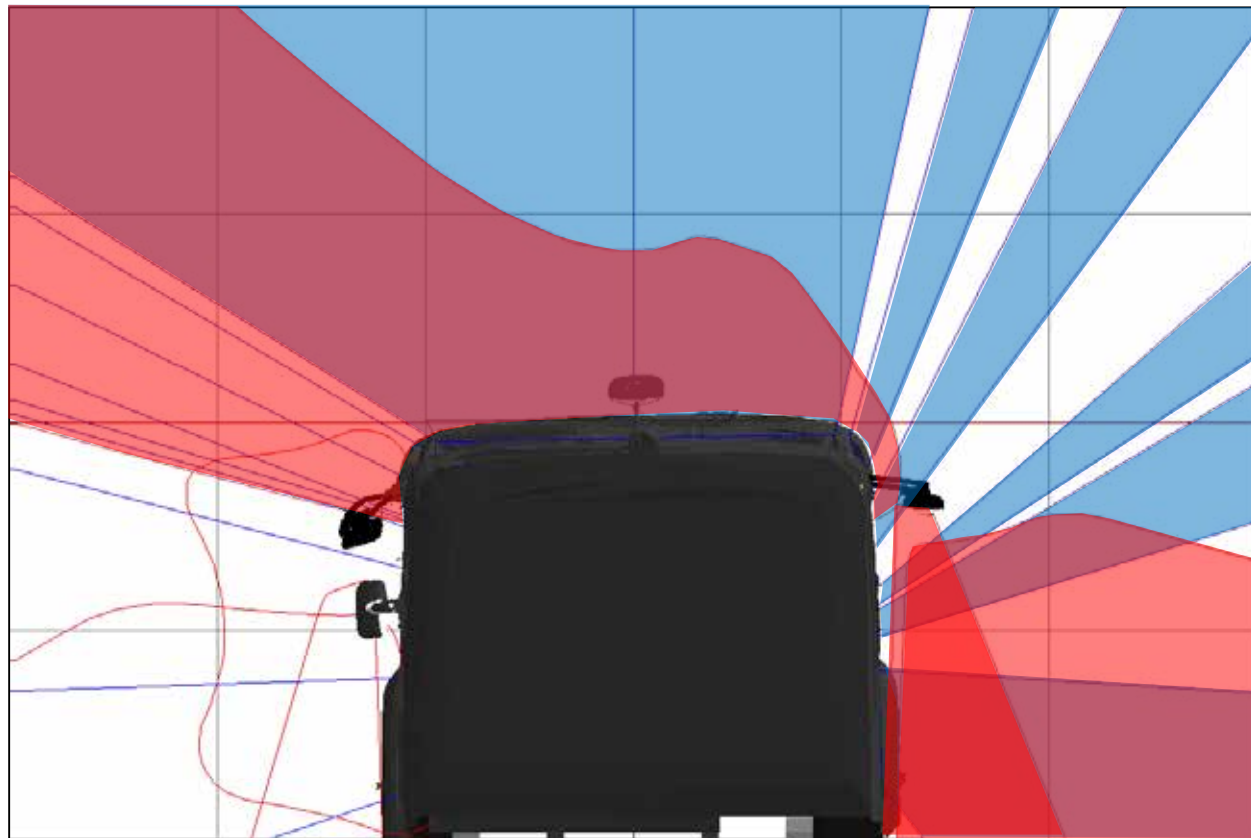


Figure 380. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 381, Figure 382 and Figure 383 show that there is no gap between the offside of the vehicle and the cyclists. Figure 383 shows that the rear most (blue) cyclist is only partially visible in this location used for the analysis, and a location more rearwards would need a more deliberate observation by the driver through the rear window in order to directly view the cyclist.

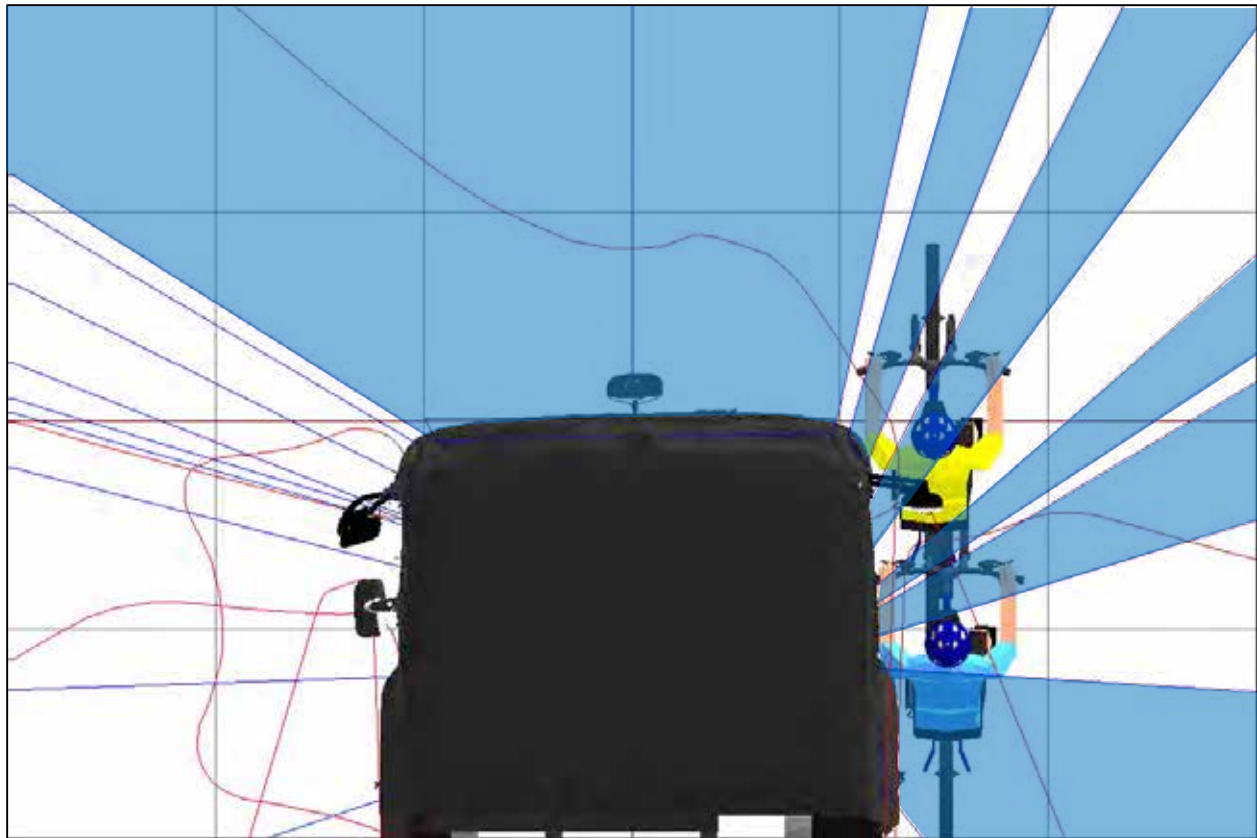


Figure 381. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cycle

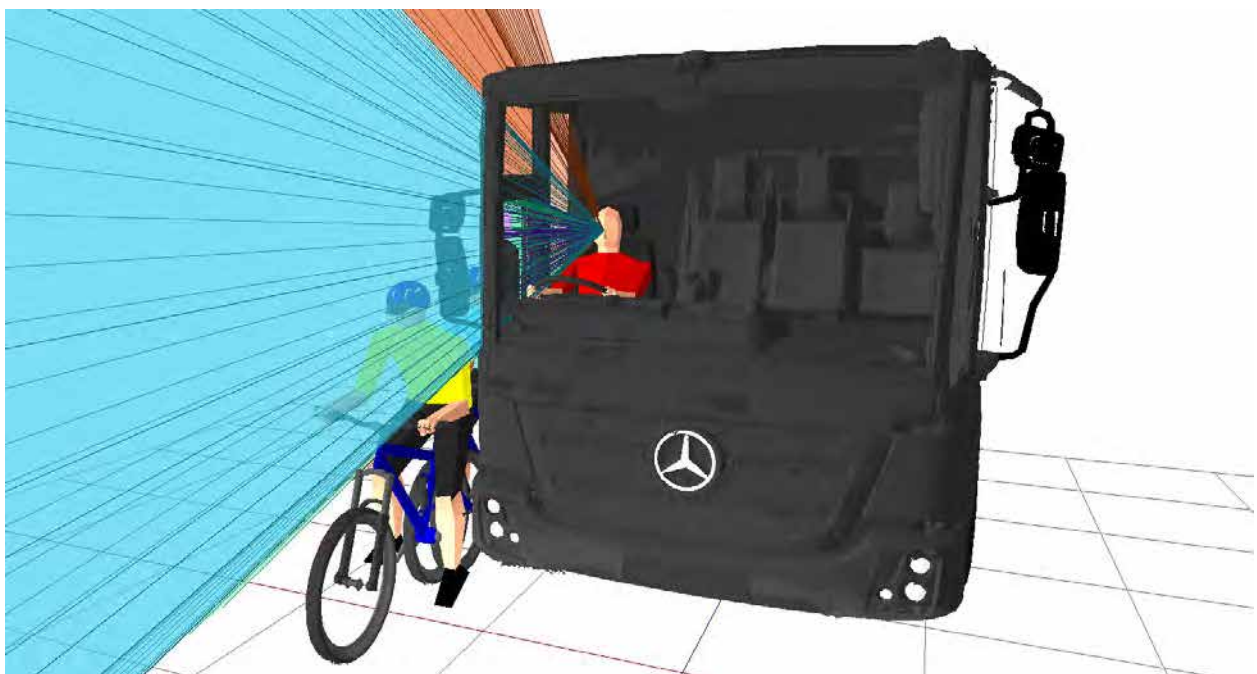


Figure 382. 3D view showing that both cyclists cannot be hidden from direct vision to the offside of the Dennis Eagle Elite 6

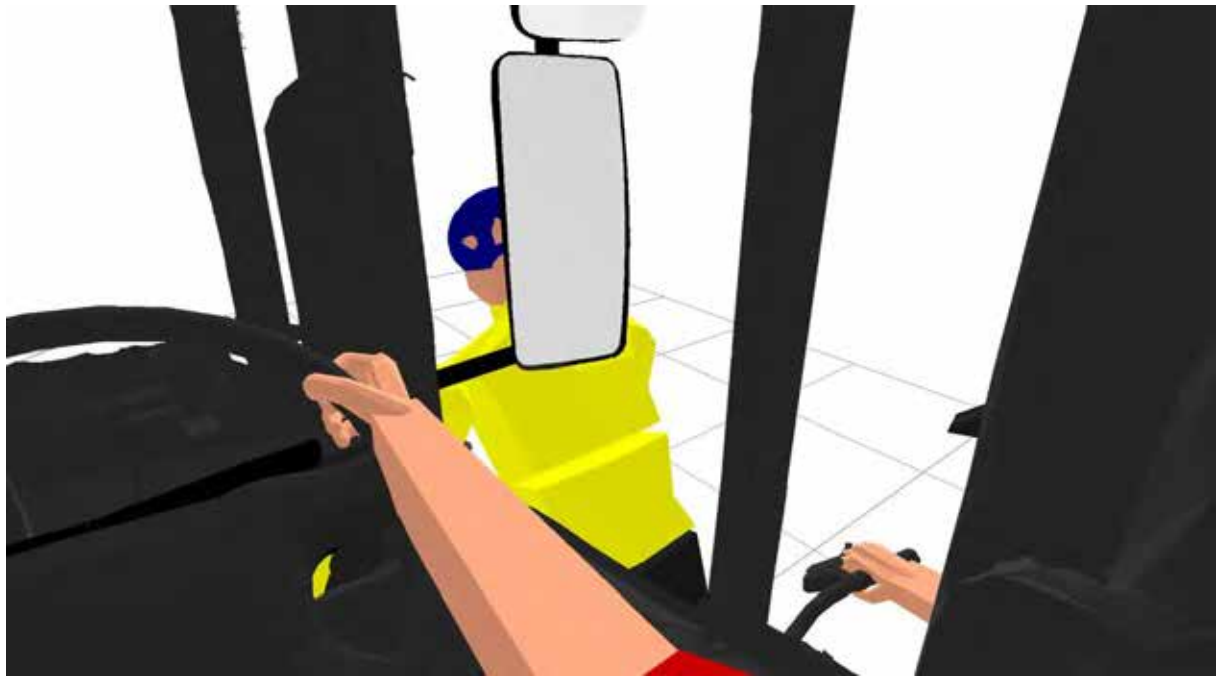


Figure 383. The view from the driver's eyes clearly shows the two cyclists are visible, even when positioned against the side of the vehicle.

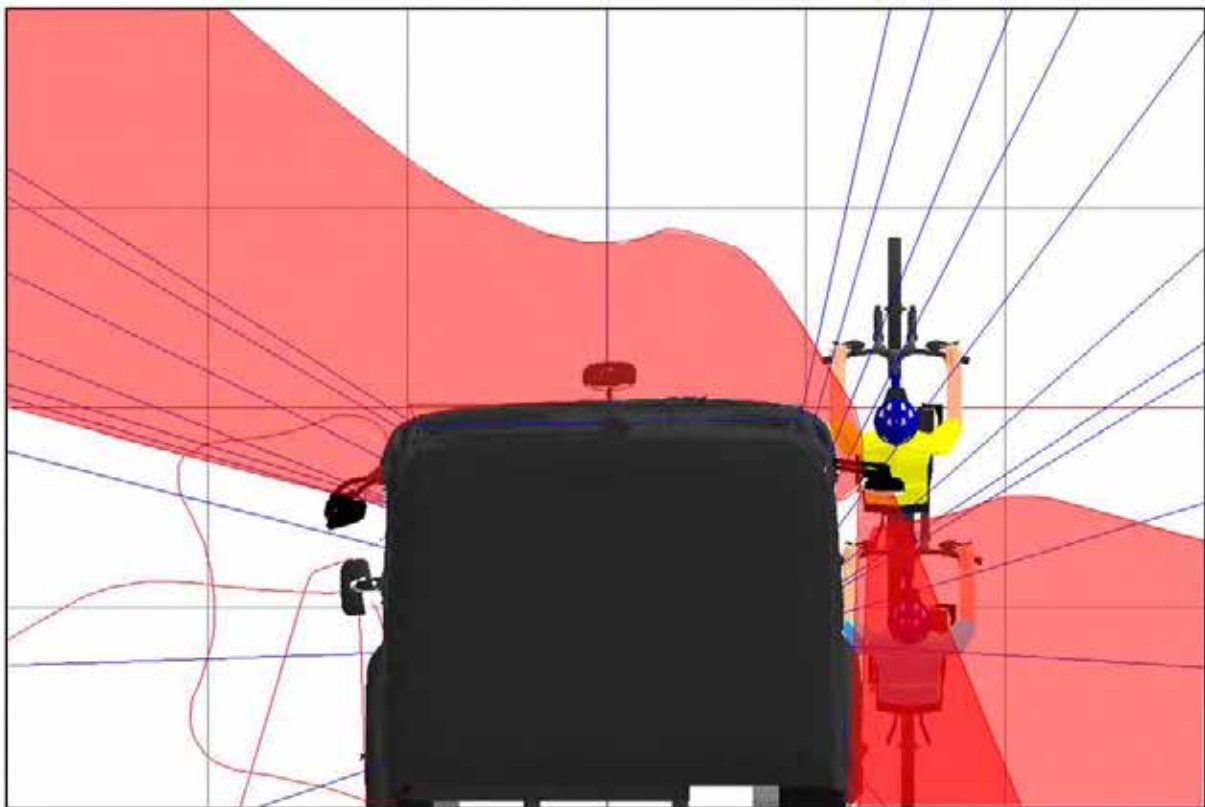


Figure 384. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

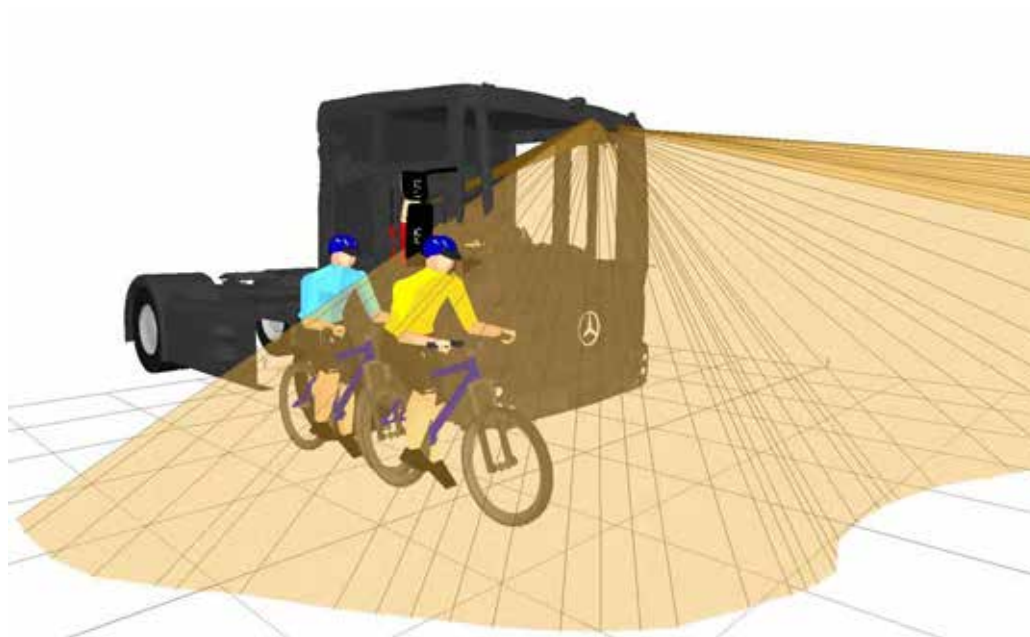


Figure 385. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

In addition to being visible in direct vision the cyclists are also visible in the mirrors. Figure 385 shows that part of the front (yellow) cyclist would also be visible in the Class VI mirror including their arms, lower legs and the front of the bicycle.



Figure 386. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class II mirror

Figure 386 shows that the rear of the two cyclists (blue) is visible in the projections of the offside Class II and Class IV mirrors. The cyclist would only be partially visible including their head and torso. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide a cyclist to the offside of the Mercedes Eonic.

4.1.11.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

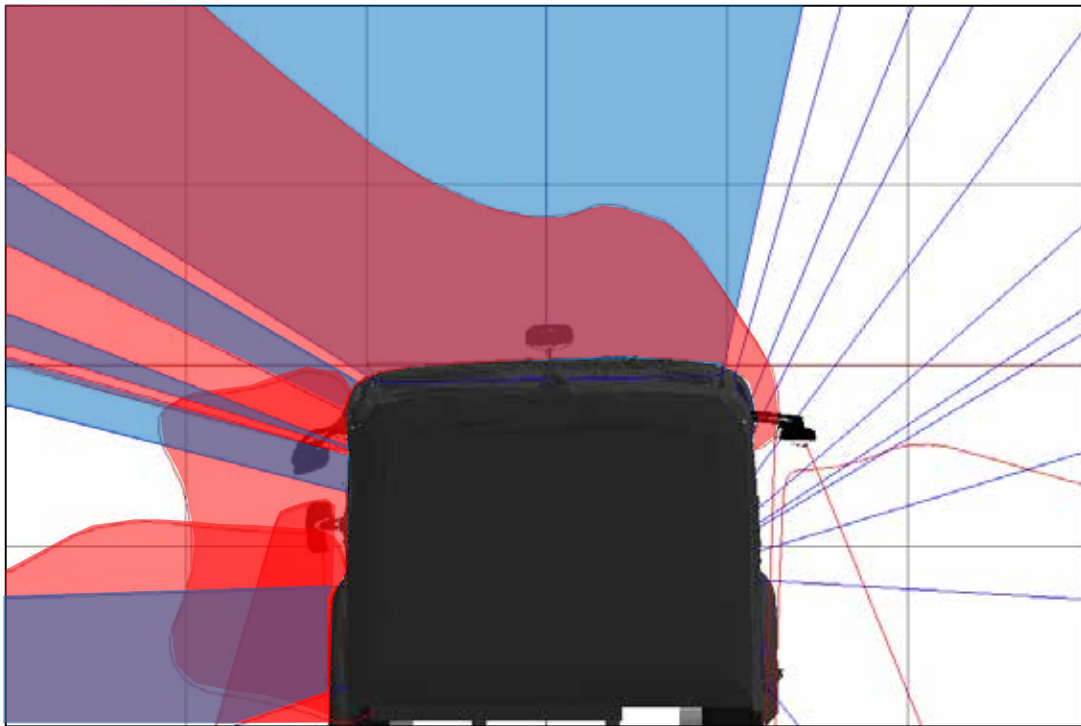


Figure 387. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 388 and Figure 389 show that both cyclists can be seen using direct vision.



Figure 388. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

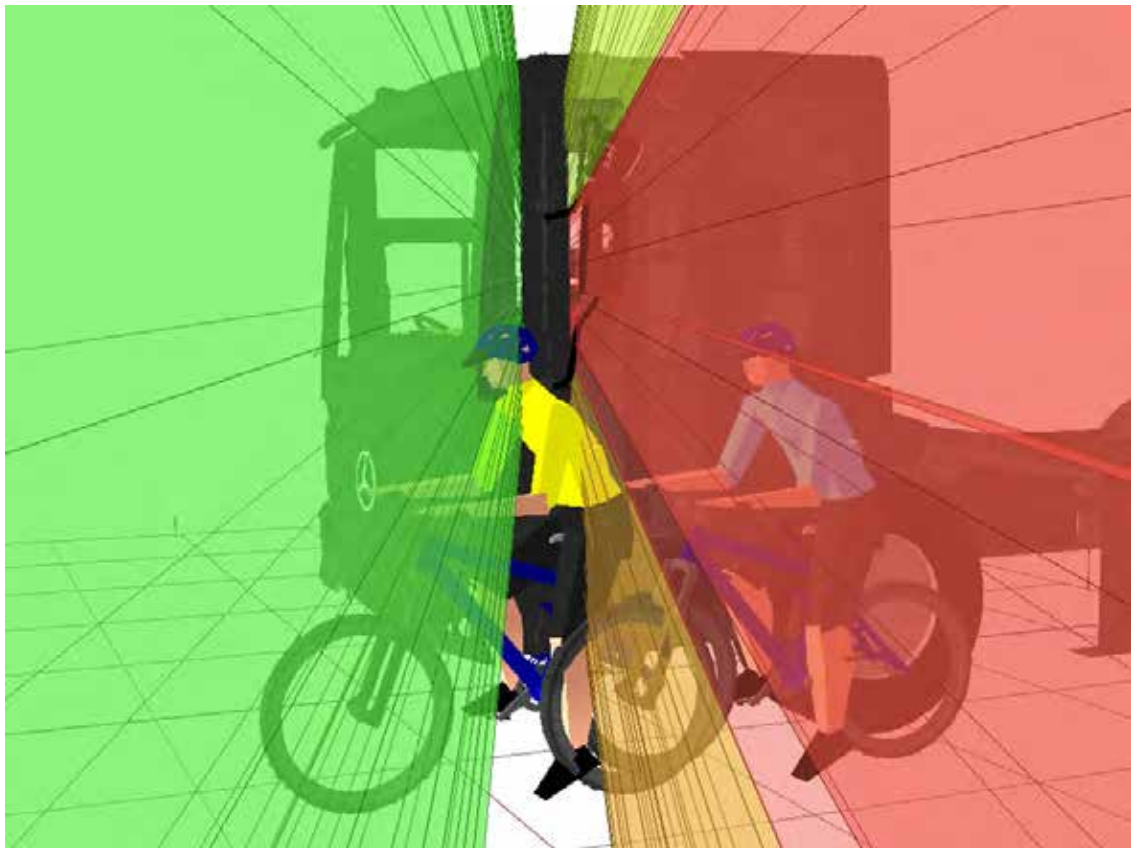


Figure 389. 3D view showing that the two human models be directly seen by the driver

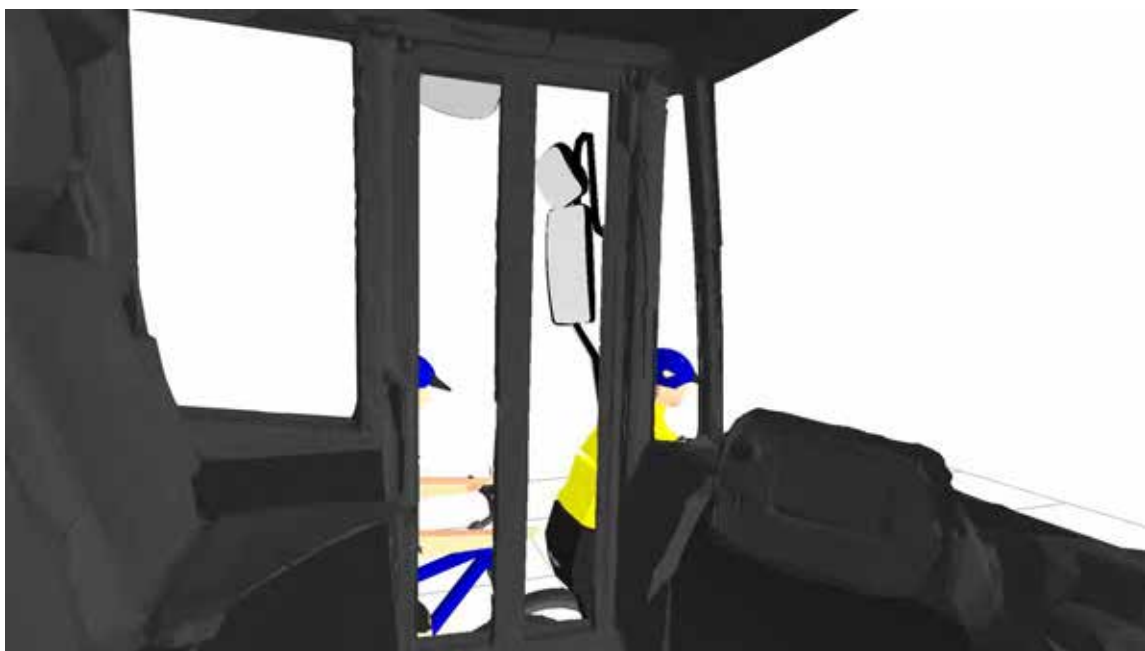


Figure 390. The view from the driver's eyes clearly shows the two cyclists are visible with direct vision.

For nearside visibility of the cyclists both can be seen from the driver's direct vision.

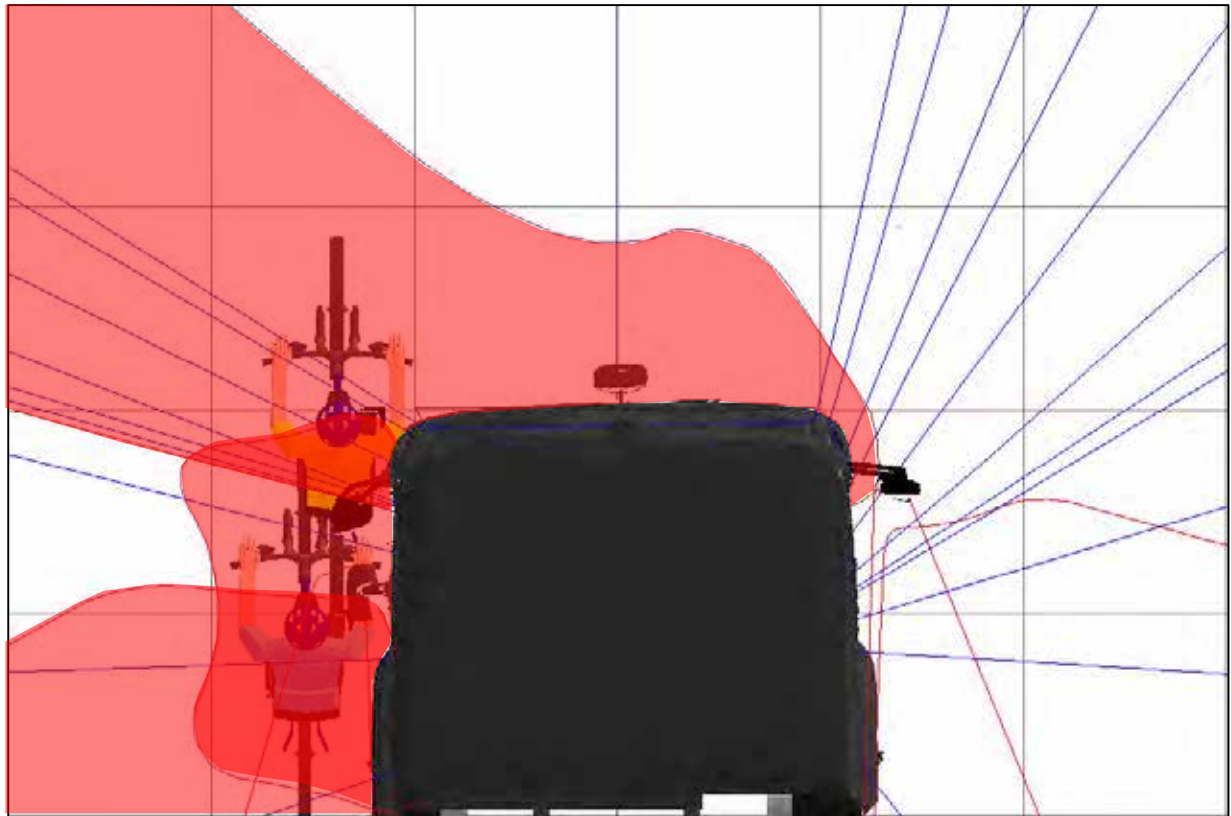


Figure 391. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

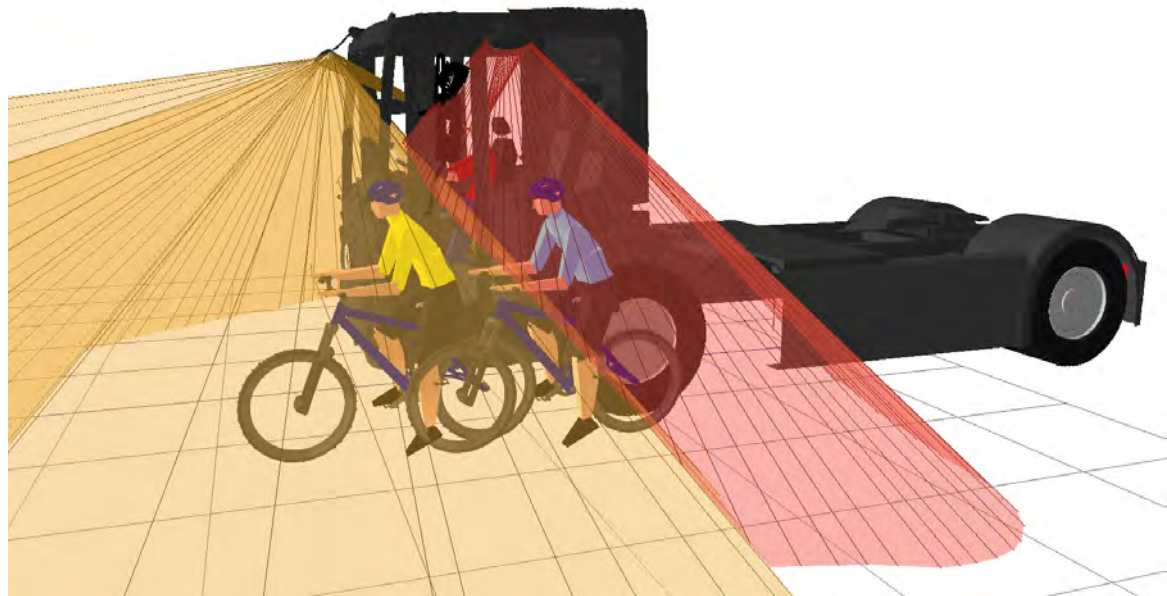


Figure 392. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

The two cyclists cannot be hidden from direct view to the nearside of the vehicle and Figure 392 shows and both are visible in the Class V and Class VI mirrors. The front (yellow) cyclist is partially visible in the Class VI mirror and from the neck down in the Class V mirror. Part of the rear (blue) cyclist's front wheel is visible in the Class VI and completely visible in the Class V mirror.



Figure 393. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is visible in the projection of the Class IV mirror

Figure 393 shows that the rear of the two cyclists (blue) is also visible in the projection of the nearside Class IV mirror. The cyclist would only be partially visible including the head and back of the torso of the rider. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide a cyclist to the nearside of the Mercedes Econic.

4.1.11.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

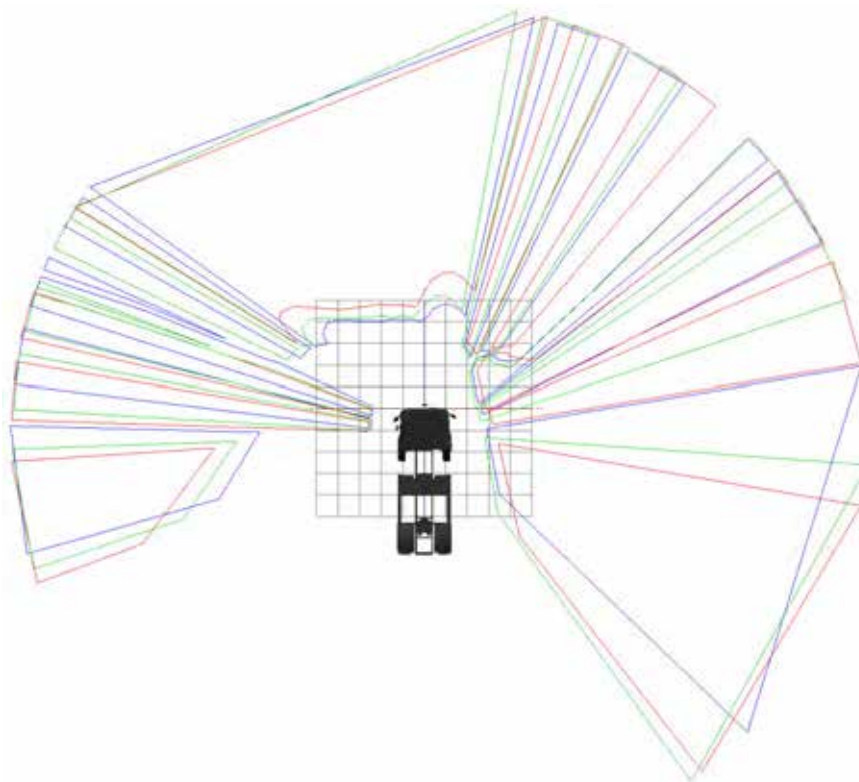


Figure 394. A plan view of the projection of the windscreen and side windows onto the ground plane for the Dennis Eagle Elite 6 for a range of driver eye positions. Red=smallest driver (5th%ile UK female stature), Green=average sized driver (50th%ile UK male stature), and Blue=tallest driver (95th%ile UK male stature).

4.1.12 SCANIA P N3 DISTRIBUTION - 50TH %ILE MALE DRIVER

Figure 395. Evaluation model of Scania P N3 Distribution variant vehicle

4.1.12.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 396 shows a top-down view of all of the window projections for the Scania P N3 cab with a 50th %ile UK Male Driver. The image on the right of Figure 396 shows the areas of these projections that intersect with the ground. Figure 397 shows the same for the the mirror projections and Figure 398 shows the two combined. In this case the projections have been clipped to a radius of twenty metres. Any area outside of the coloured projections, within that twenty metre radius, is effectively a blind spot at the ground plane.

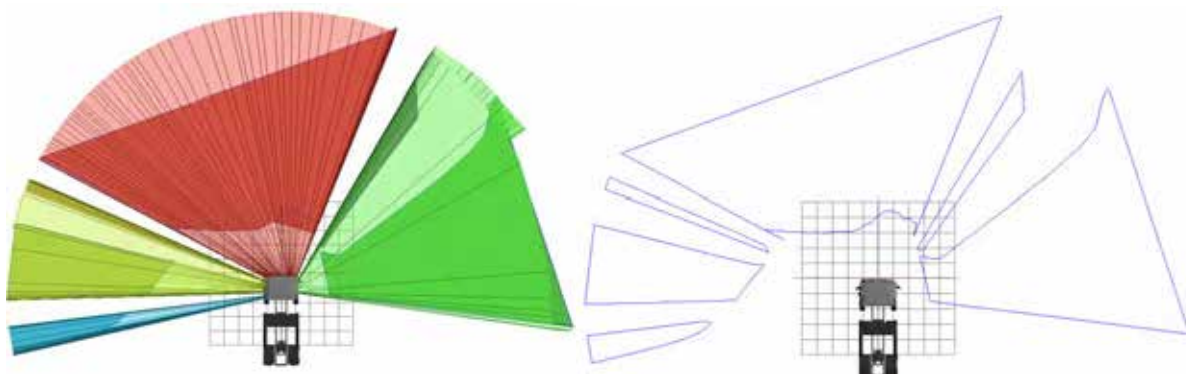


Figure 396. The projection of the windscreen and window apertures at the ground plane for the Scania P N3

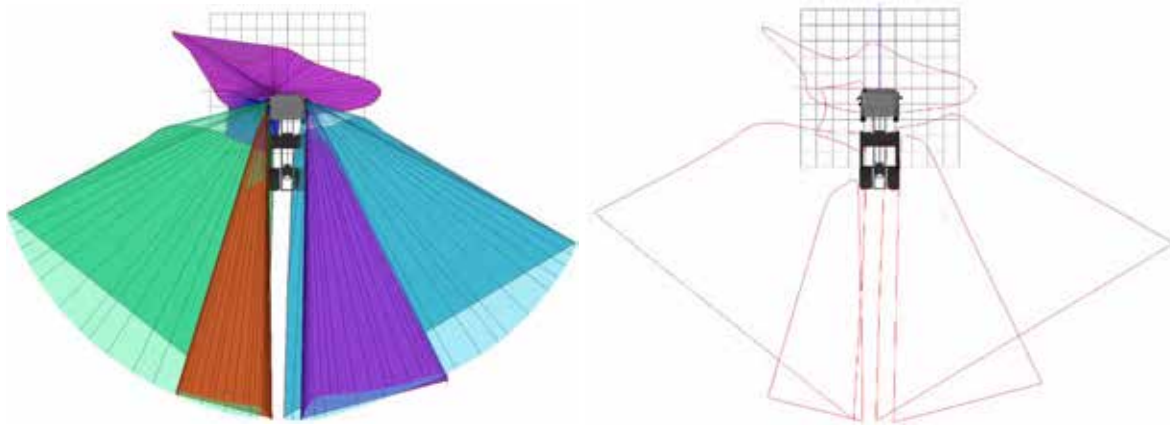


Figure 397. The projection of the mirrors at the ground plane for the Scania P N3

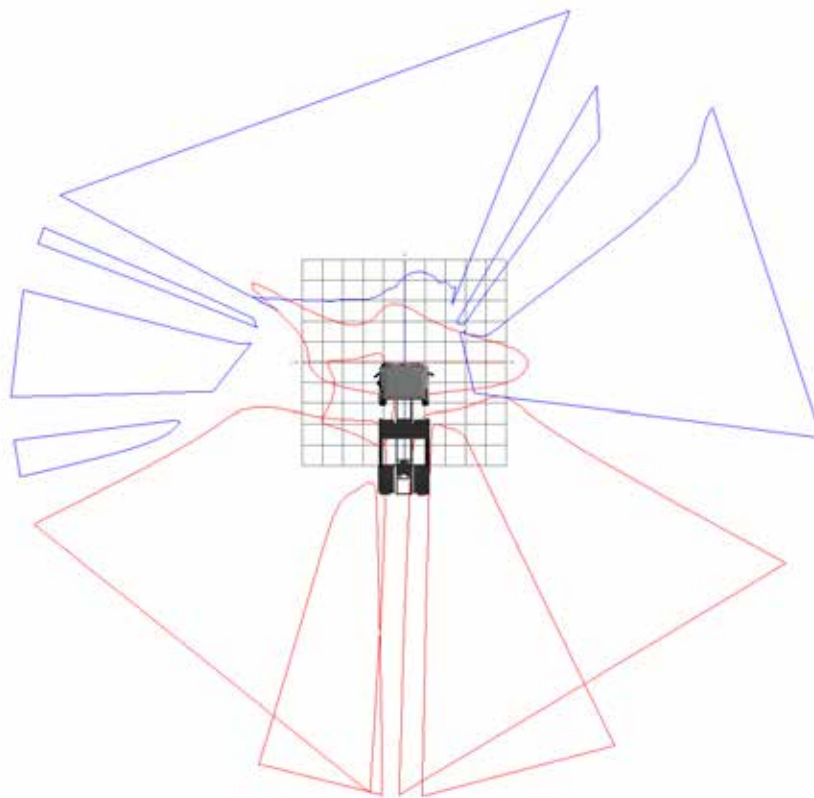


Figure 398. The combined direct and indirect vision projections at the ground plane for the Scania P N3

Figure 399 through Figure 403 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 404 and Figure 405 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

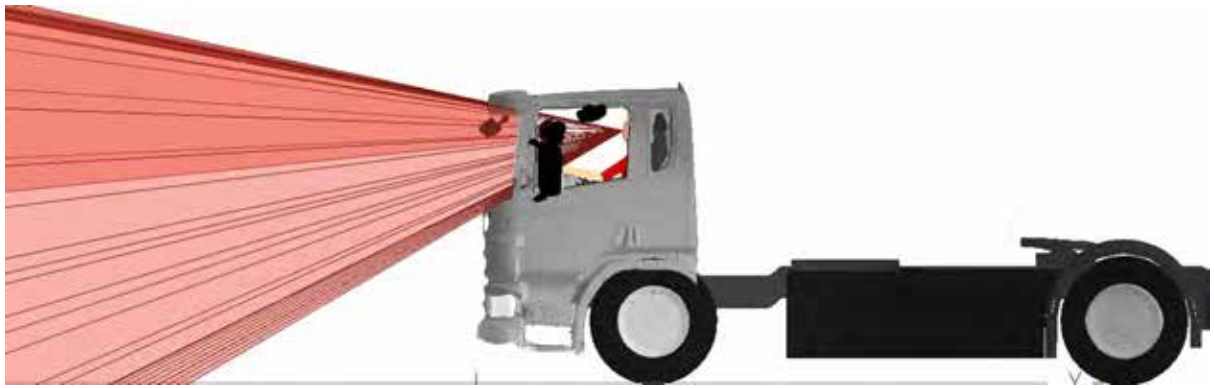


Figure 399. A side view of the windscreen aperture projection for the Scania P N3

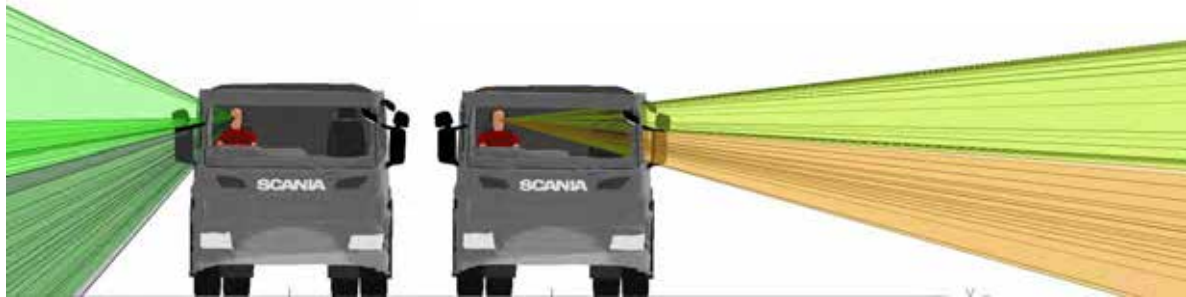


Figure 400. Frontal views of the off side and near side door window projections for the Scania P N3



Figure 401. A side view of the Class VI mirror projection for the Scania P N3



Figure 402. A front view of the Class V mirror projection for the Scania P N3

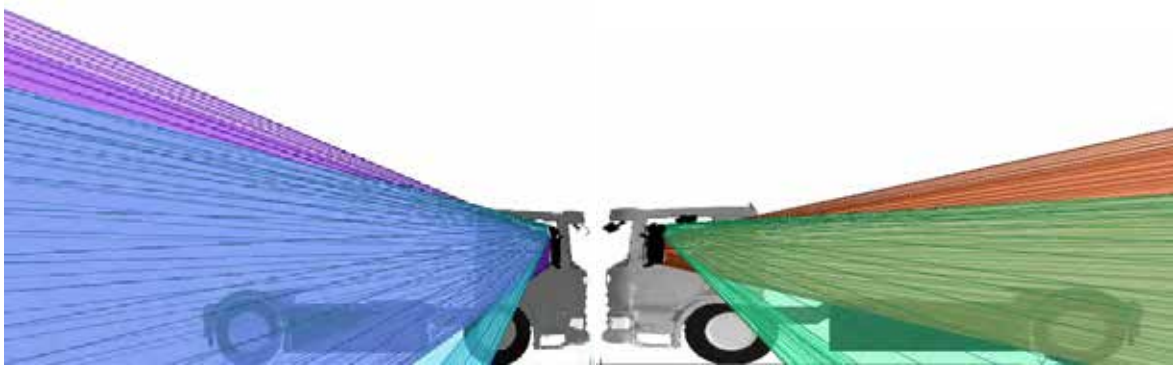


Figure 403. Side views of the combined Class II and Class IV mirror projections for the Scania P N3

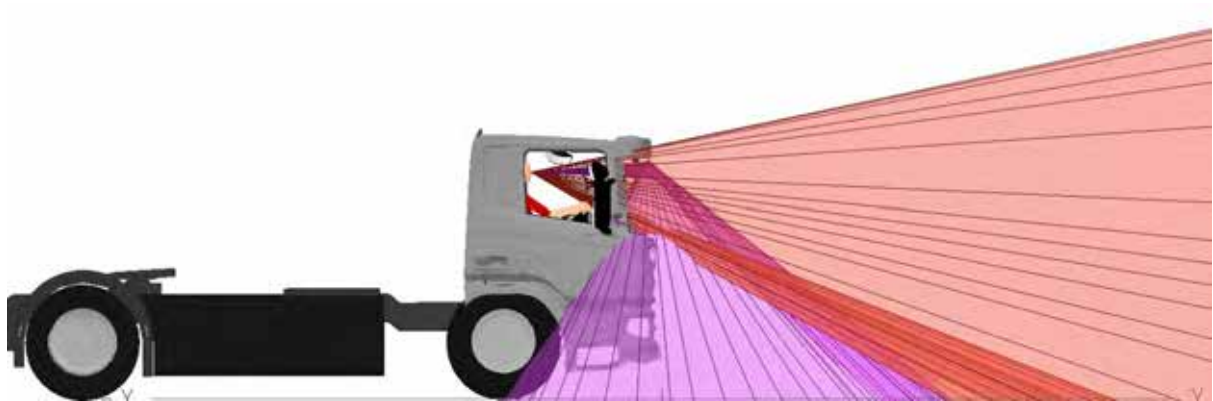


Figure 404. Combined projection of the windscreen and Class VI mirror to the front of the Scania P N3

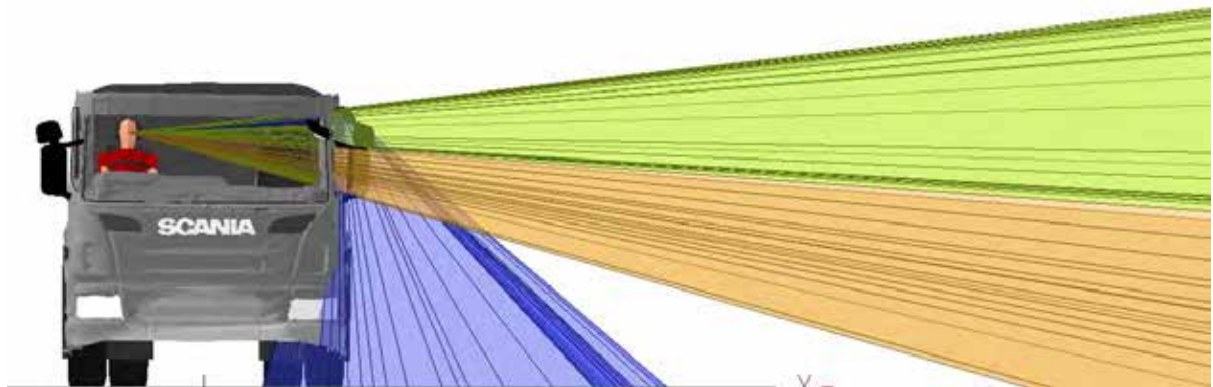


Figure 405. Combined projection of the near side windows and Class V mirror to the side of the Scania P N3

4.1.12.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 406 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

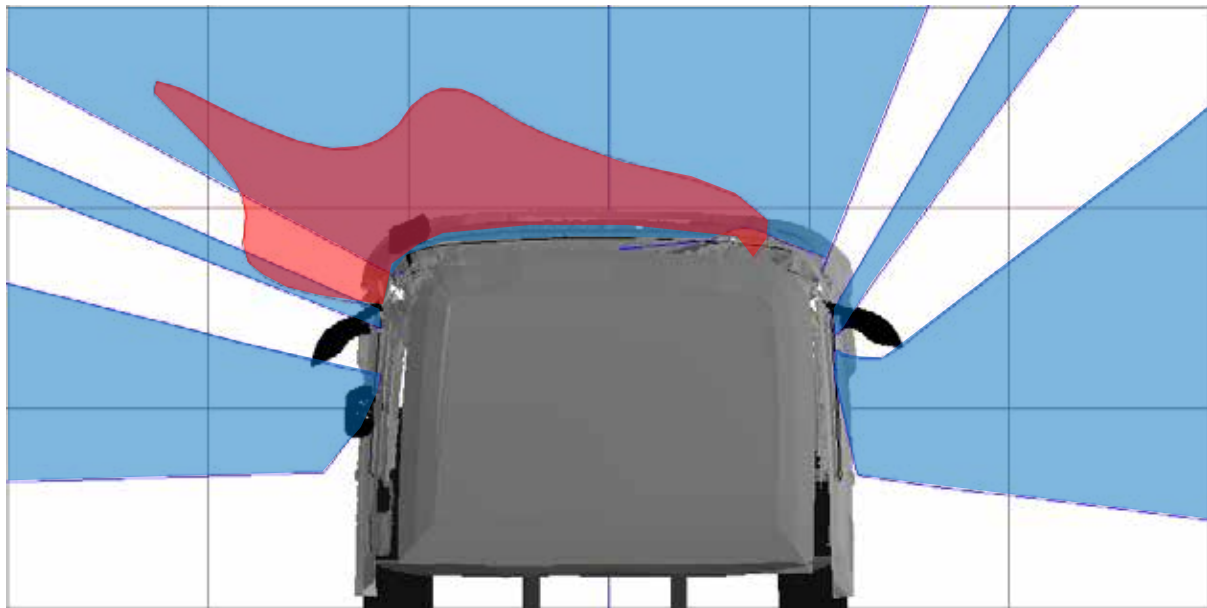


Figure 406. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 398. Figure 407 and Figure 408 show that there is no space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.

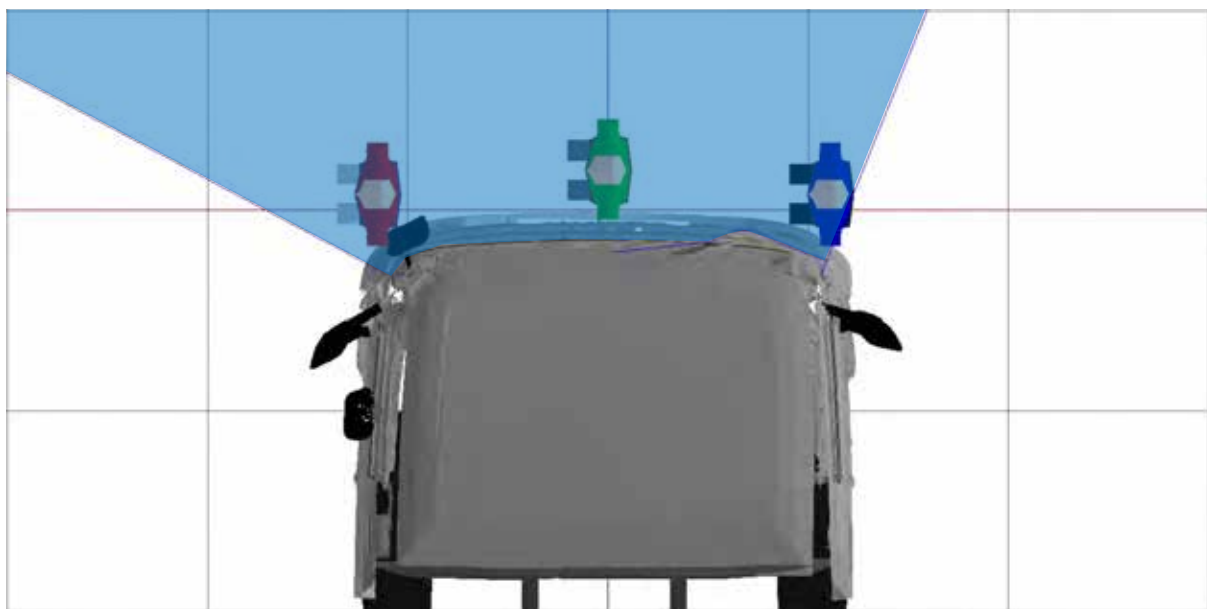


Figure 407. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

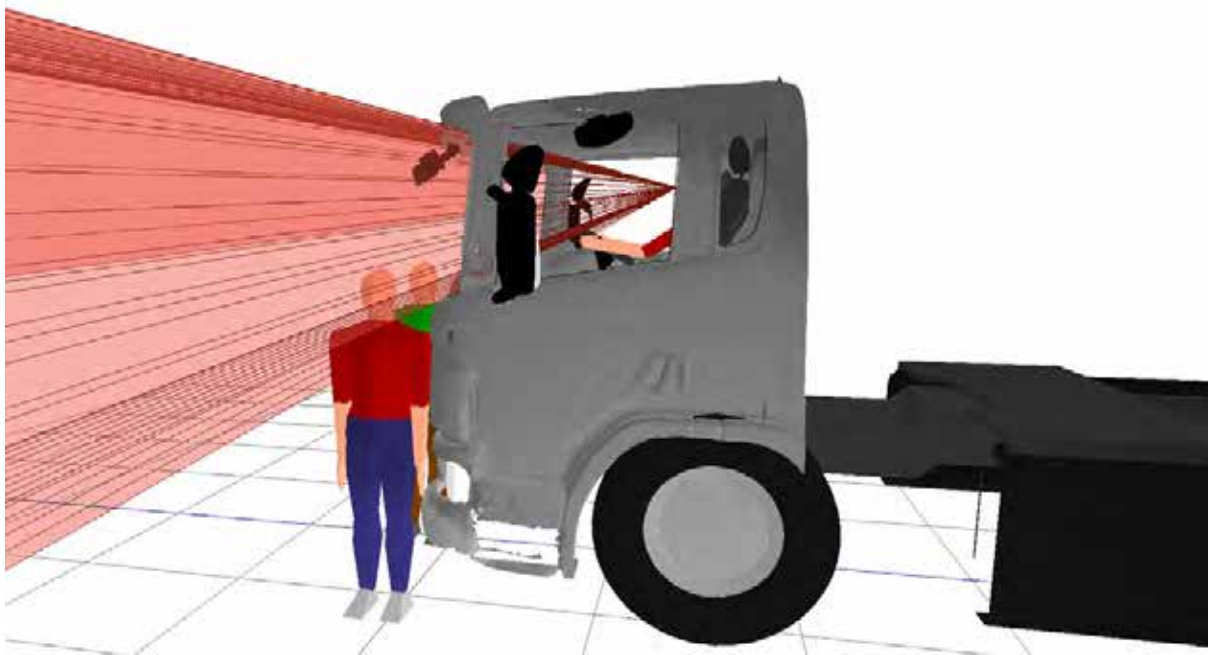


Figure 408. 3D view showing that the left (red), centre (green) and blue (right) pedestrians cannot be hidden from the direct vision of the driver in the standardised driving posture

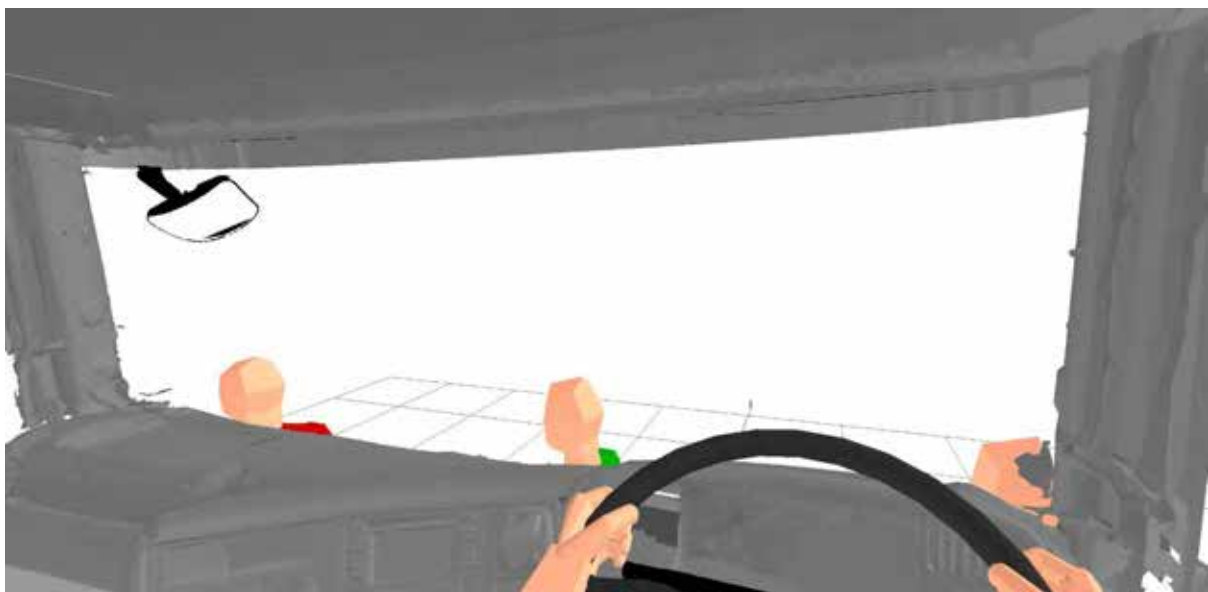


Figure 409. The view from the driver's eyes shows that all three pedestrians are clearly visible to the driver.

For forwards visibility of the pedestrians all three are clearly visible even when positioned directly against the front of the cab. Thus it is not possible for a pedestrian of 50th %ile UK male height or taller to be hidden from direct vision when positioned to the front of the Scania P N3.

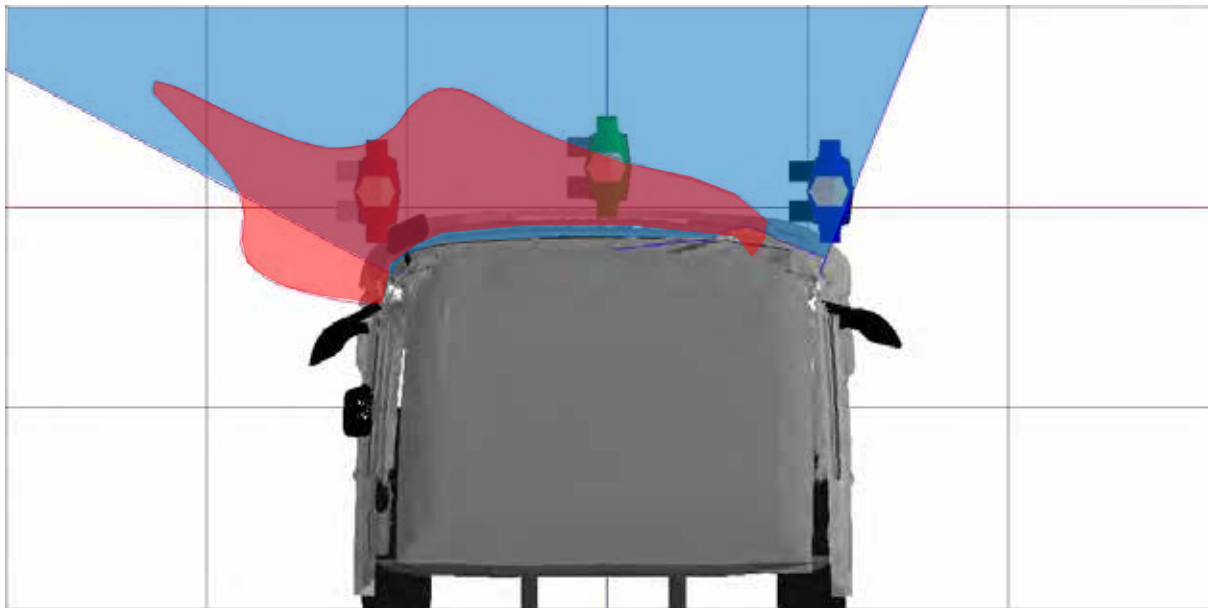


Figure 410. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

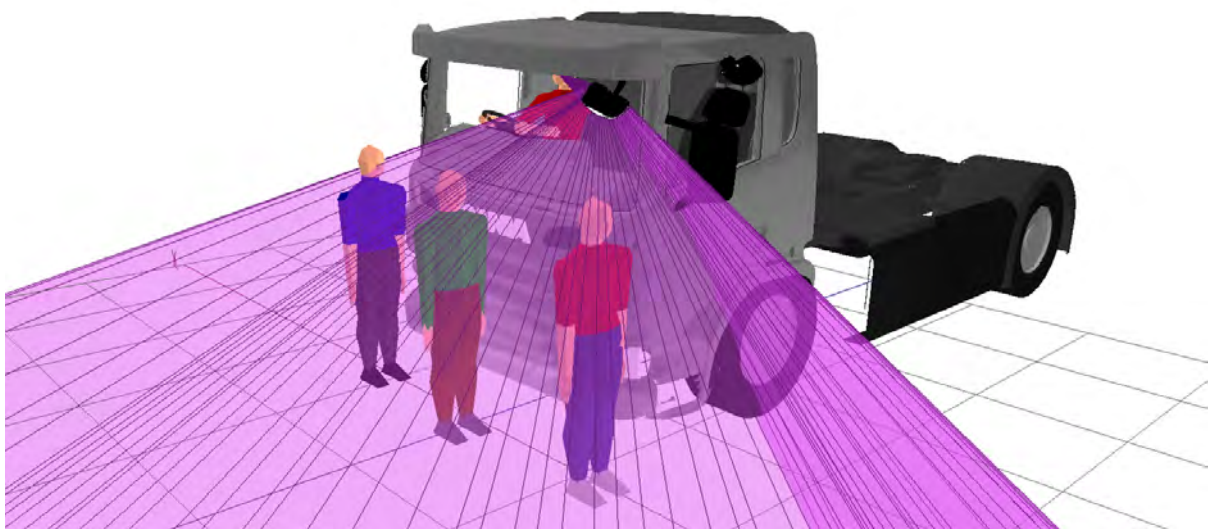


Figure 411. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

In addition to being visible via direct vision to the front of the vehicle all three are also visible in the Class VI mirror. Figure 411 shows that the pedestrian to the left (red) and centre (green) would be completely visible and the pedestrian to the right (blue) would be visible from the neck down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide the pedestrian models that have been tested to the front of the Scania P N3.

4.1.12.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

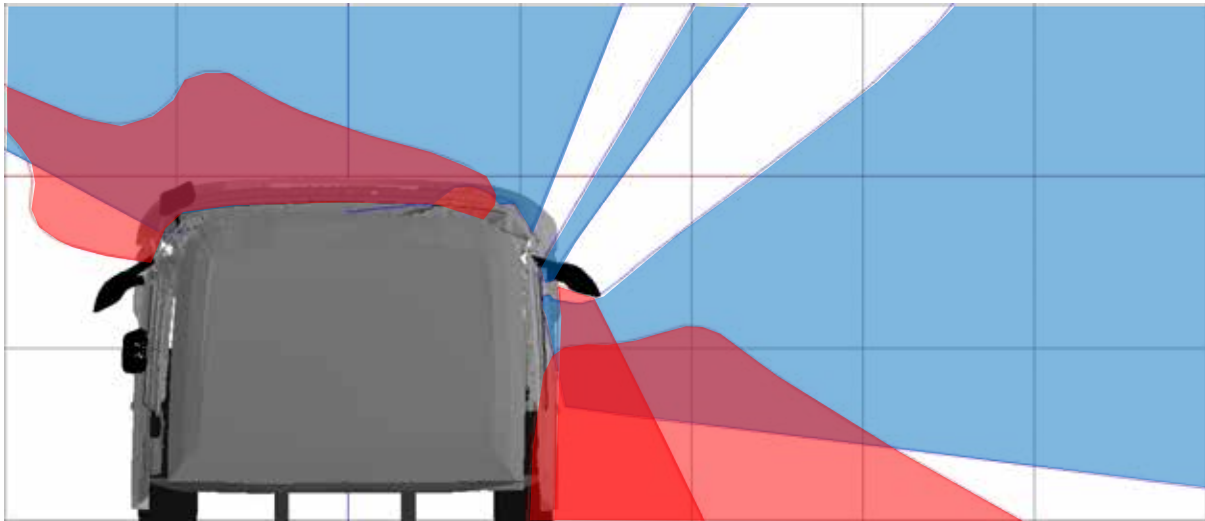


Figure 412. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

From Figure 412 it is clear that the visible areas at a height representative of a cyclist are closer to the vehicle than those taken at ground level shown in Figure 398. Figure 413, Figure 414 and Figure 415 show that there is effectively no gap between the offside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

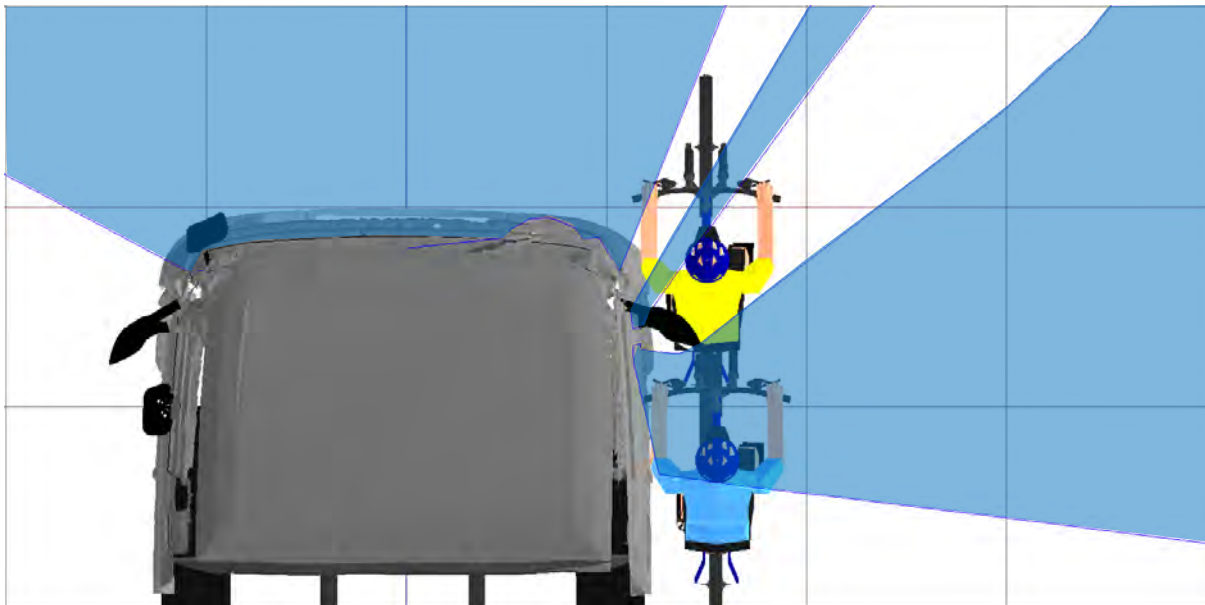


Figure 413. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist

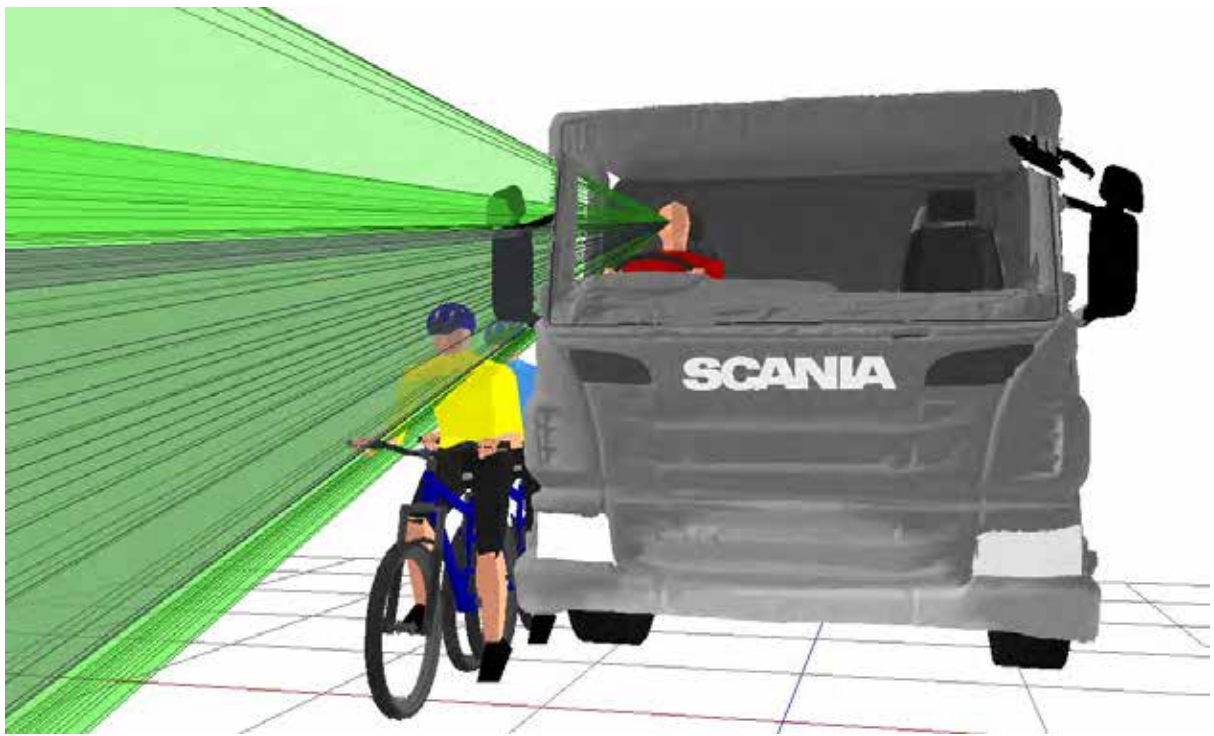


Figure 414. 3D view showing that both cyclists cannot be hidden from direct vision to the offside of the Scania P N3

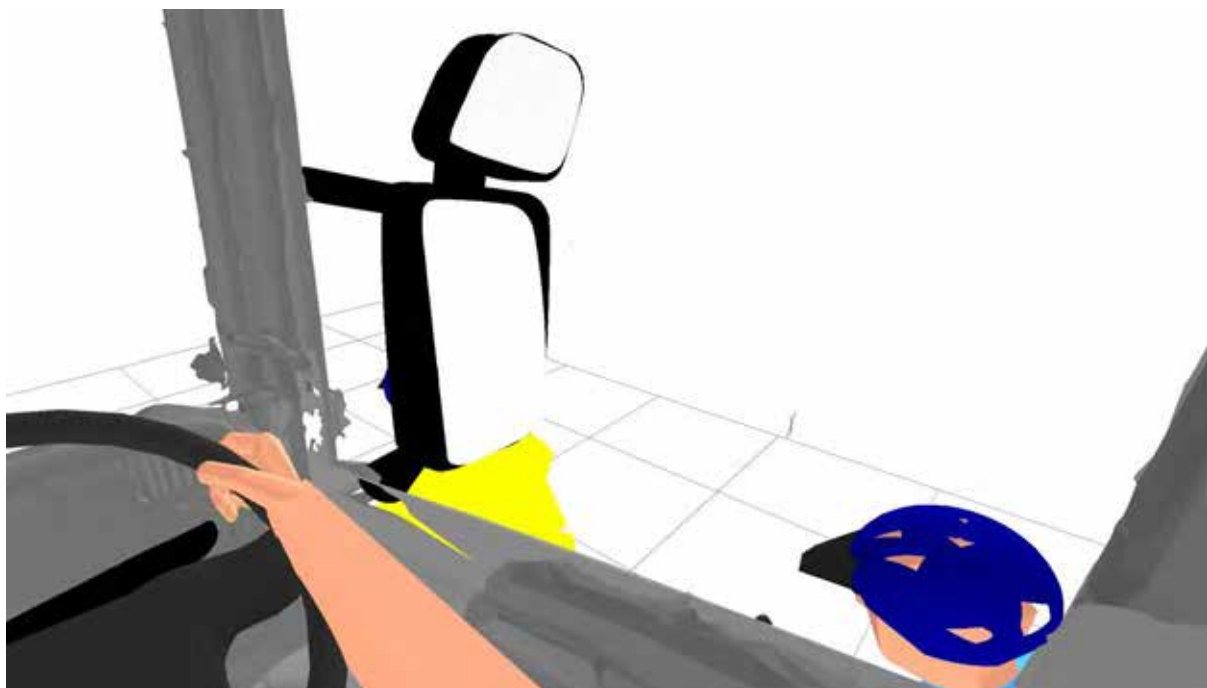


Figure 415. The view from the driver's eyes clearly shows the two cyclists are visible, even when positioned against the side of the vehicle.

For offside visibility of the cyclists there is no blind spot that could obscure a cyclist. Figure 415 shows that even with the cyclists touching the side of the cab they would still be visible to the driver.

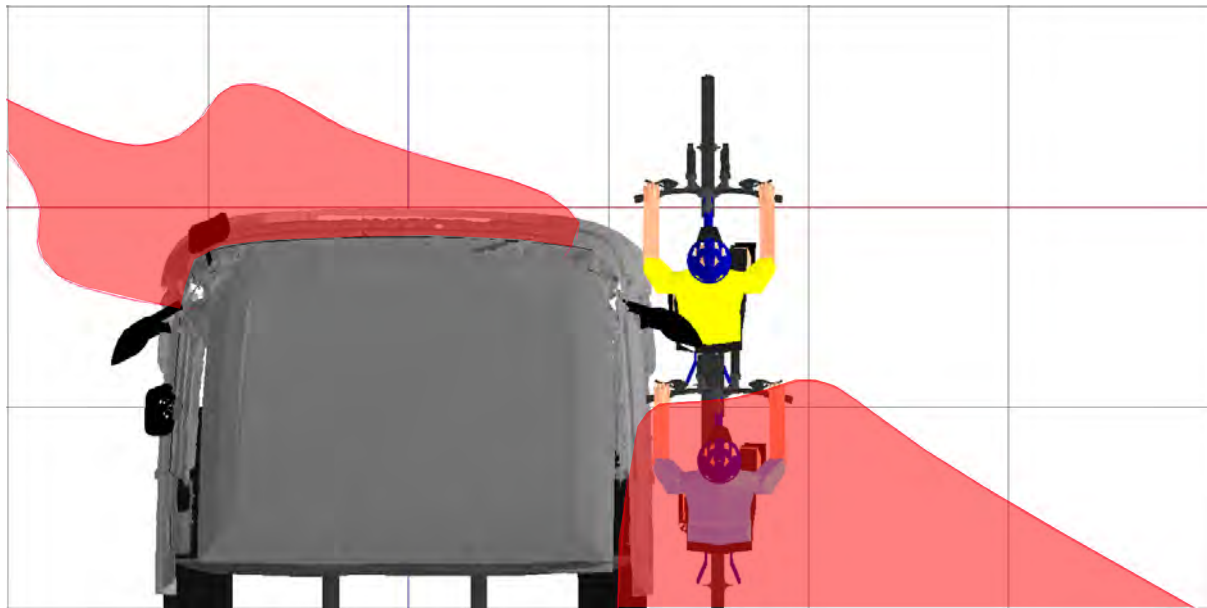


Figure 416. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

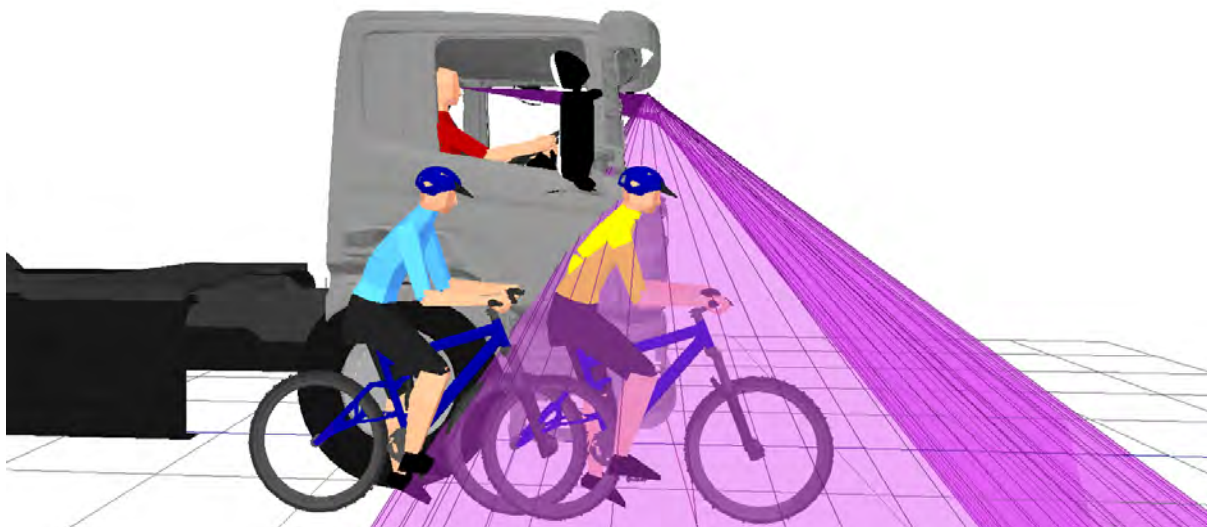


Figure 417. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

In addition to being visible in direct vision the cyclists are also visible in the mirrors. Figure 417 shows that part of the front (yellow) cyclist would also be visible in the Class VI mirror including their hands, and the front of the bicycle.

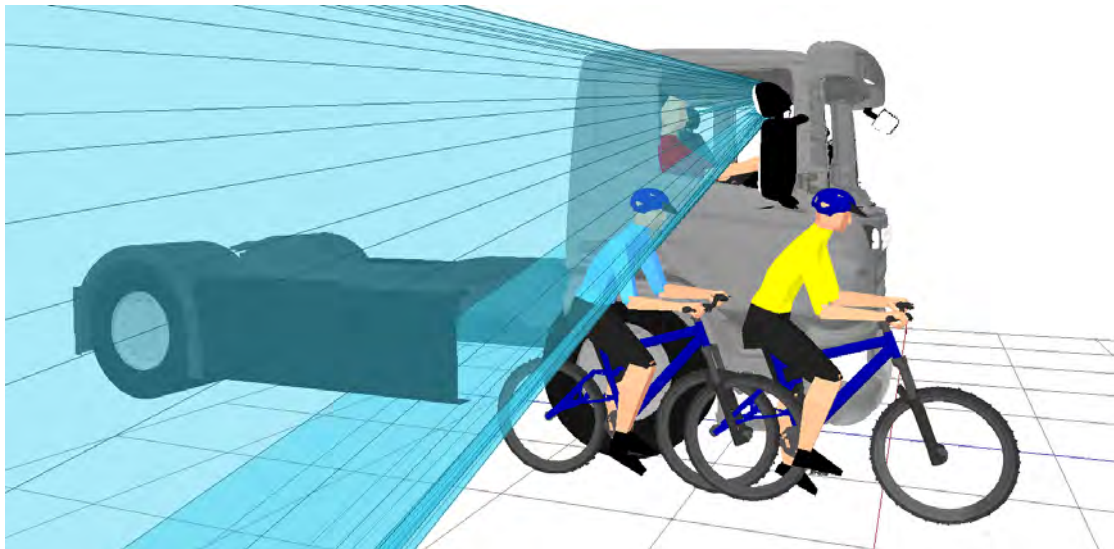


Figure 418. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 418 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head, torso and upper arms. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the offside of the Scania P N3.

4.1.12.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

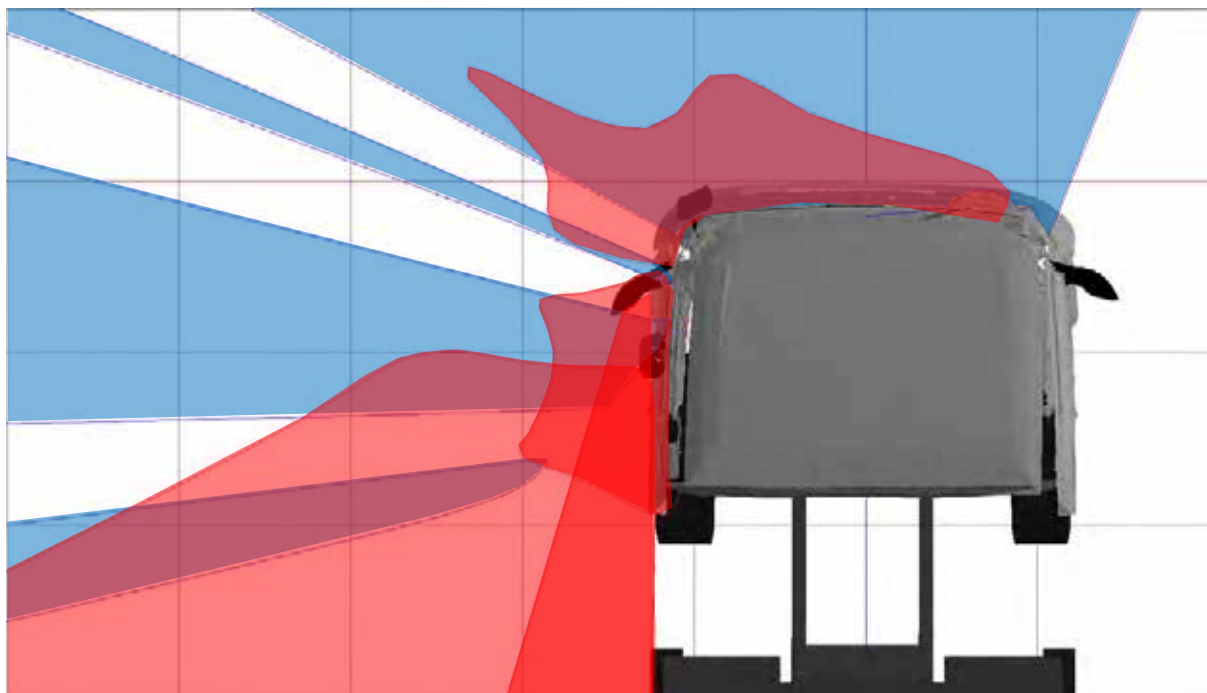


Figure 419. The areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 420 and Figure 421 show that there is no space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

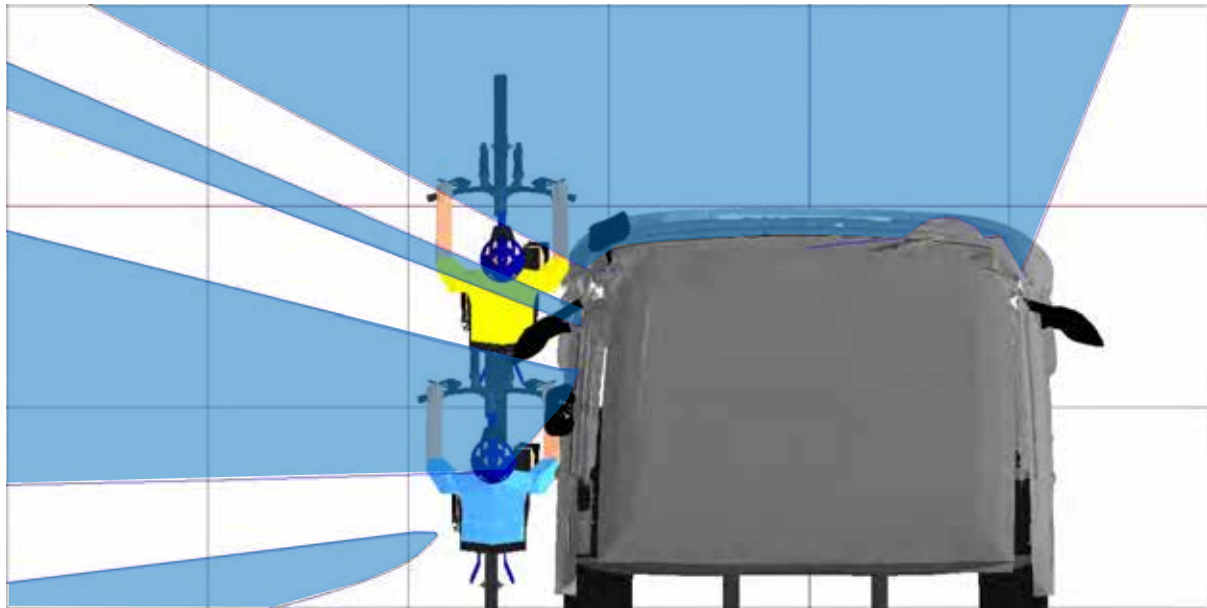


Figure 420. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist



Figure 421. 3D view showing that the two human models can be seen through direct vision by the driver in the standardised driving posture

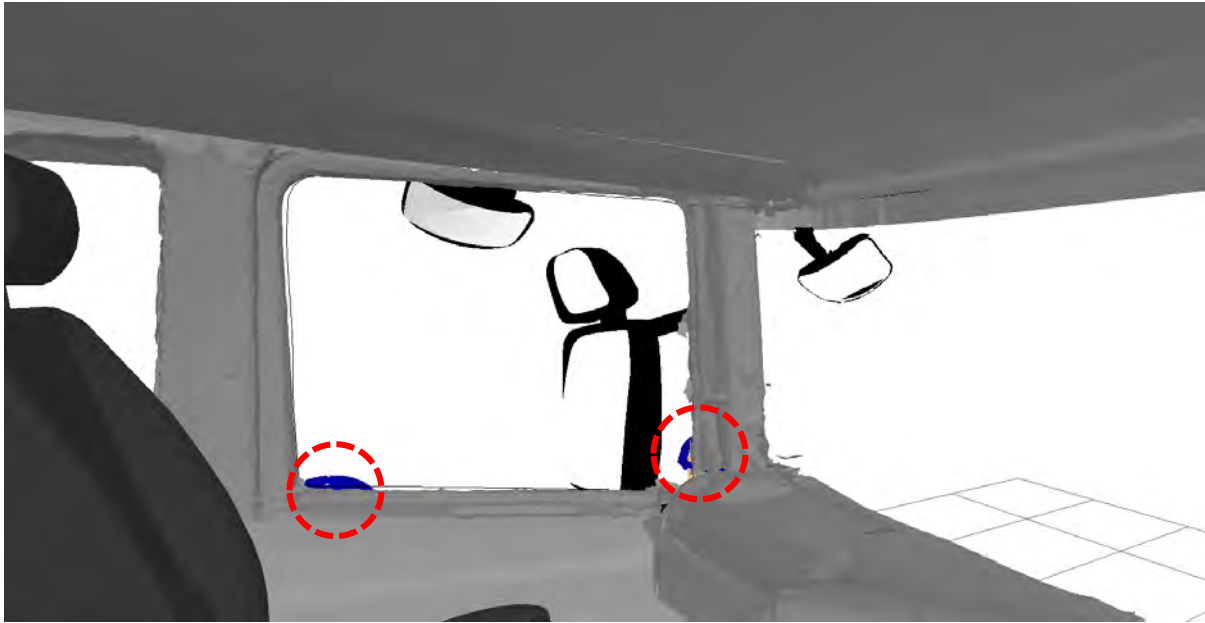


Figure 422. The view from the driver’s eyes shows the two cyclists are just visible even when positioned directly adjacent to the vehicle.

For nearside visibility of the cyclists there is no blind spot that could obscure the cyclists in the assessed locations. Figure 422 shows that even with the cyclists touching the side of the cab they would still be visible to the driver. Very small portions of the cyclists are visible, with the rearmost cyclist being hidden if moved further rearwards and the front cyclist being hidden if moved further forward into the A-pillar blind spot.

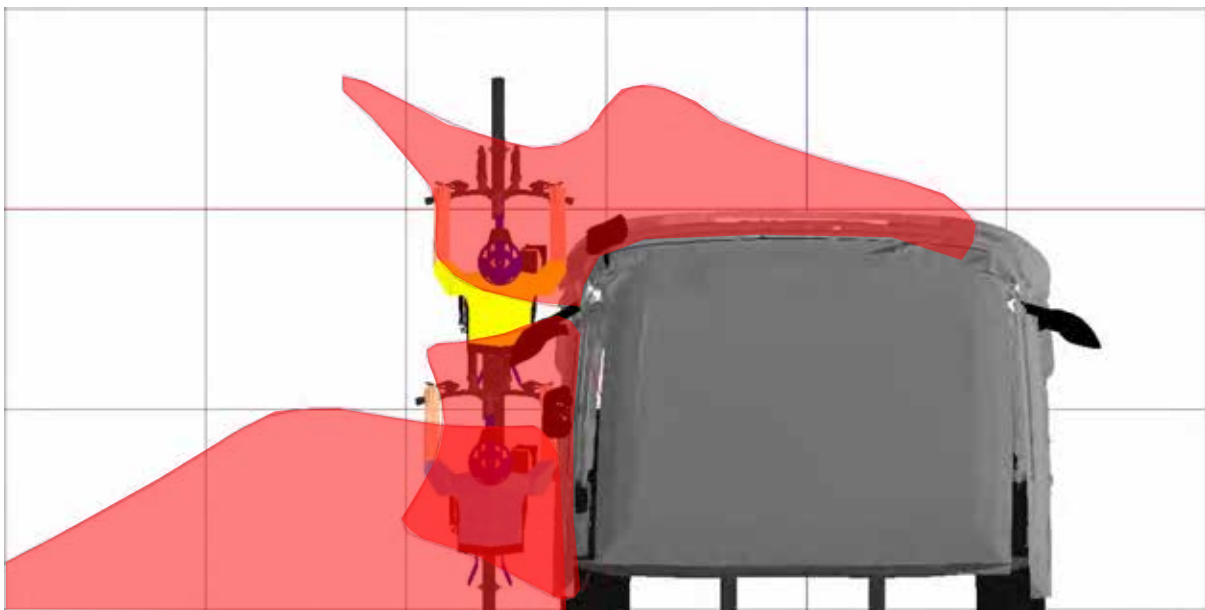


Figure 423. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

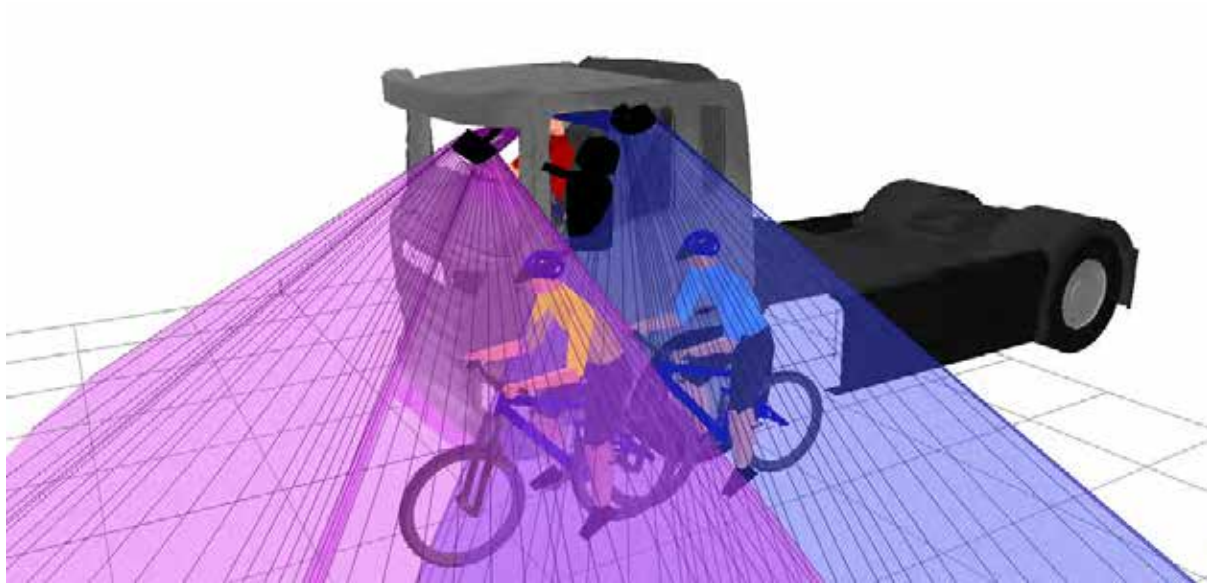


Figure 424. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

In addition to the cyclists being visible through direct vision to the nearside of the vehicle Figure 424 shows that both are visible in the Class V and Class VI mirrors. The front (yellow) cyclist is completely visible in the Class VI mirror and from the chest down in the Class V mirror. Part of the rear (blue) cyclist's front wheel is visible in the Class VI and completely visible in the Class V mirror.

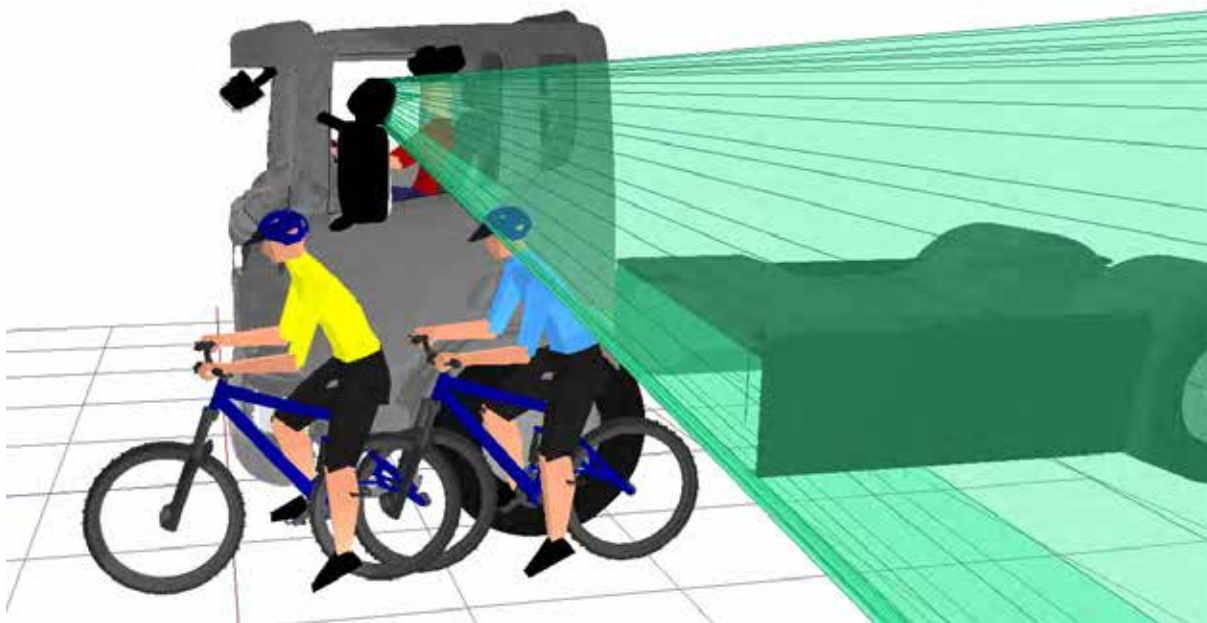


Figure 425. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is visible in the projection of the Class IV mirror

Figure 425 shows that the rear of the two cyclists (blue) is also visible in the projection of the nearside Class IV mirror. The cyclist would only be partially visible including part of the head and back of the torso of the rider. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the nearside of the Scania P N3.

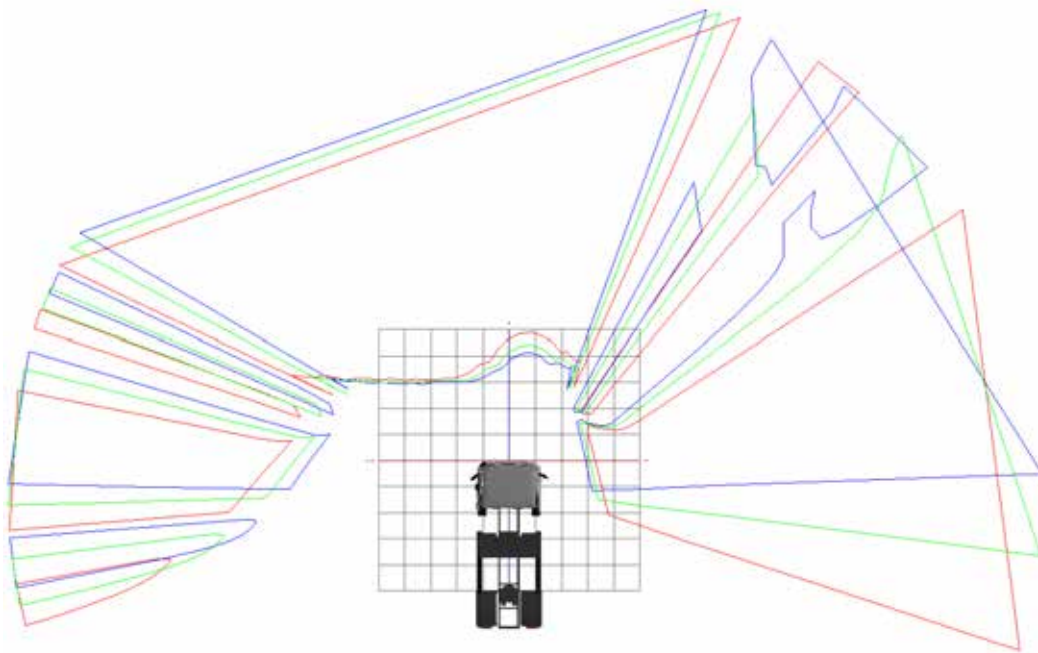
4.1.12.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

Figure 426. A plan view of the projection of the windscreen and side windows onto the ground plane for the Scania P N3 for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.1.13 SCANIA P N3G CONSTRUCTION - 50TH %ILE MALE DRIVER



Figure 427. Evaluation model of Scania P N3G Construction variant vehicle

4.1.13.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 428 shows a top-down view of all of the window projections for the Scania P N3G cab with a 50th %ile UK Male Driver. The image on the right of Figure 428 shows the areas of these projections that intersect with the ground. Figure 429 shows the same for the mirror projections and Figure 430 shows the two combined. Any area outside of the coloured projections is effectively a blind spot at the ground plane.

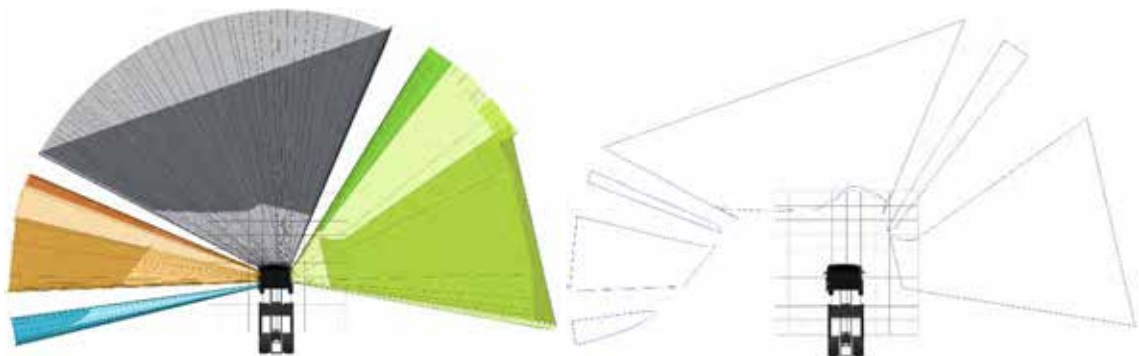


Figure 428. The projection of the windscreen and window apertures at the ground plane for the Scania P N3G

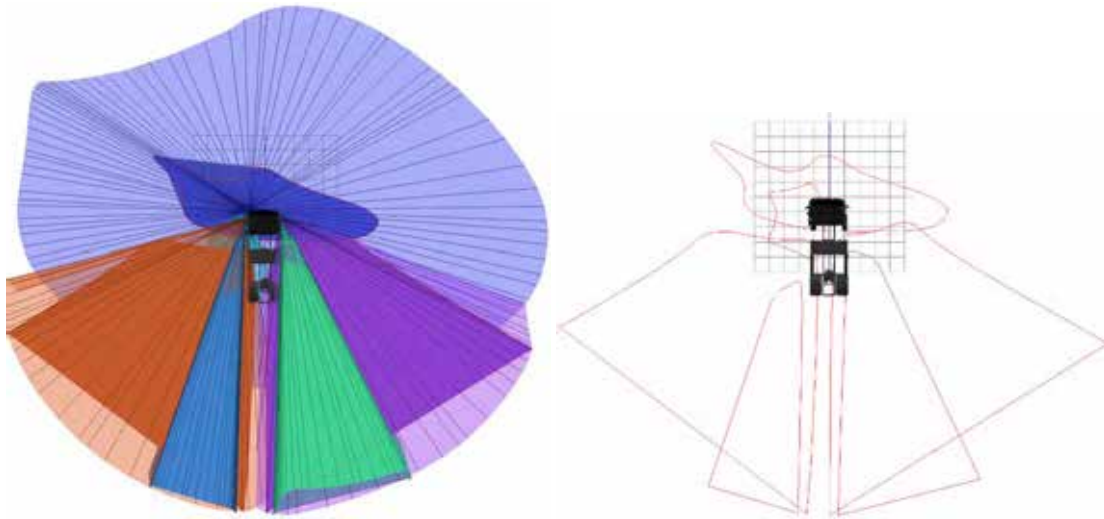


Figure 429. The projection of the mirrors at the ground plane for the Scania P N3G

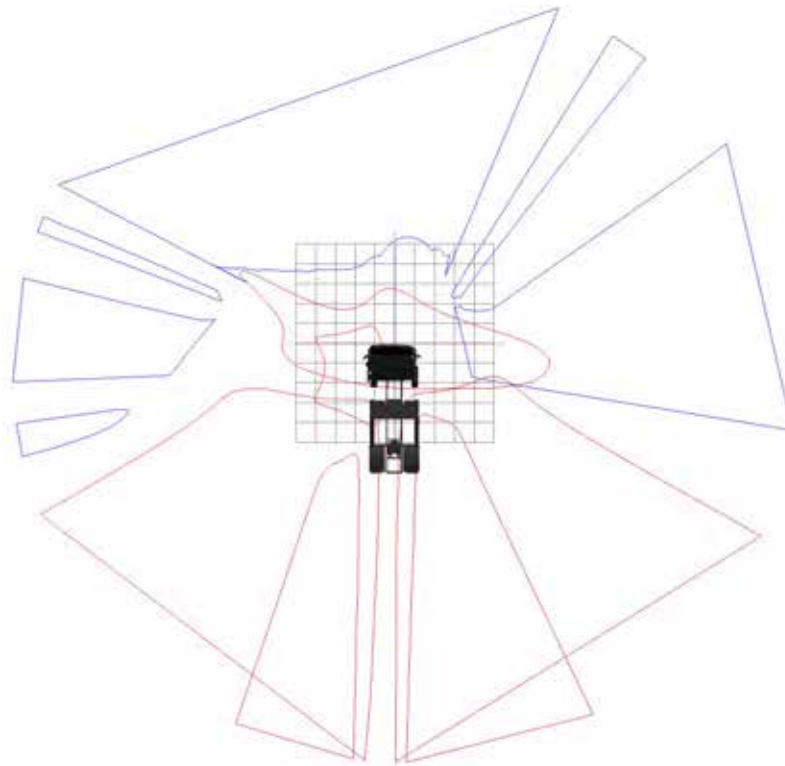


Figure 430. The combined direct and indirect vision projections at the ground plane for the Scania P N3G

Figure 431 through Figure 435 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 436 and Figure 437 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.



Figure 431. A side view of the windscreen aperture projection for the Scania P N3G

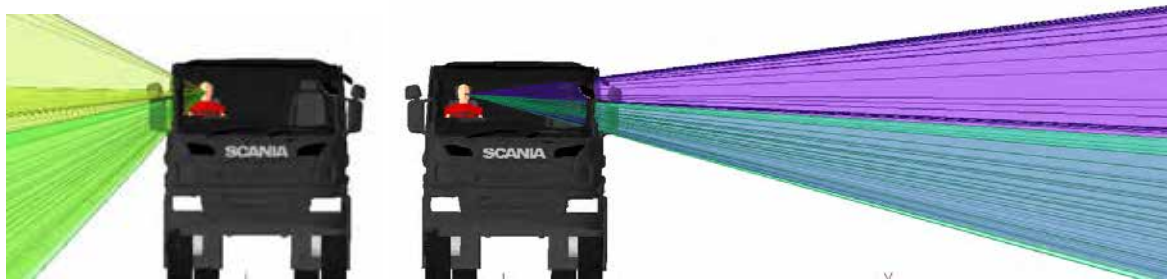


Figure 432. Frontal views of the off side and near side door window projections for the Scania P N3G



Figure 433. A side view of the Class VI mirror projection for the Scania P N3G



Figure 434. A front view of the Class V mirror projection for the Scania P N3G

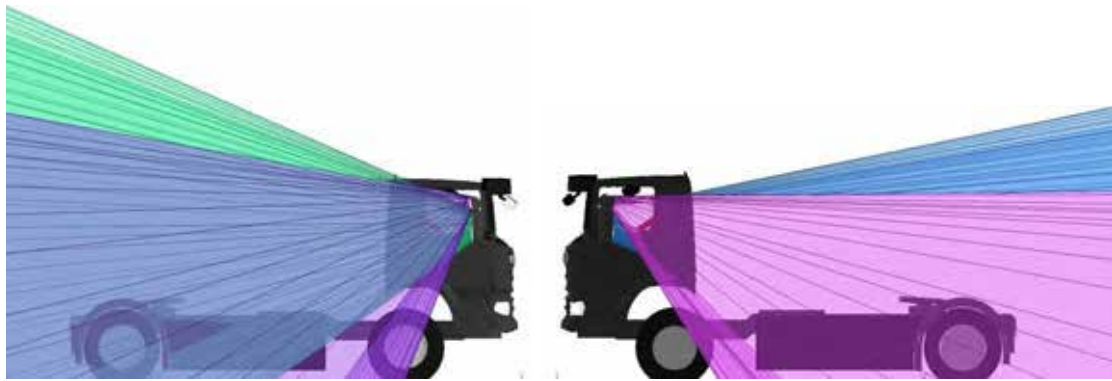


Figure 435. Side views of the combined Class II and Class IV mirror projections for the Scania P N3G

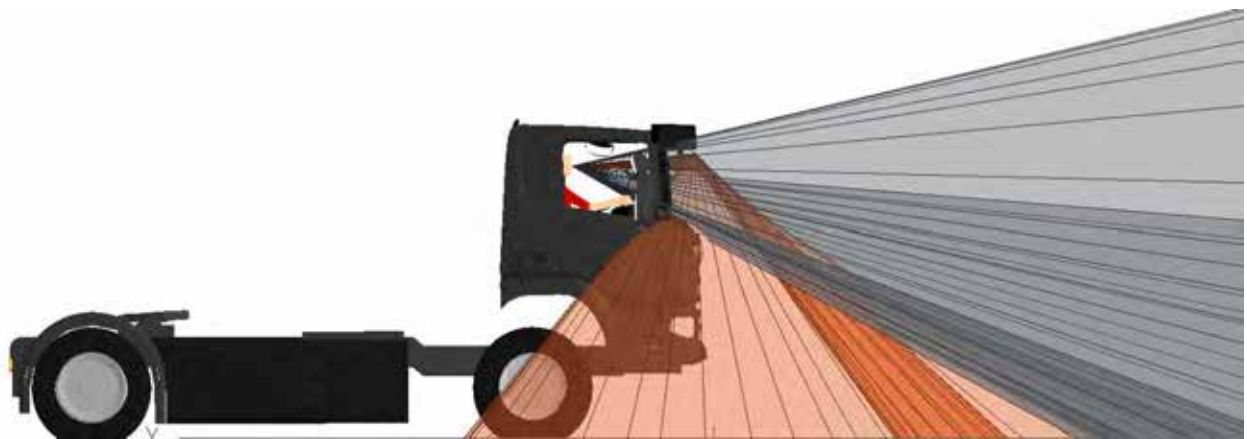


Figure 436. Combined projection of the windscreen and Class VI mirror to the front of the Scania P N3G

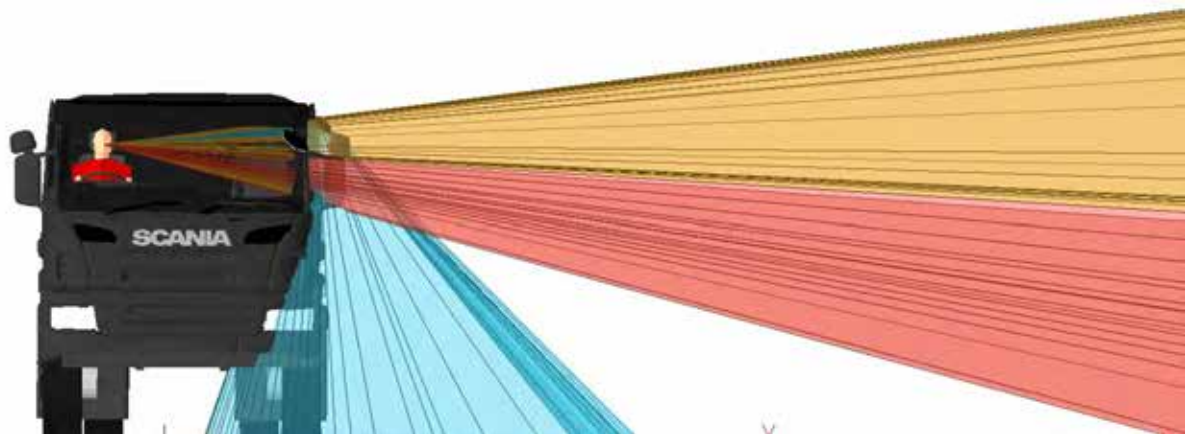


Figure 437. Combined projection of the near side windows and Class V mirror to the side of the Scania P N3G

4.1.13.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 438 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

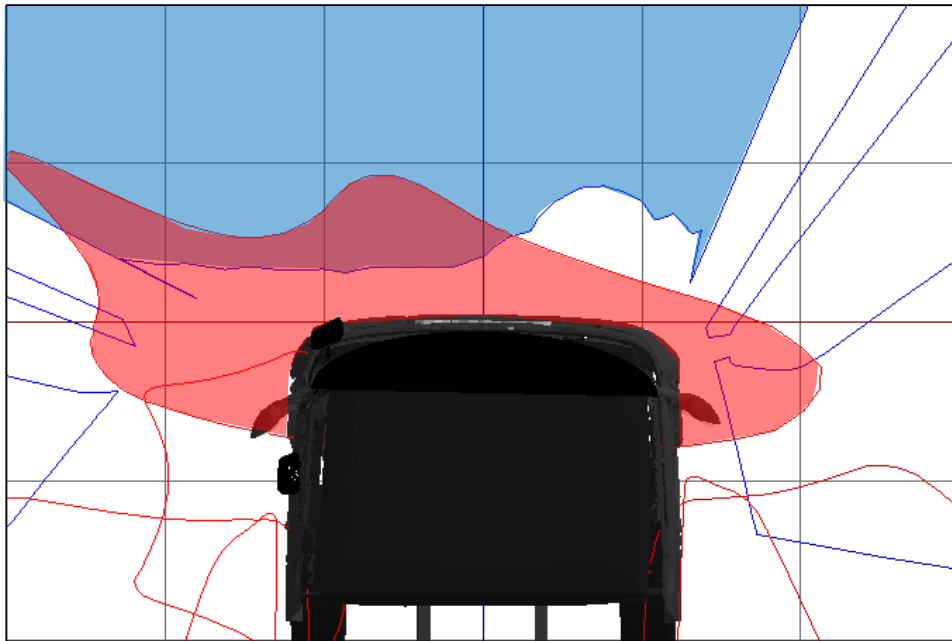


Figure 438. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 430. However Figure 439 and Figure 440 show that there is a clear space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.

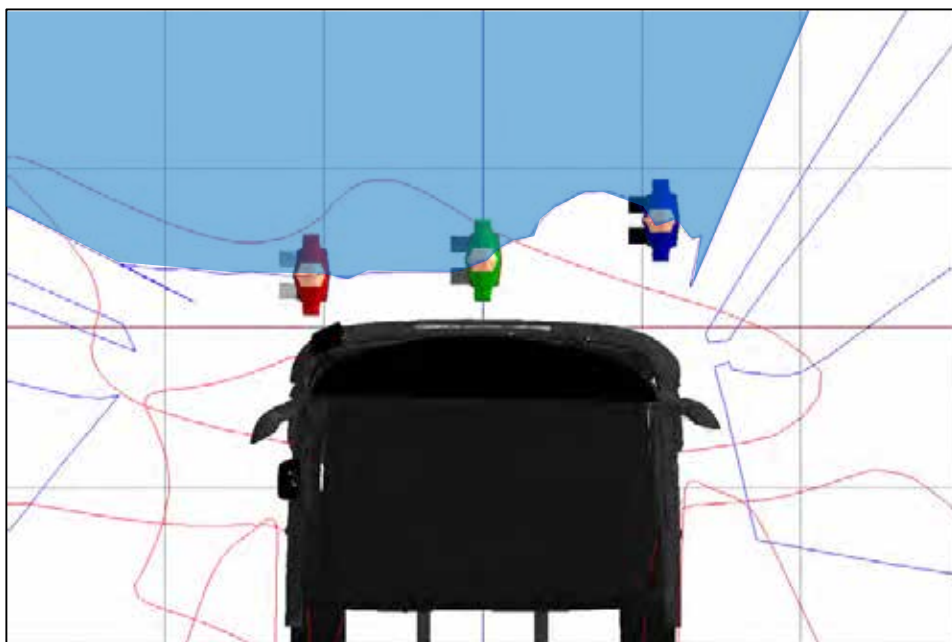


Figure 439. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

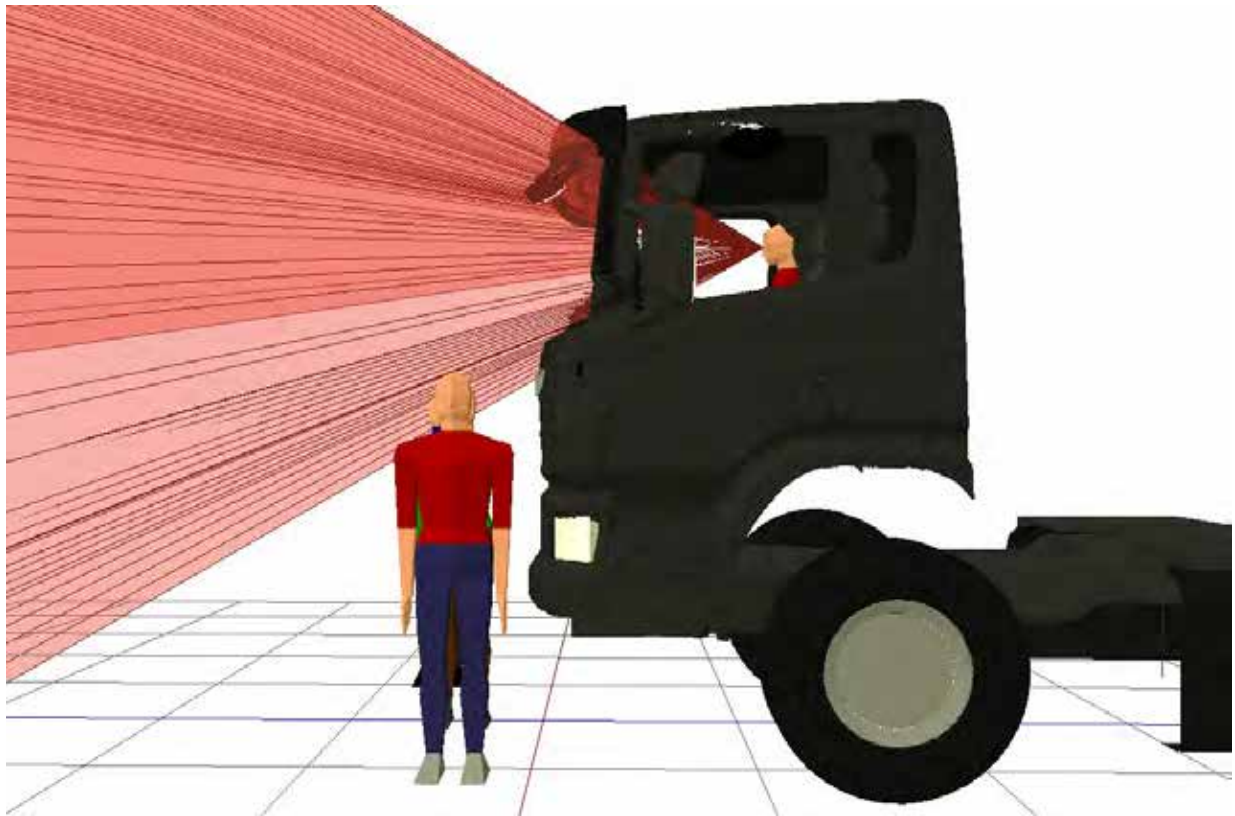


Figure 440. 3D view showing that the three human models can stand 751mm (blue), 224mm (green) and 219mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 441. The view from the driver's eyes clearly shows the three pedestrians are hidden from view.

For forwards visibility of the pedestrians all three can be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 751mm from the front of the vehicle, the left (red) pedestrian is positioned at 219mm from the front of the vehicle and the central (green) pedestrian is positioned at 224mm from the front of the vehicle. The projections show that it is possible for a pedestrian of 50th %ile UK male height or shorter to be hidden from direct vision in these locations.

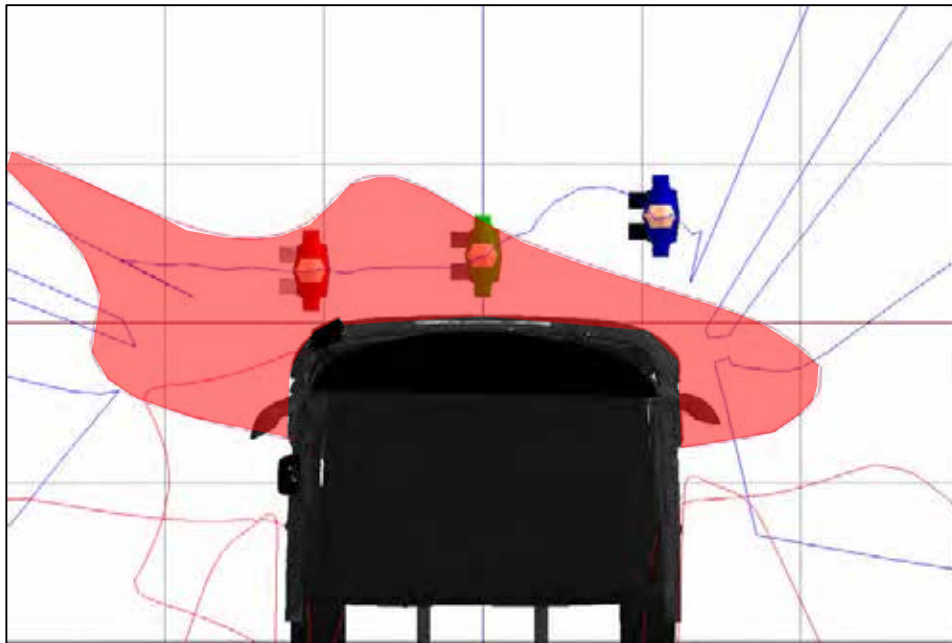


Figure 442. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

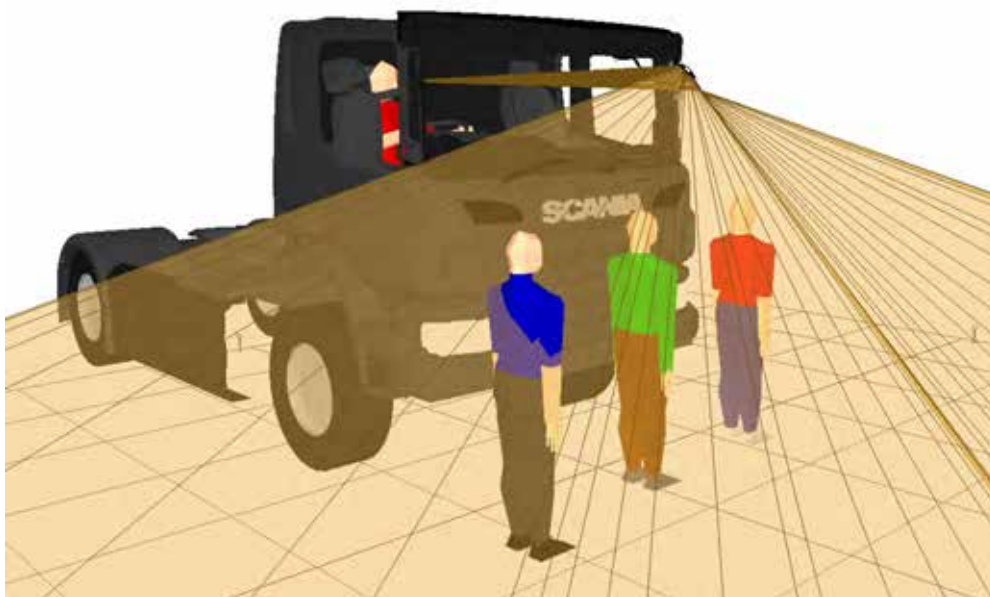


Figure 443. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 443 shows that the pedestrian to the left (red) and centre (green) would be completely visible and the pedestrian to the right (blue) would be visible from the left shoulder down. Thus, for a driver using their mirrors, it is not possible to hide a pedestrian to the front of the Scania P N3G .

4.1.13.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

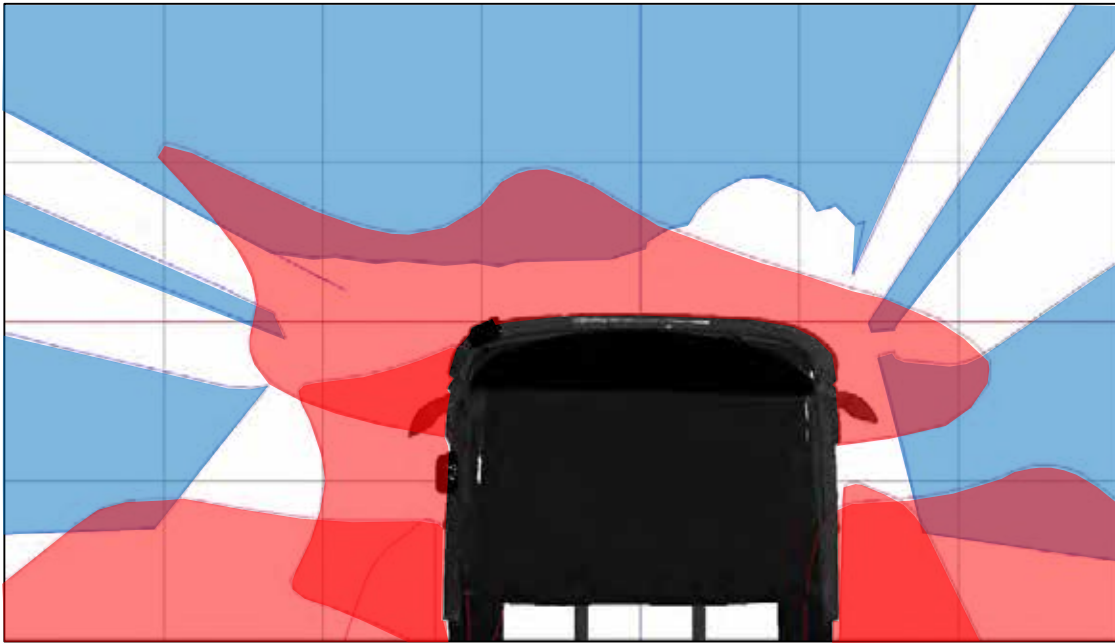


Figure 444. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 445, Figure 446 and Figure 447 show that only the rear most (blue) cyclist can be obscured from the driver’s view only when directly adjacent to the side of the vehicle. Part of the helmet of the front (yellow) cyclist is visible in the defined position.

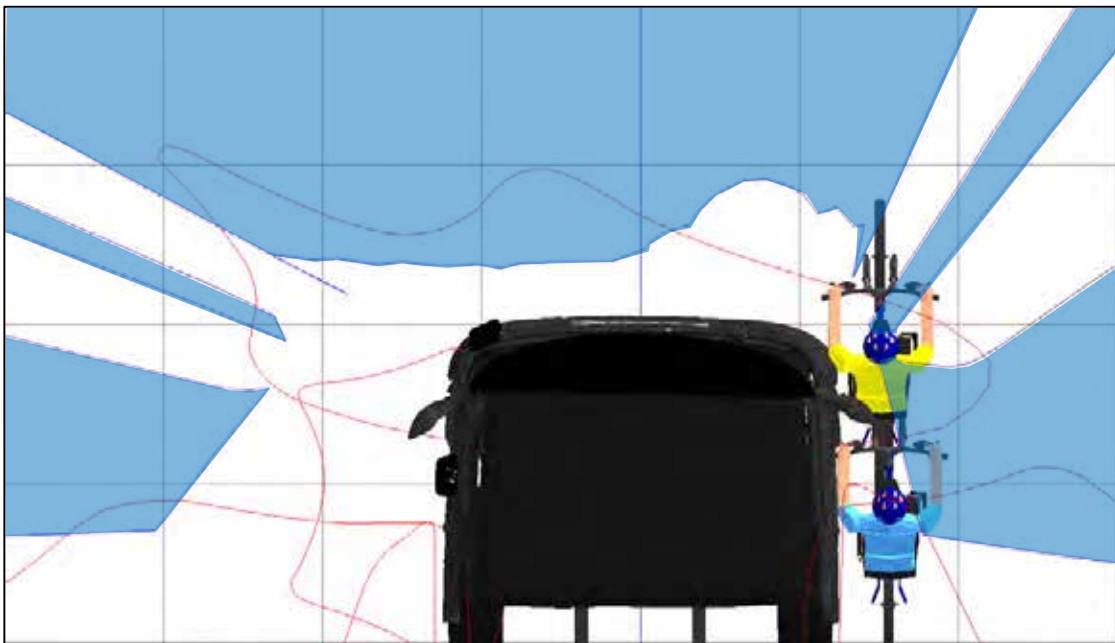


Figure 445. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist



Figure 446. 3D view showing that front (yellow) cyclists cannot be hidden from direct vision and the rear (blue) cyclist can be just hidden from direct vision to the offside of the Scania P N3G

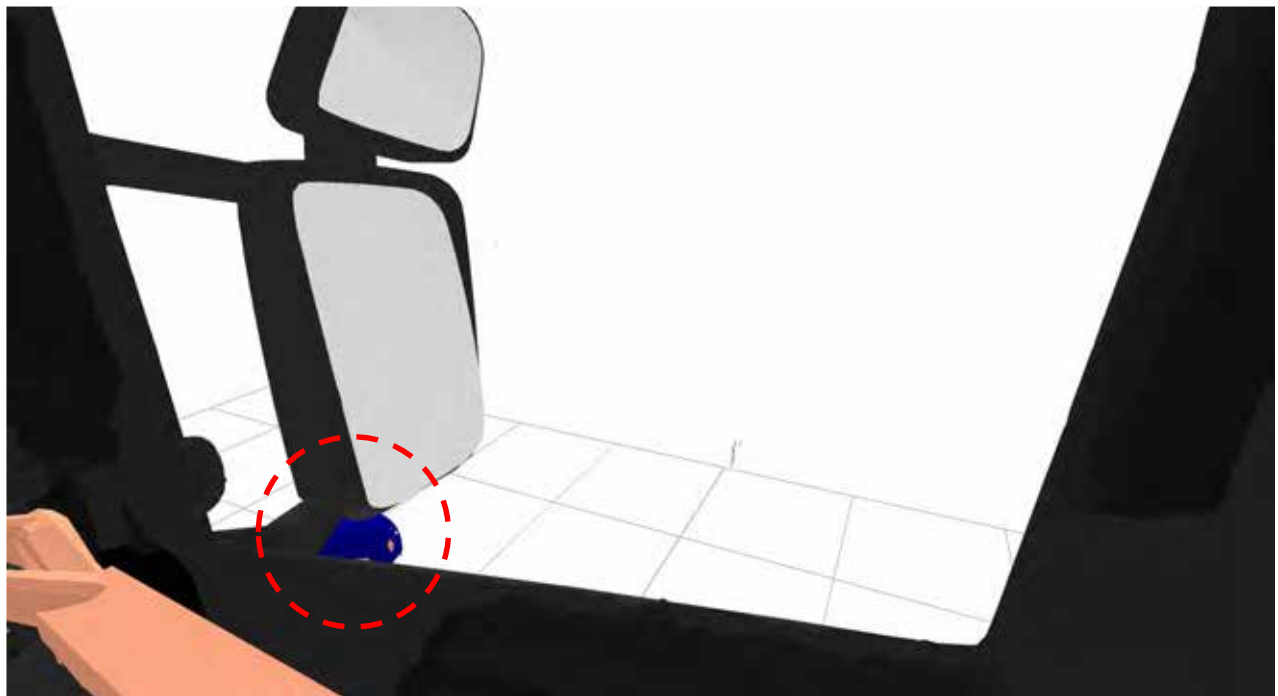


Figure 447. The view from the driver's eyes clearly shows the front (yellow) cyclist is visible, even when positioned against the side of the vehicle, though the rear (blue) cyclist is just hidden

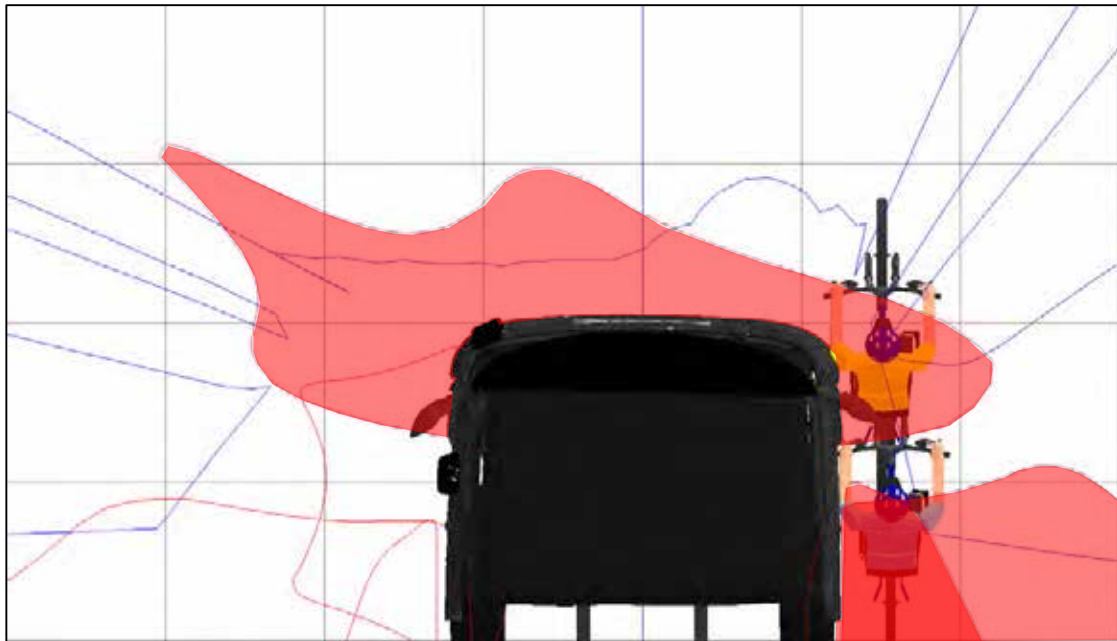


Figure 448. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist



Figure 449. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

The cyclists are visible to the driver through the use of the mirrors. Figure 449 shows that theoretically both cyclists are visible in the Class VI mirror. However, due to limitations of the projection technique, the rear cyclist (blue) would actually be hidden from view by the cab of the vehicle. However, part of the front (yellow) cyclist would be visible in the Class VI mirror including their arms and the front of the bicycle.

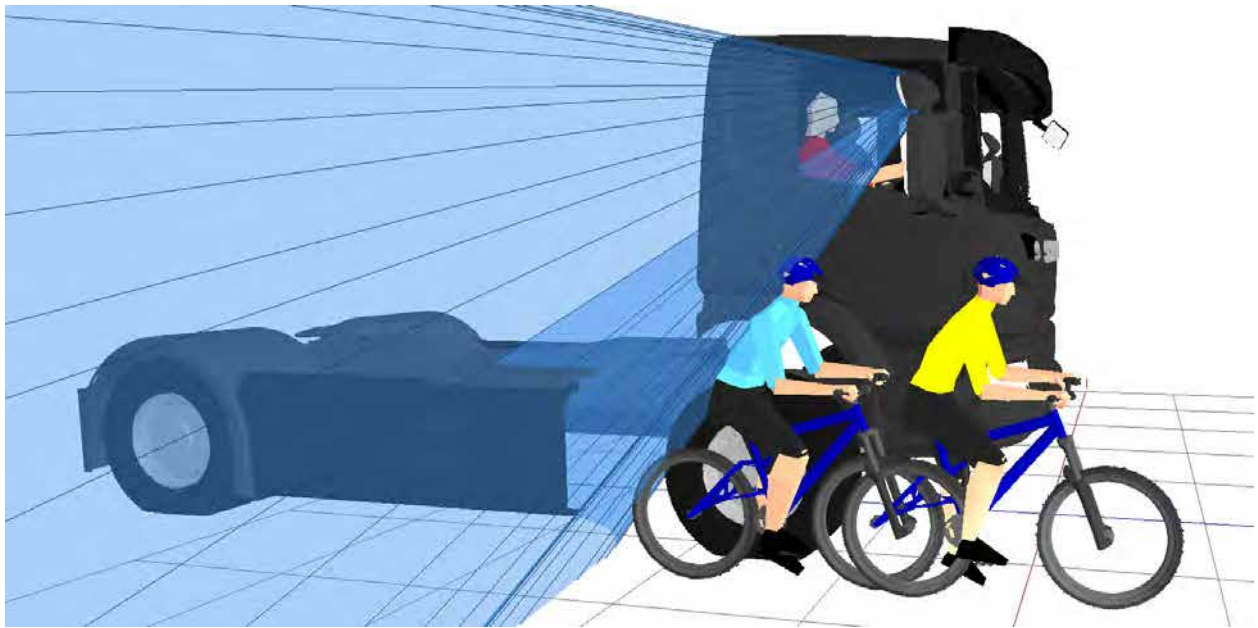


Figure 450. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 450 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including the back of their head and shoulders. The projections show that for a driver using their mirrors, it is not possible to hide a cyclist in the positions shown to the offside of the Scania P N3G.

4.1.13.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

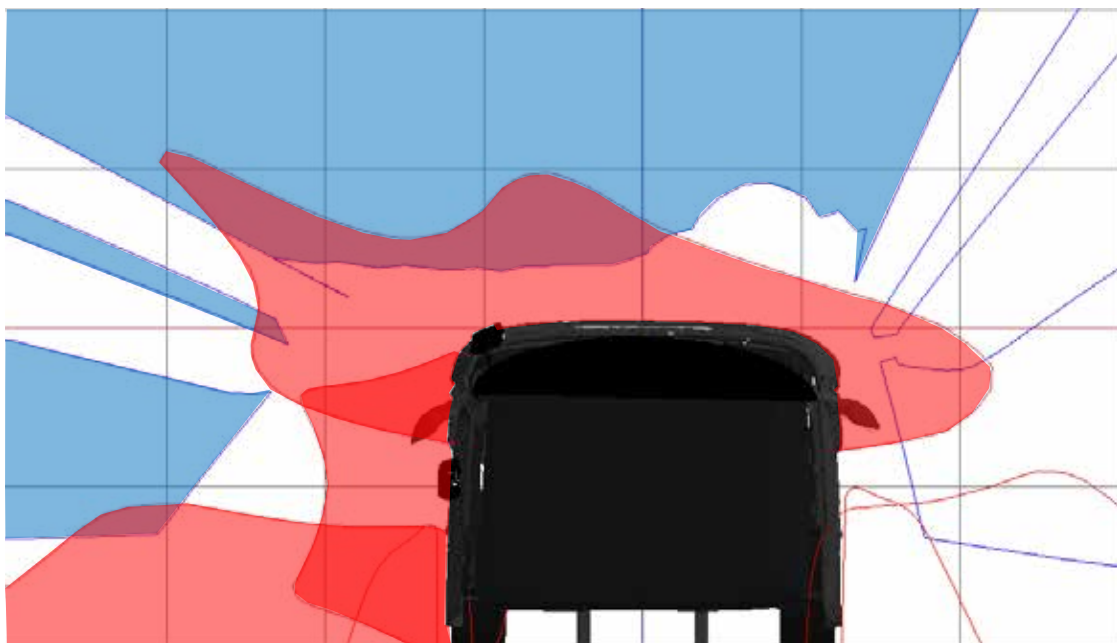


Figure 451. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 452 and Figure 453 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

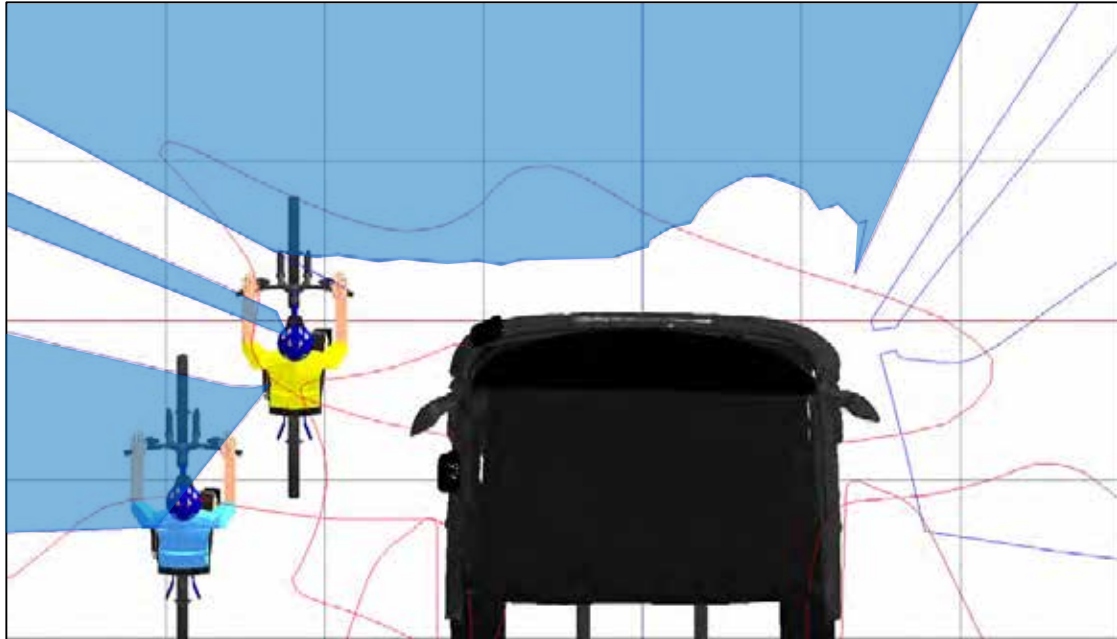


Figure 452. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

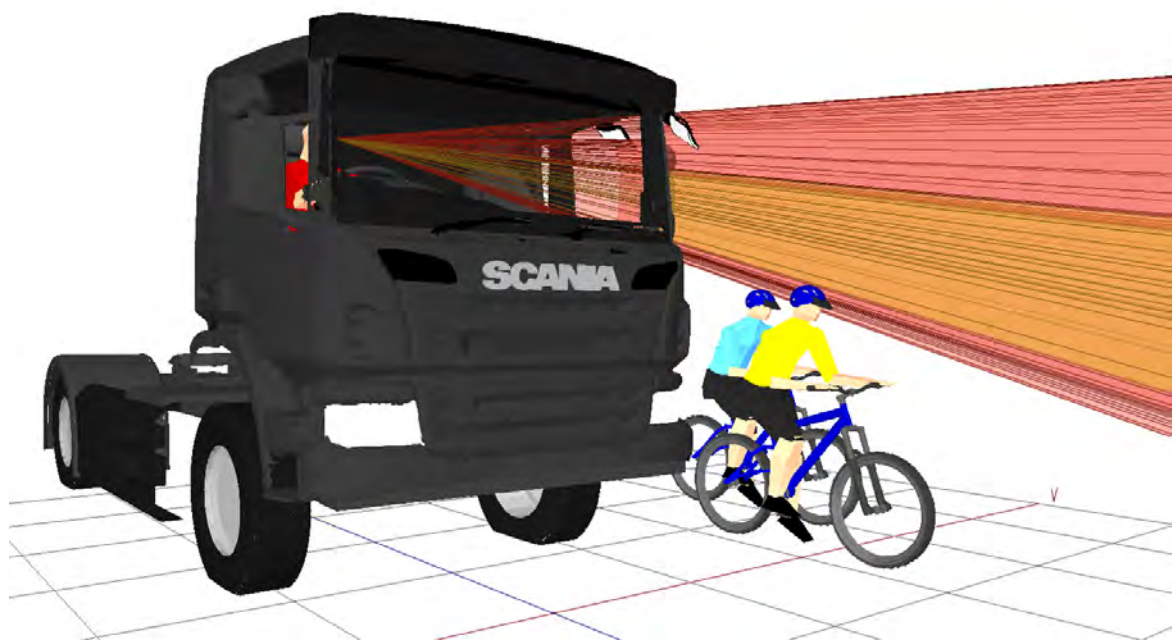


Figure 453. 3D view showing that the two human models can be positioned 769mm (yellow) and 1315mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 454. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 769mm from the side of the vehicle, the rear (blue) cyclist is positioned at 1315mm from the side of the vehicle.

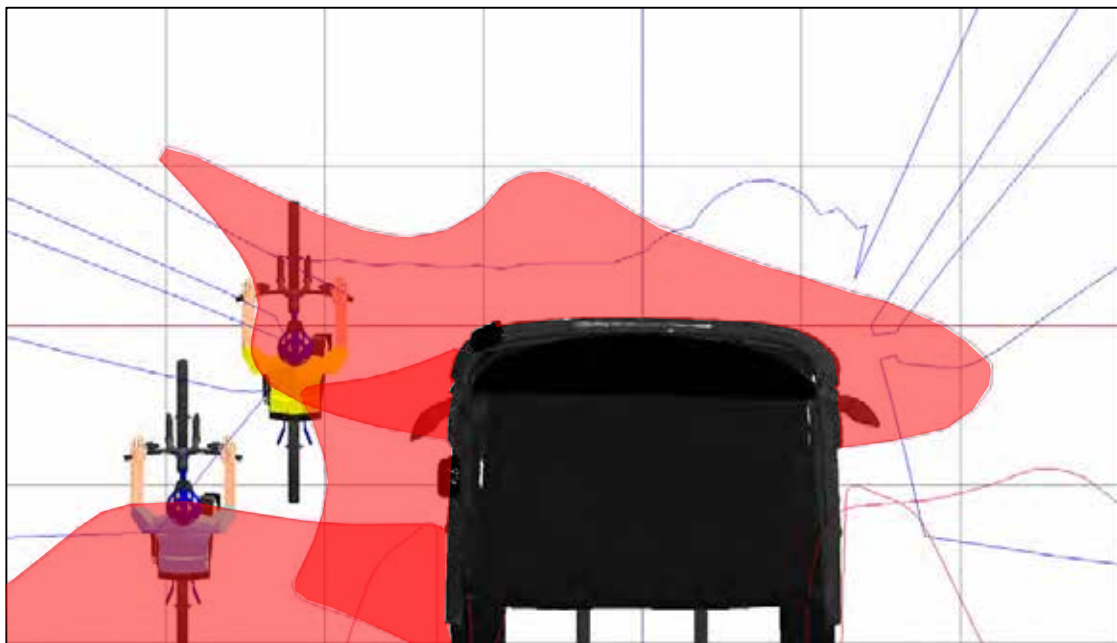


Figure 455. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

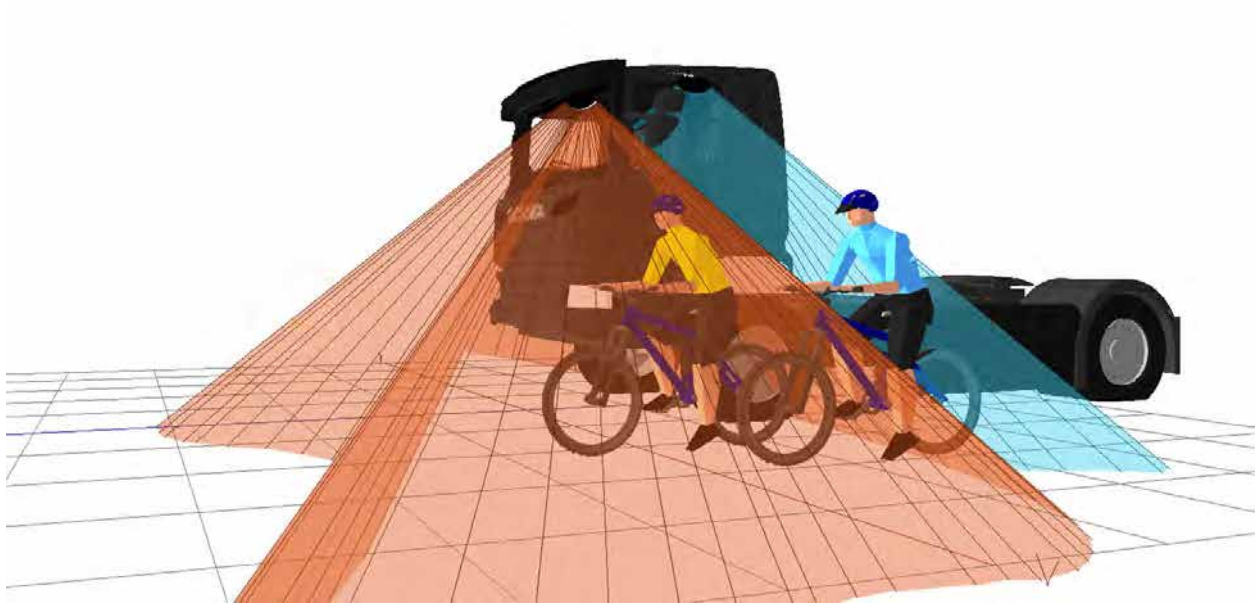


Figure 456. 3D view showing that the Front (yellow) cyclists positioned to the nearside of the vehicle is visible in the projection of the Class V and / or Class VI mirrors, but that the rearmost Cyclist is not visible in either mirror

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 456 shows that the front (yellow) cyclist is visible in the Class V and Class VI mirrors. The rear (blue) cyclist partially visible in the Class V mirror. Only a small portion of the rear wheel would be visible in the Class V mirror, at the bottom left edge of the mirror.



Figure 457. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is not visible in the projection of the Class IV or Class II mirror

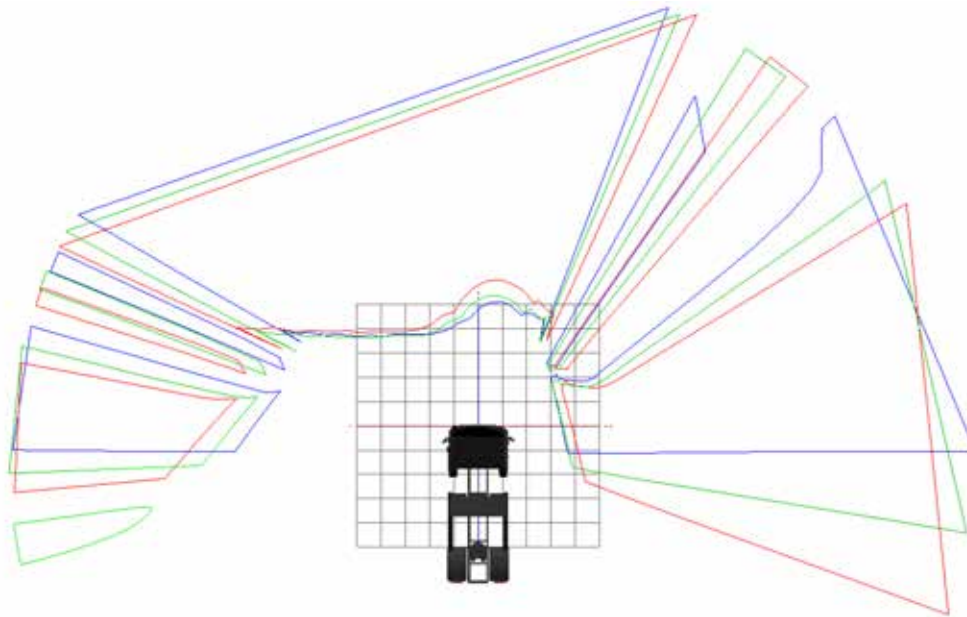
4.1.13.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

Figure 458. A plan view of the projection of the windscreen and side windows onto the ground plane for the Scania P N3G for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.1.14 SCANIA R - 50TH %ILE MALE DRIVER



Figure 459. Evaluation model of Scania R N3 variant vehicle

4.1.14.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 460 shows a top-down view of all of the window projections for the Scania R N3 cab with a 50th %ile UK Male Driver. The image on the right of Figure 460 shows the areas of these projections that intersect with the ground. Figure 461 shows the same for the the mirror projections and Figure 462 shows the two combined. Any area outside of the coloured projections is effectively a blind spot at the ground plane.

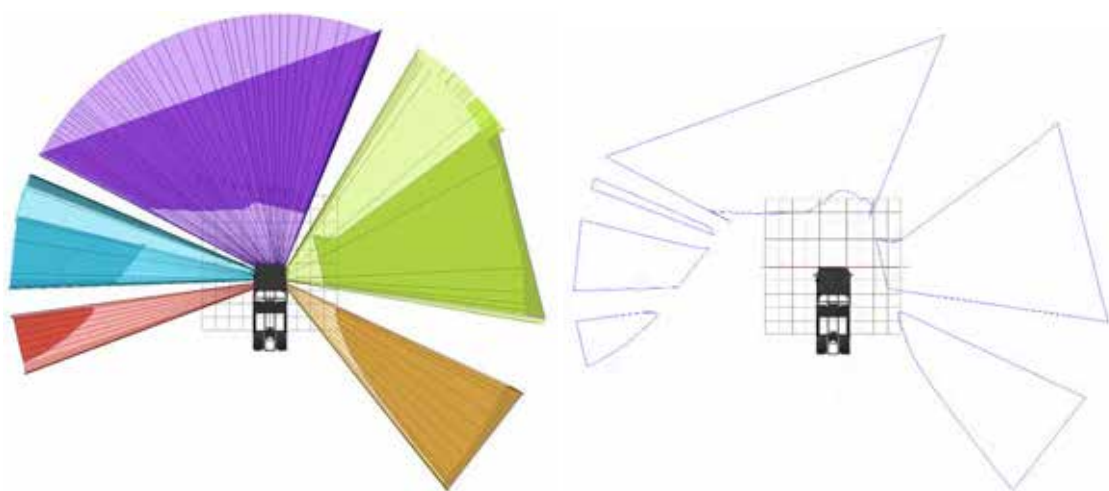


Figure 460. The projection of the windscreen and window apertures at the ground plane for the Scania R N3

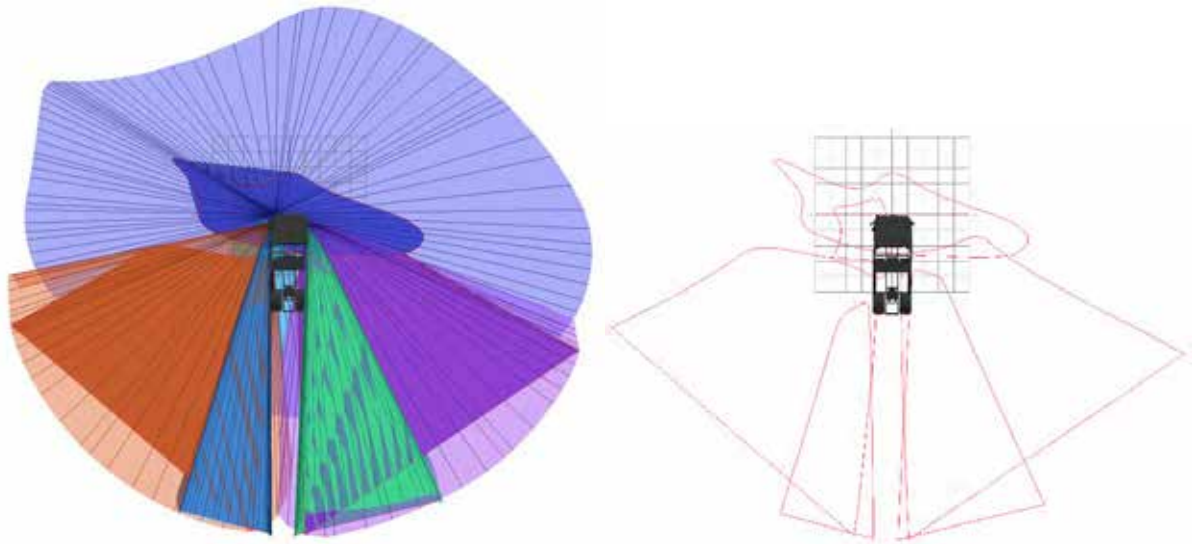


Figure 461. The projection of the mirrors at the ground plane for the Scania P N3G

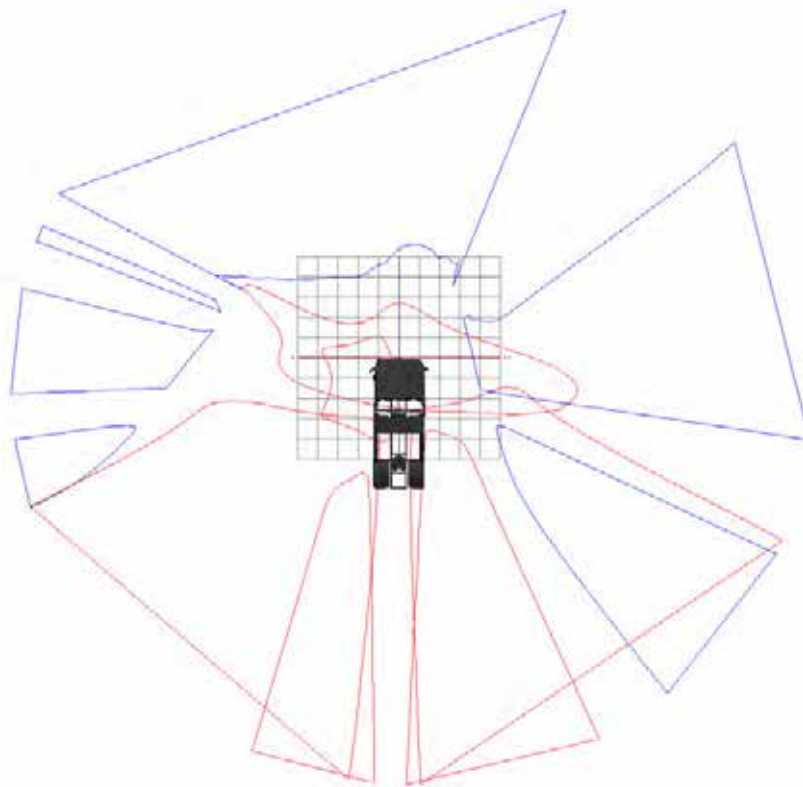


Figure 462. The combined direct and indirect vision projections at the ground plane for the Scania R N3

Figure 463 through Figure 467 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 468 and Figure 469 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

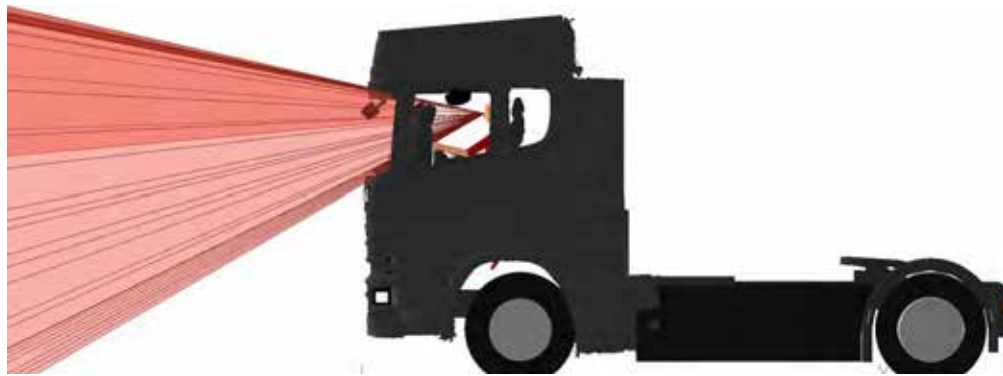


Figure 463. A side view of the windscreen aperture projection for the Scania R N3



Figure 464. Frontal views of the off side and near side door window projections for the Scania R N3



Figure 465. A side view of the Class VI mirror projection for the Scania R N3



Figure 466. A front view of the Class V mirror projection for the Scania R N3

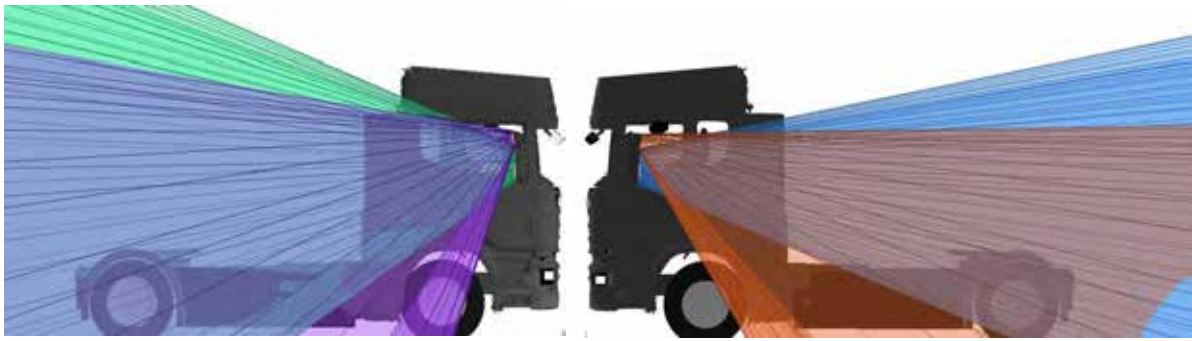


Figure 467. Side views of the combined Class II and Class IV mirror projections for the Scania R N3

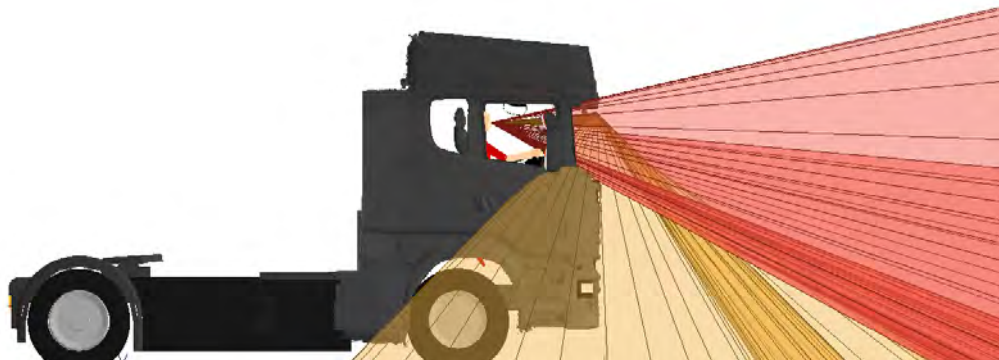


Figure 468. Combined projection of the windscreen and Class VI mirror to the front of the Scania R N3

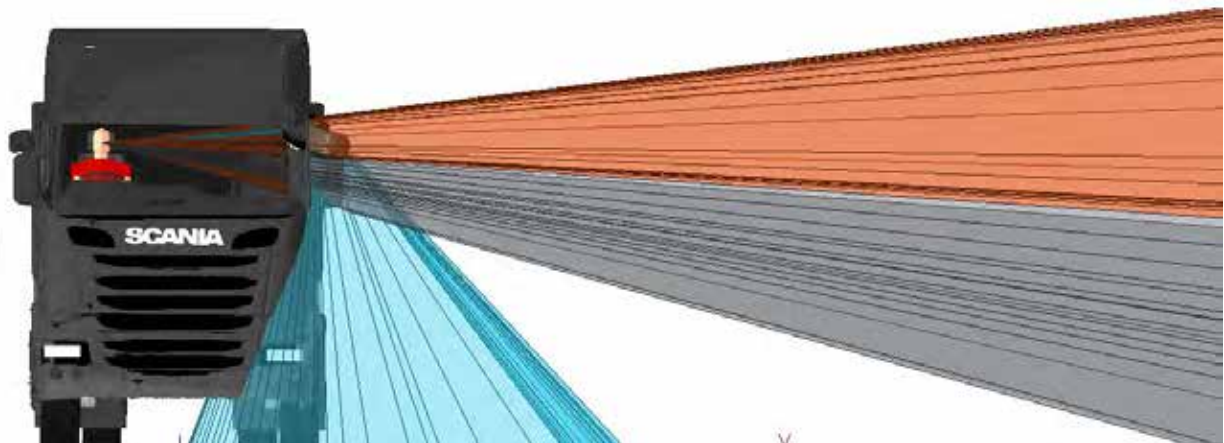


Figure 469. Combined projection of the near side windows and Class V mirror to the side of the Scania R N3

4.1.14.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 470 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

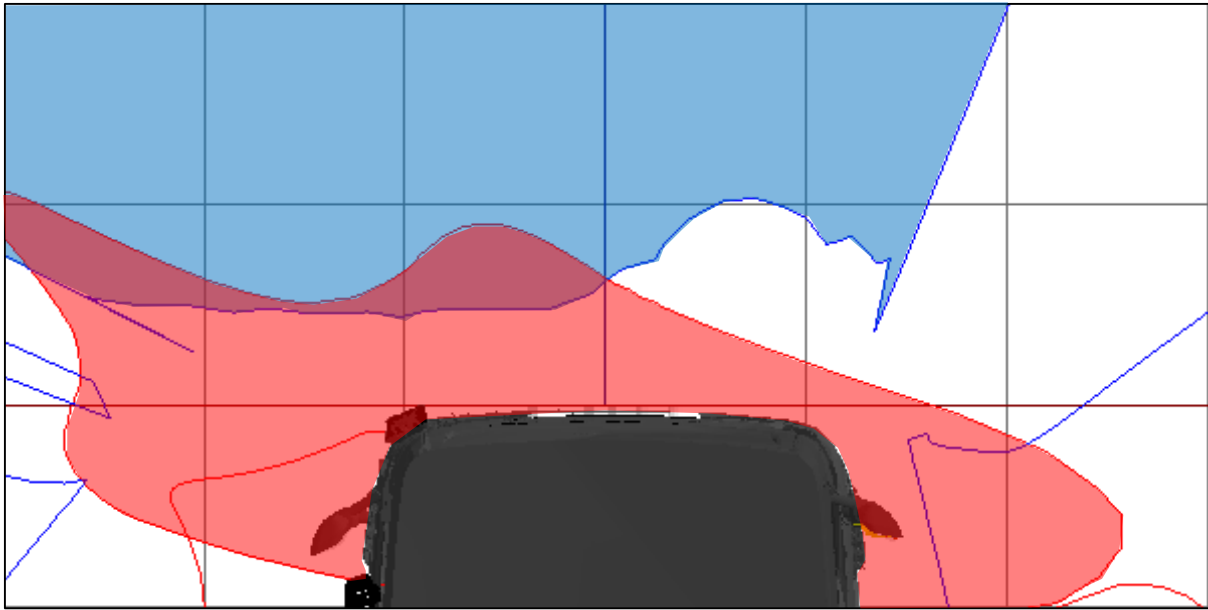


Figure 470. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 462. However Figure 471 and Figure 472 show that there is a clear space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.



Figure 471. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

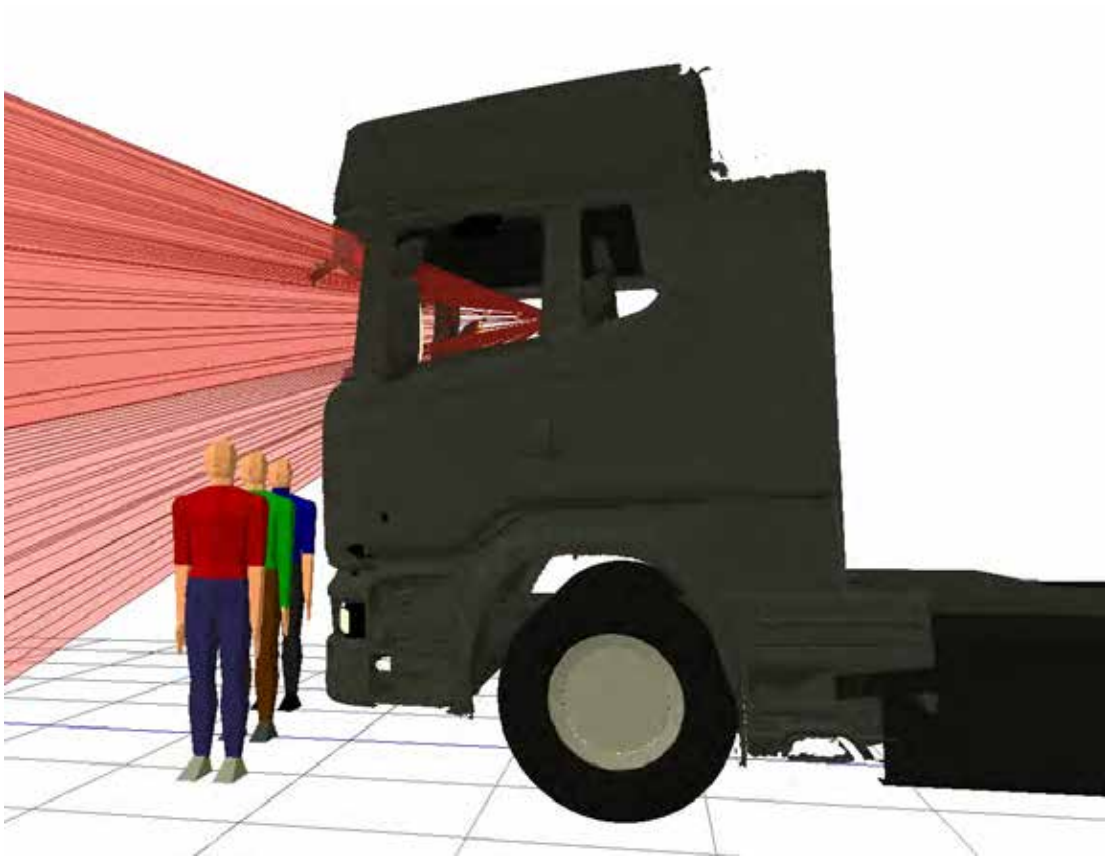


Figure 472. 3D view showing that the three human models can stand 781mm (blue), 391mm (green) and 295mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 473. The view from the driver's eyes clearly shows the three pedestrians are hidden from view.

For forwards visibility of the pedestrians all three can be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 781mm from the front of the vehicle, the left (red) pedestrian is positioned at 295mm from the front of the vehicle and the central (green) pedestrian is positioned at 391mm from the front of the vehicle. The projections show that it is possible for a pedestrian of 50th %ile UK male height or shorter to be hidden from direct vision in these locations.

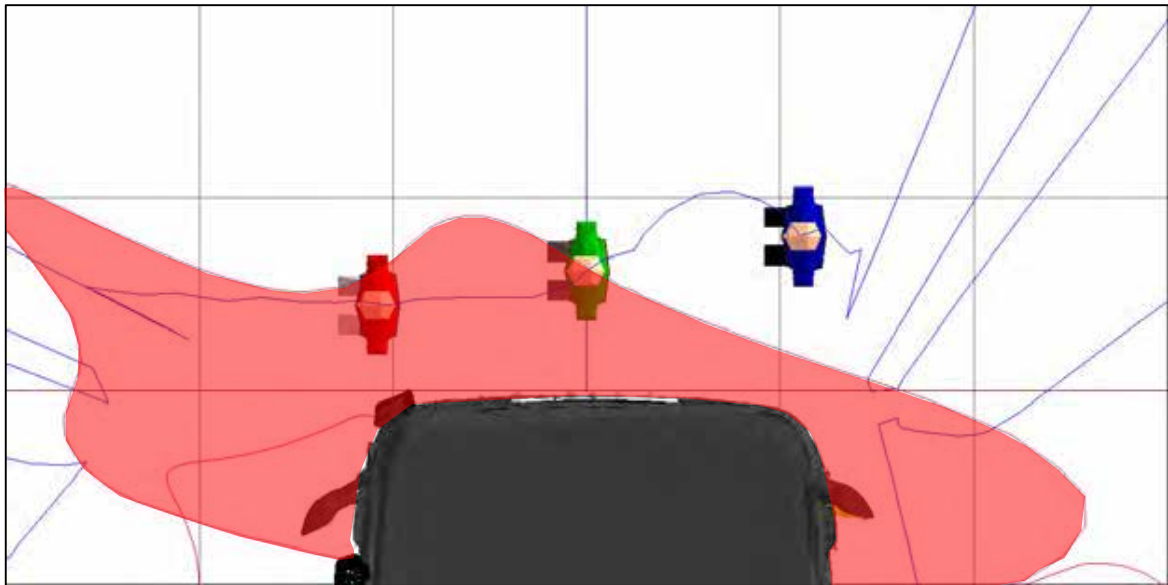


Figure 474. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

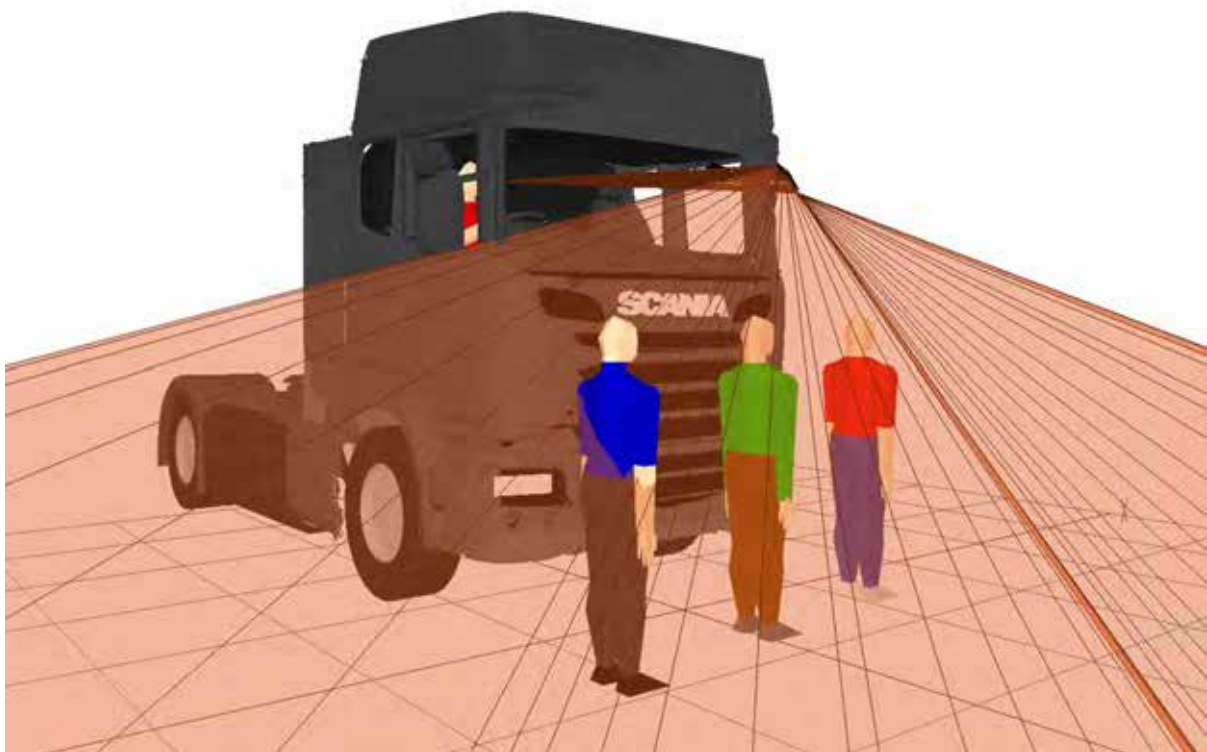


Figure 475. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 475 shows that the pedestrian to the left (red) and centre (green) would be completely visible and the pedestrian to the right (blue) would be visible from the left shoulder down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide a pedestrian as defined to the front of the Scania R N3.

4.1.14.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

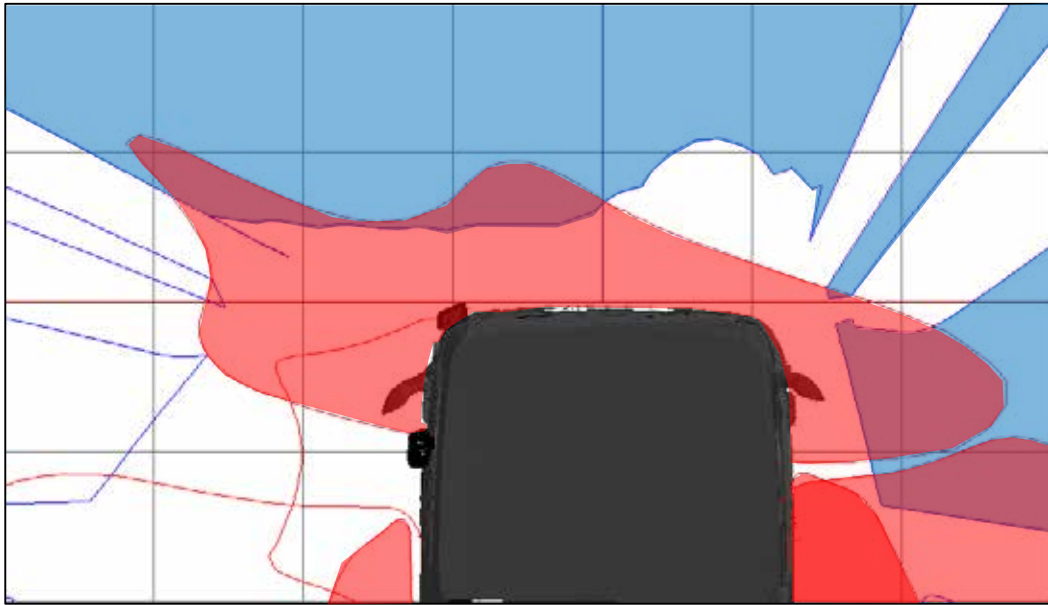


Figure 476. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 476 shows that the front (yellow) cyclist can be hidden from vision when directly adjacent to the vehicle side and the rear (blue) cyclist can be obscured from the driver’s view when up to 277mm from the side of the vehicle.



Figure 477. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist

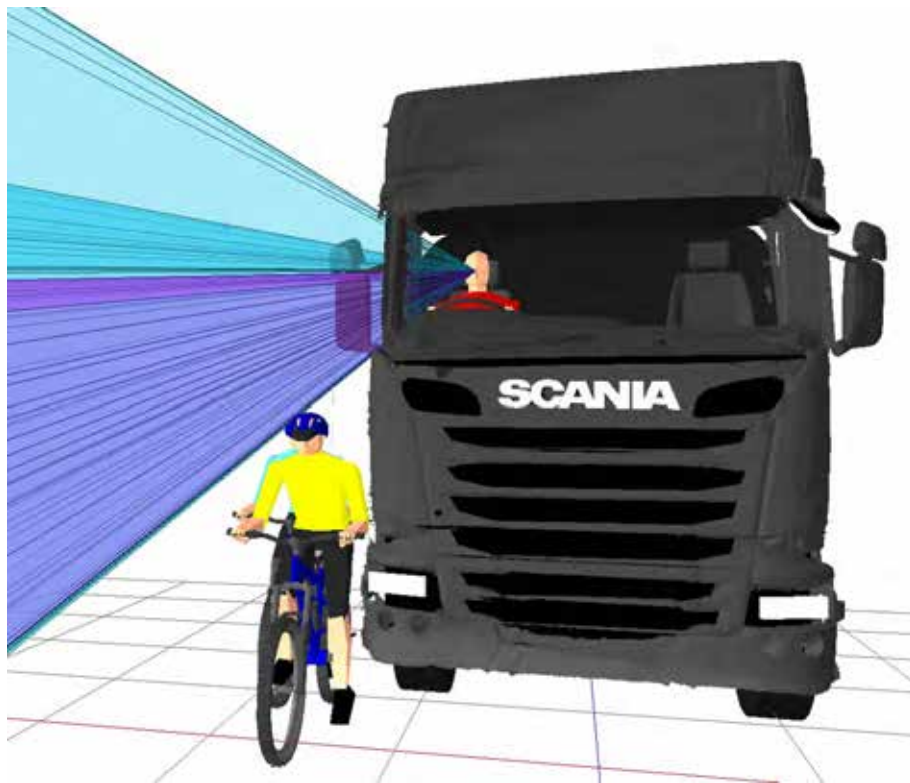


Figure 478. 3D view showing that both cyclists can be hidden from direct vision to the offside of the Scania R N3



Figure 479. The view from the driver's eyes clearly shows the two cyclists are hidden from the driver's view.

For offside direct visibility of the cyclists there is a blind spot that can obscure both cyclists but both cyclists need to be directly adjacent to the side of the cab. Figure 479 shows that the cyclists can be obscured from the driver when using direct vision.

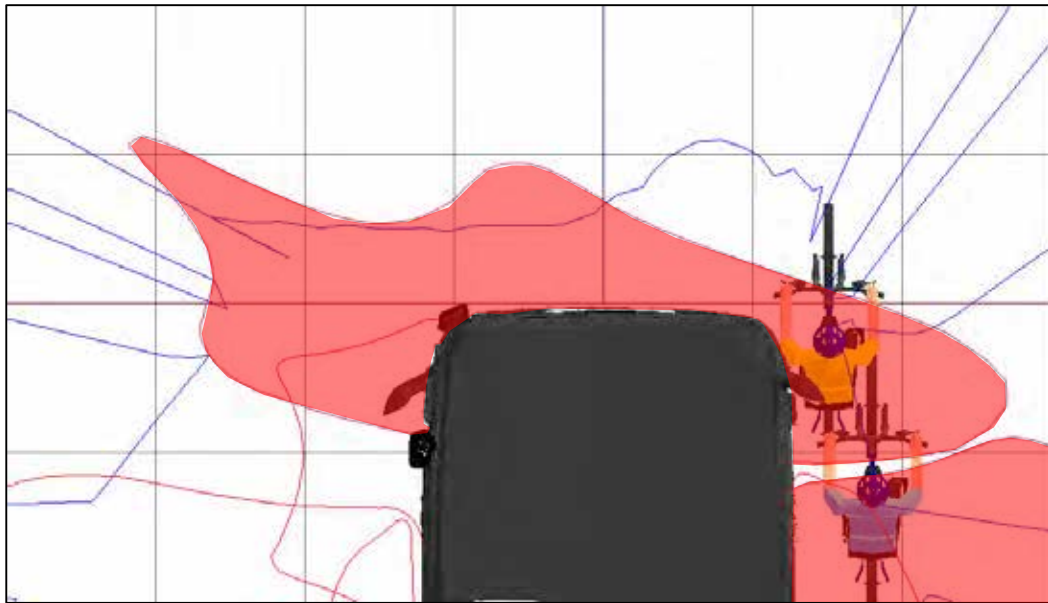


Figure 480. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist



Figure 481. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

The cyclists are visible to the driver through the use of the mirrors. Figure 481 shows that theoretically both cyclists are visible in the Class VI mirror. However, due to limitations of the projection technique, the rear cyclist (blue) would actually be hidden from view by the cab of the vehicle. However, part of the front (yellow) cyclist would be visible in the Class VI mirror including their arms and the front of the bicycle.

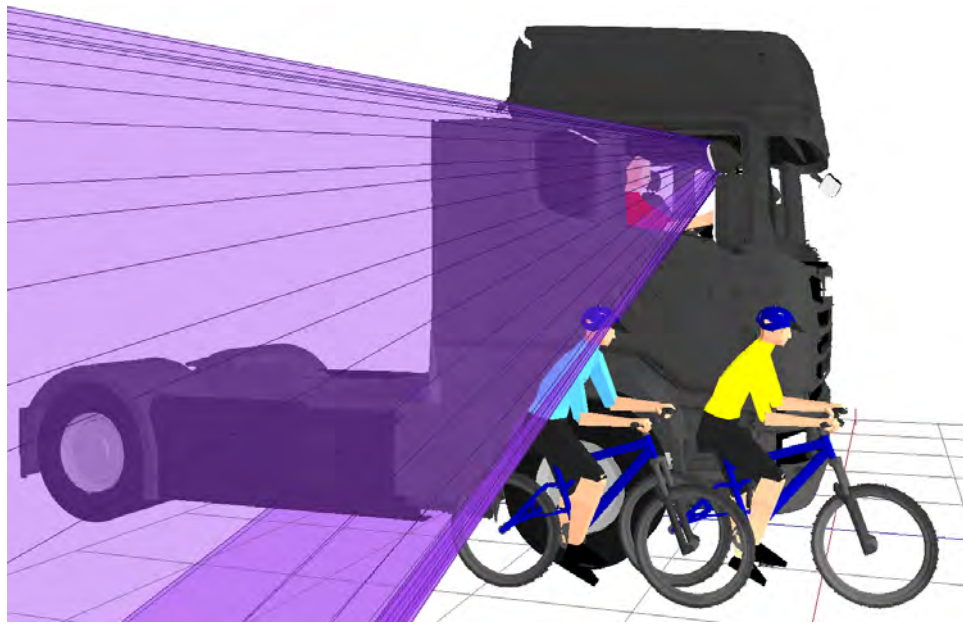


Figure 482. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 482 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and shoulders. The projections show that for a driver using their mirrors, it is not possible to hide a cyclist in the positions shown to the offside of the Scania R N3.

4.1.14.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

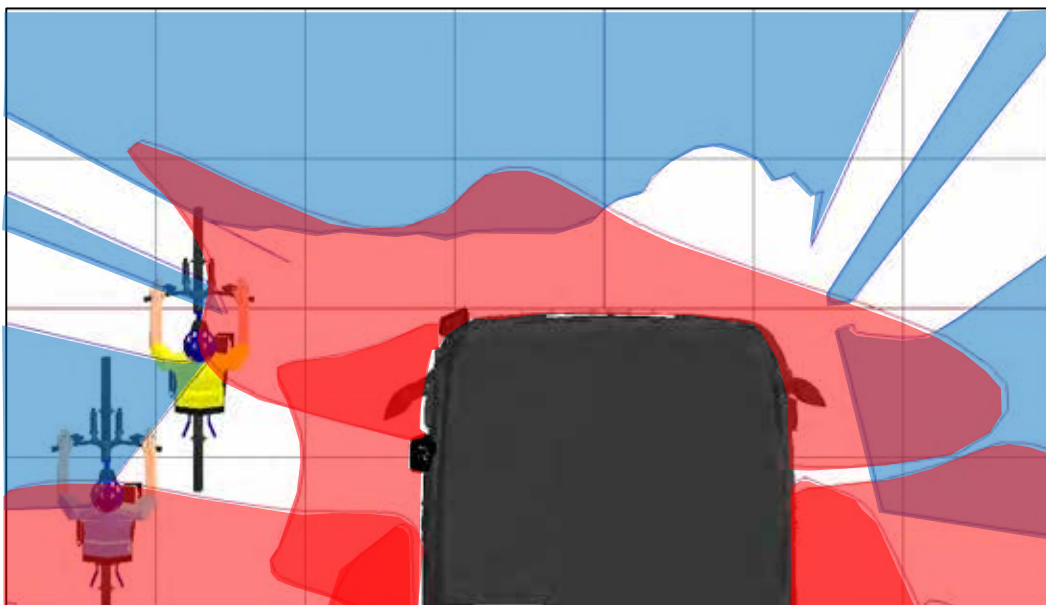


Figure 483. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 484 and Figure 485 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

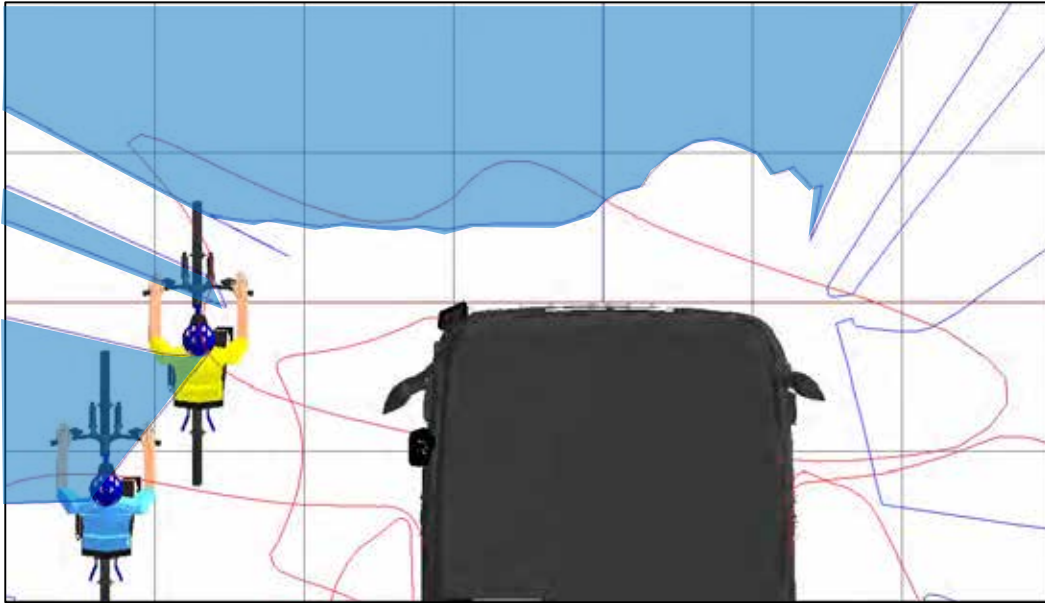


Figure 484. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

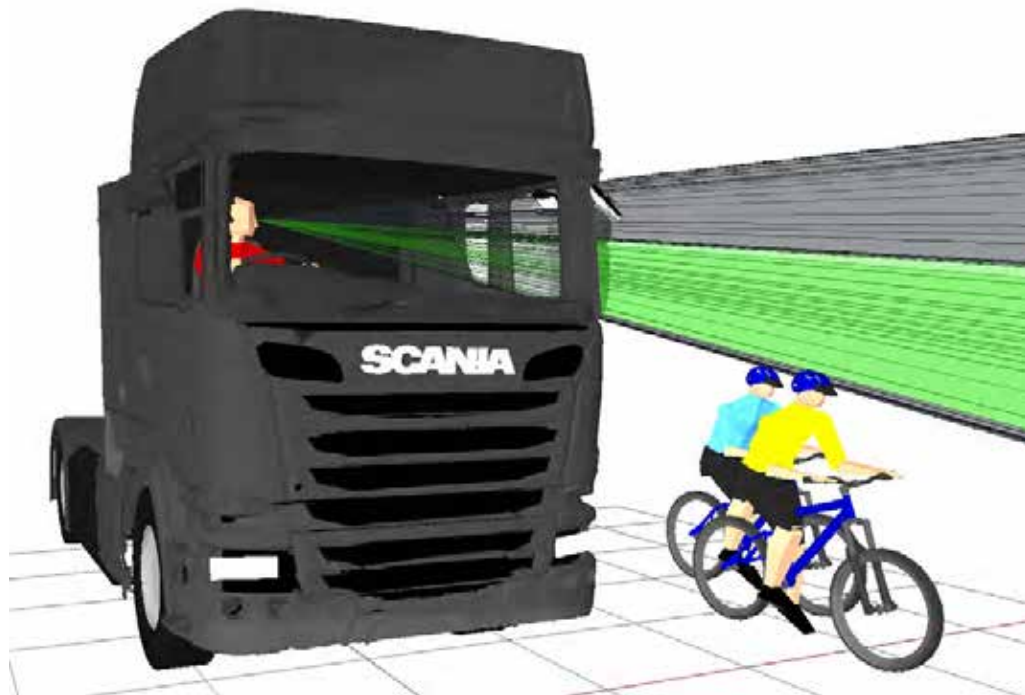


Figure 485. 3D view showing that the two human models can be positioned 1260mm (yellow) and 1766mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 486. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 1260mm from the side of the vehicle, the rear (blue) cyclist is positioned at 1766mm from the side of the vehicle.

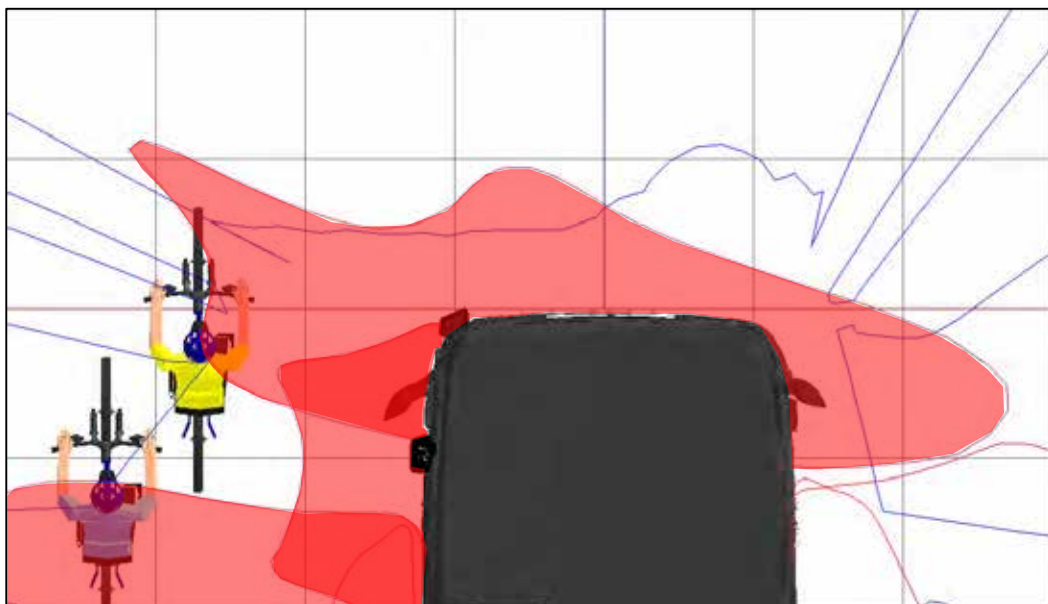


Figure 487. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

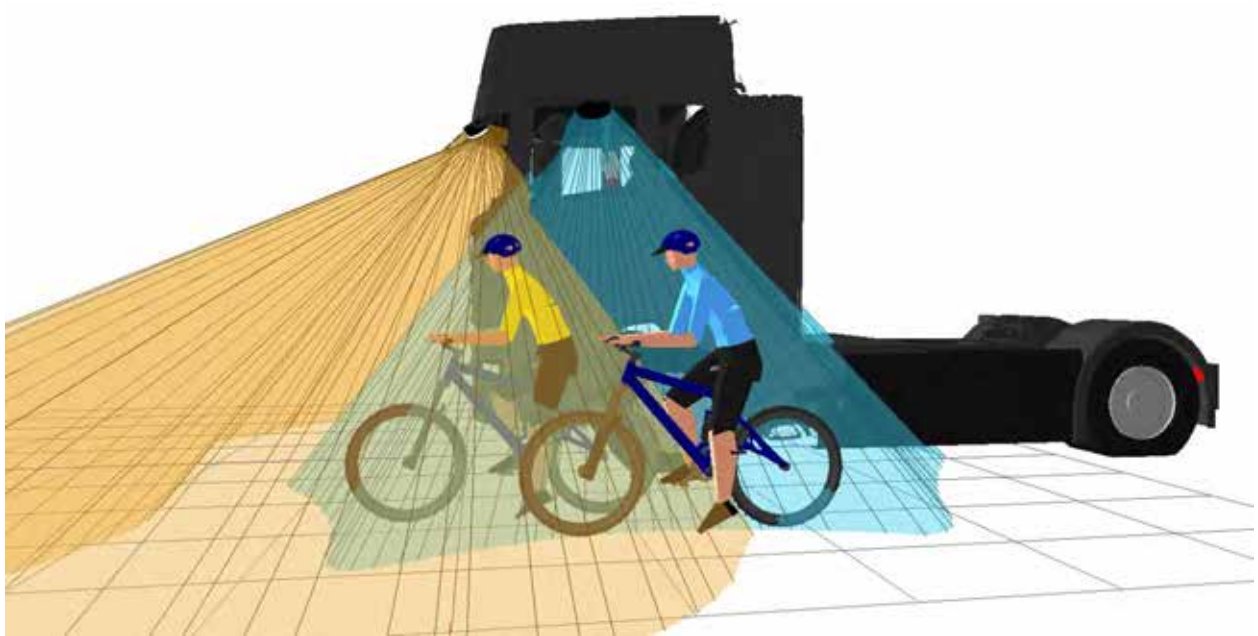


Figure 488. 3D view showing that the Front (yellow) cyclists positioned to the nearside of the vehicle is visible in the projection of the Class V and / or Class VI mirrors, but that the rearmost Cyclist is not visible in either mirror

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 488 shows that the front (yellow) cyclist is visible in the Class V and Class VI mirrors. The rear (blue) cyclist is not visible in any mirror in the location shown.

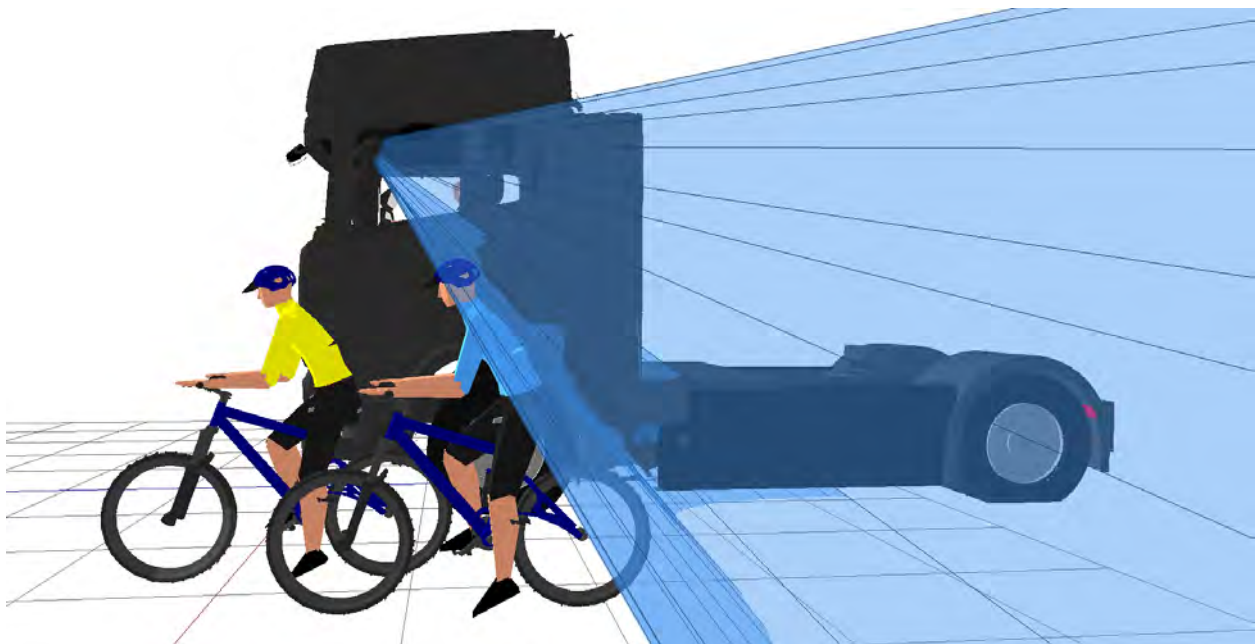


Figure 489. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is not visible in the projection of the Class IV or Class II mirror

The analysis shows that there are locations on the nearside of the vehicle, adjacent to the drivers cab, in which cyclists can be completely obscured from the driver using both direct and indirect vision.

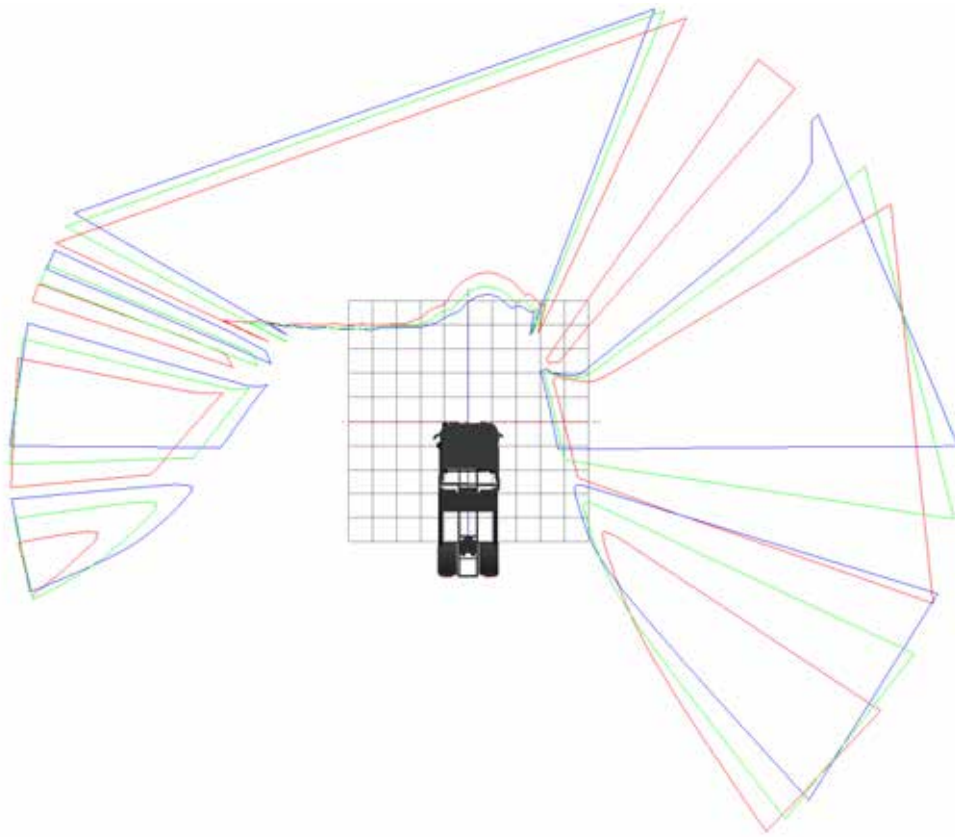
4.1.14.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

Figure 490. A plan view of the projection of the windscreen and side windows onto the ground plane for the Scania R N3 for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.1.15 SCANIA LOW ENTRY CAB - 50TH %ILE MALE DRIVER

Figure 491. Evaluation model of Scania Low Entry Cab N3 variant vehicle

4.1.15.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 492 shows a top-down view of all of the window projections for the Scania N3 LEC cab with a 50th %ile UK Male Driver. The image on the right of Figure 492 shows the areas of these projections that intersect with the ground. Figure 493 shows the same for the mirror projections and Figure 494 shows the two combined. Any area outside of the coloured projections is effectively a blind spot at the ground plane.

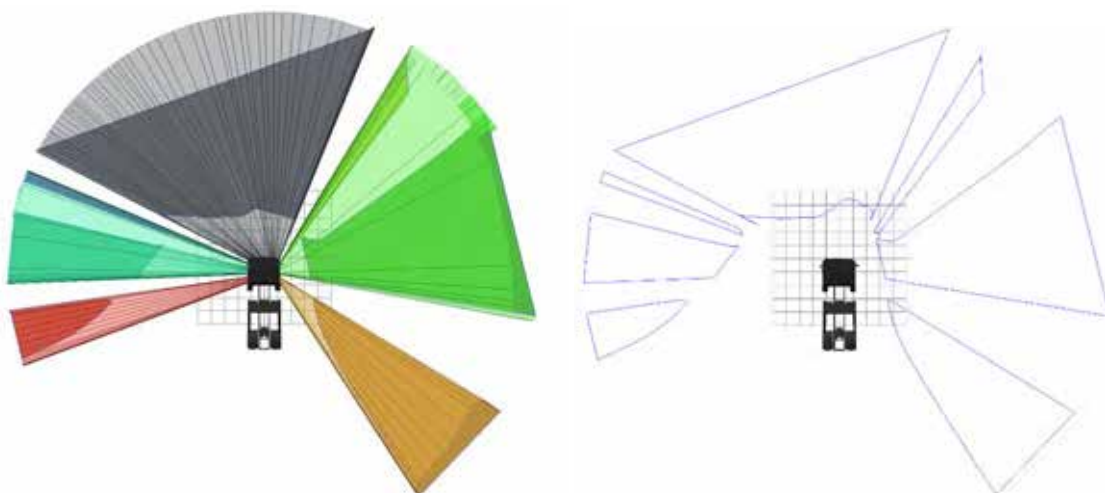


Figure 492. The projection of the windscreen and window apertures at the ground plane for the Scania N3 LEC

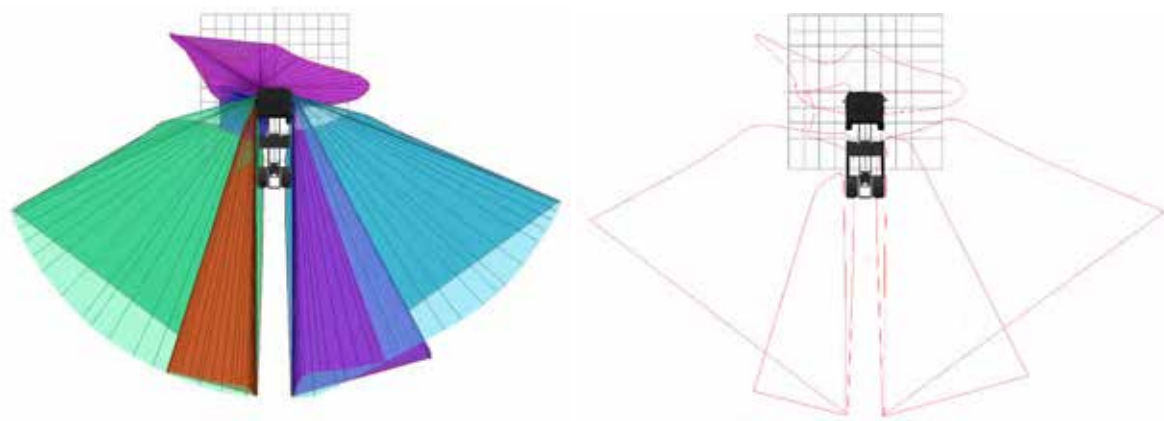


Figure 493. The projection of the mirrors at the ground plane for the Scania N3 LEC

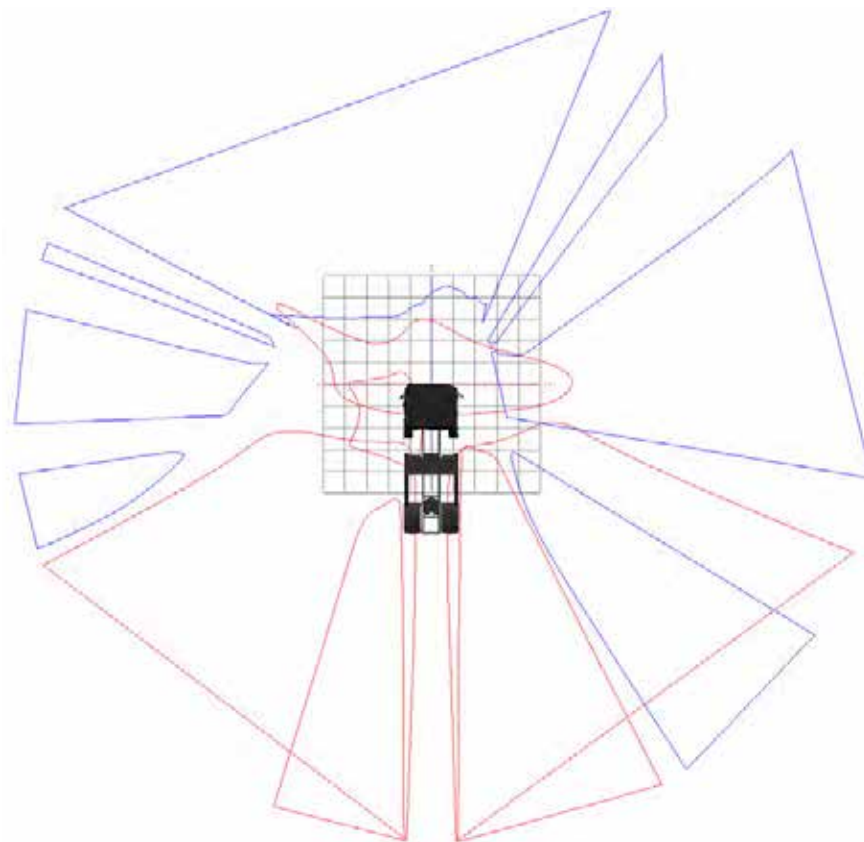


Figure 494. The combined direct and indirect vision projections at the ground plane for the Scania N3 LEC

Figure 495 through Figure 499 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 500 and Figure 501 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.



Figure 495. A side view of the windscreen aperture projection for the Scania N3 LEC



Figure 496. Frontal views of the off side and near side door window projections for the Scania N3 LEC



Figure 497. A side view of the Class VI mirror projection for the Scania N3 LEC



Figure 498. A front view of the Class V mirror projection for the Scania N3 LEC

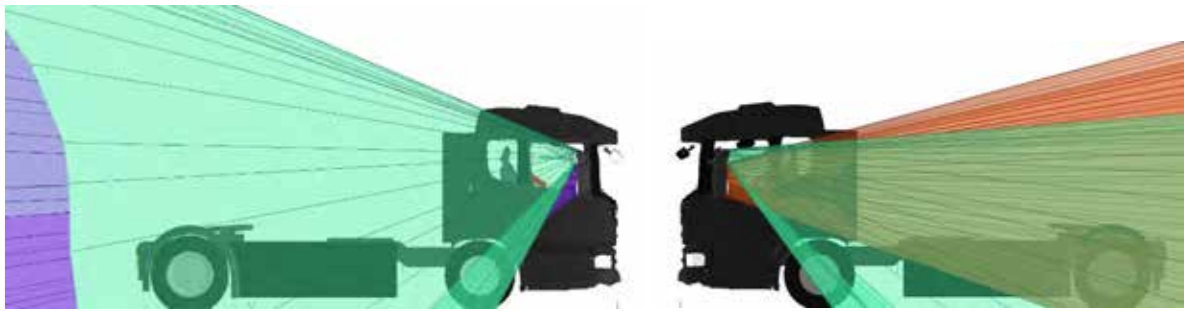


Figure 499. Side views of the combined Class II and Class IV mirror projections for the Scania N3 LEC



Figure 500. Combined projection of the windscreen and Class VI mirror to the front of the Scania N3 LEC

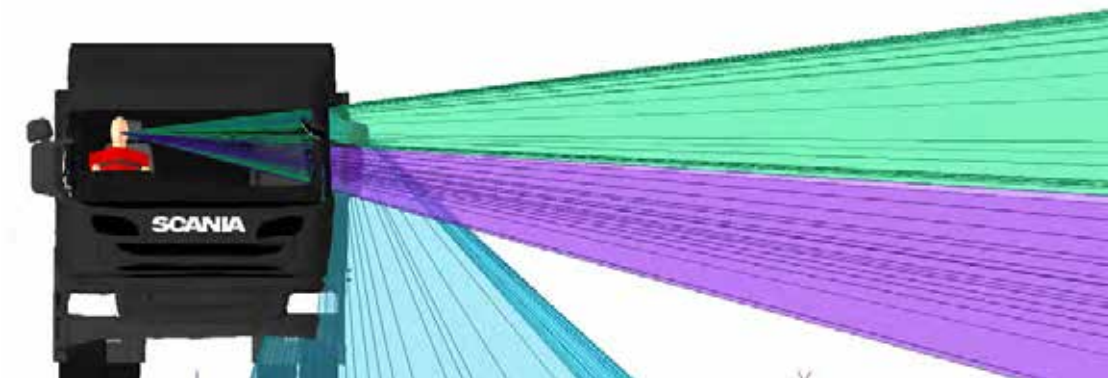


Figure 501. Combined projection of the near side windows and Class V mirror to the side of the Scania N3 LEC

4.1.15.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 502 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

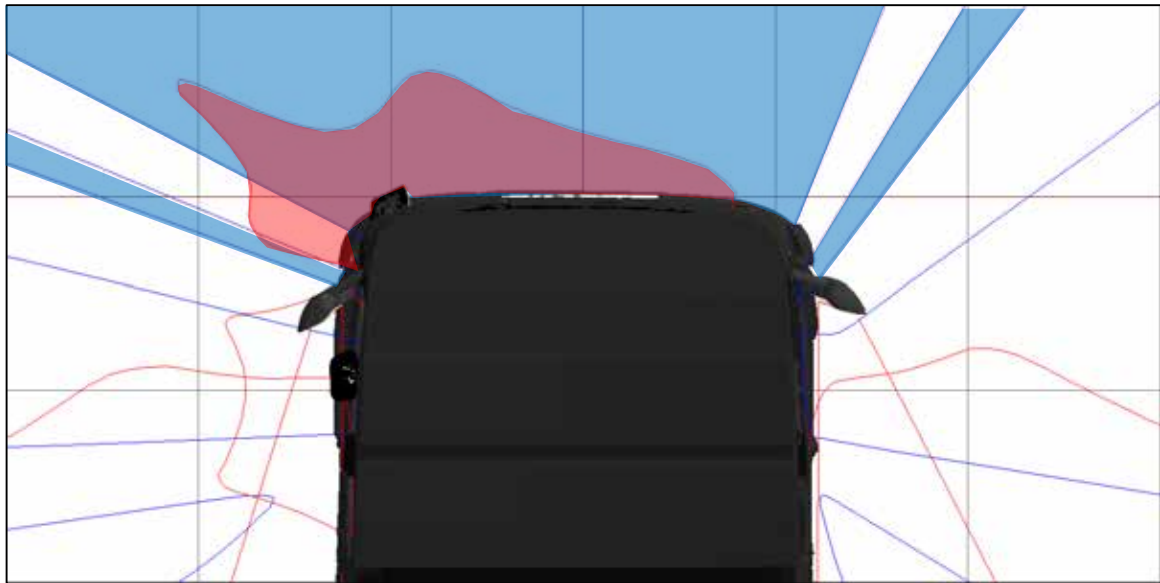


Figure 502. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are adjacent to the vehicle. Figure 504 and Figure 505 show that the pedestrian human models cannot be hidden from the direct vision of the driver.



Figure 503. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

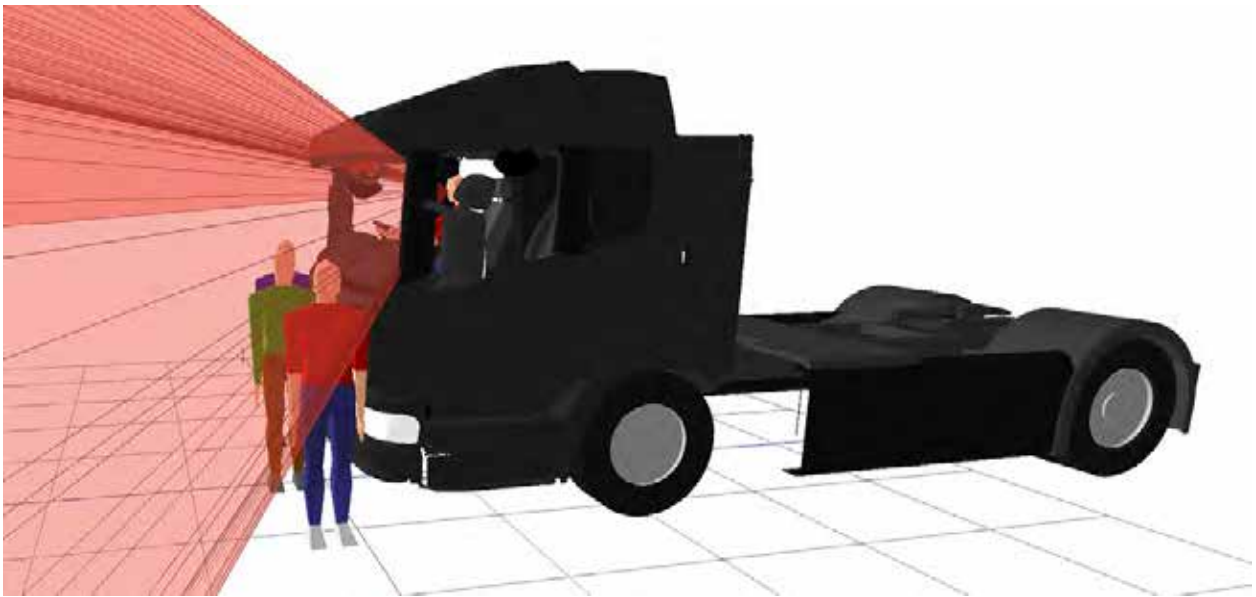


Figure 504. 3D view showing that the three human models can stand adjacent to the front of the vehicle and still be visible to the driver

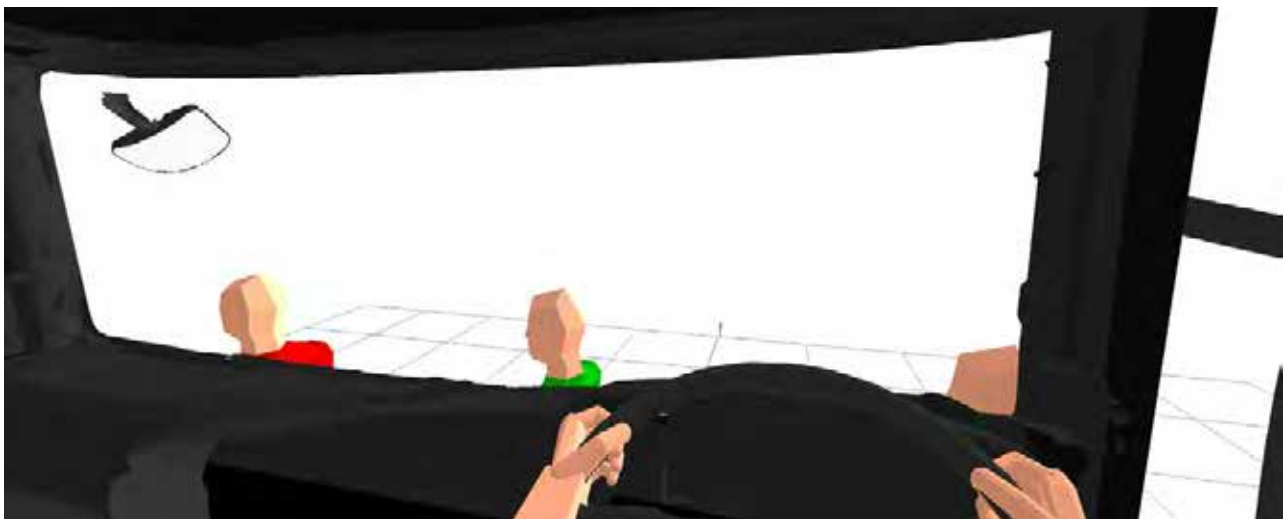


Figure 505. The view from the driver's eyes clearly shows the three pedestrians are visible

The view through the eyes of the driver demonstrates that all three pedestrians can be seen in the positions shown. It is also clear that the pedestrian could be hidden by the A-pillar structure of the cab if they were stationary.

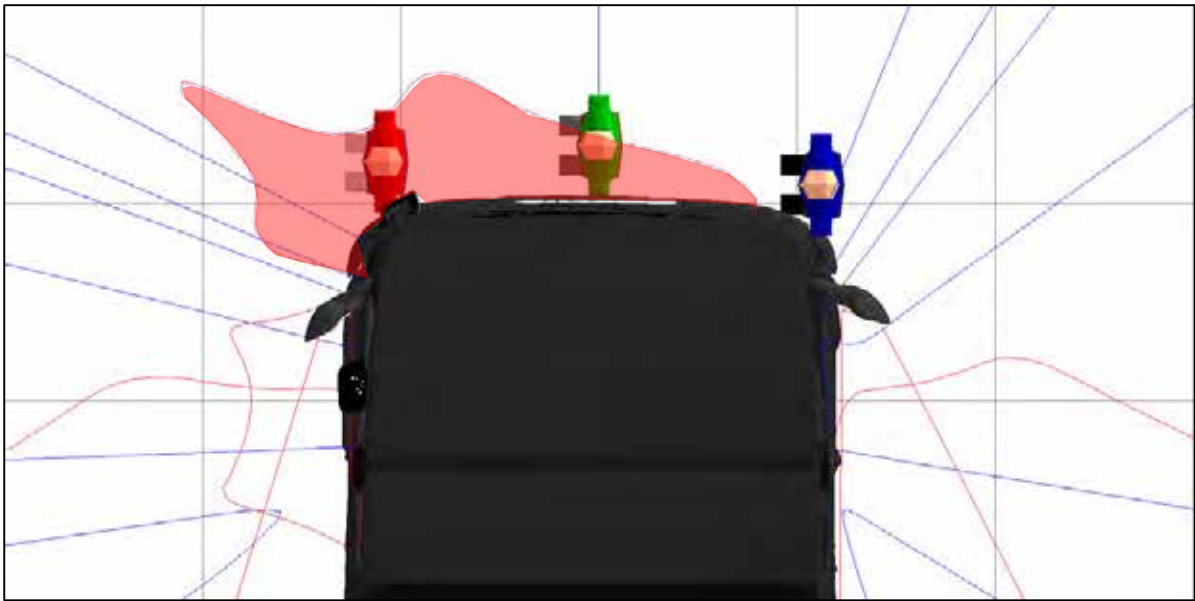


Figure 506. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian



Figure 507. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Figure 507 shows that the pedestrians would also be visible in the Class VI mirror. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide a pedestrian human model as defined in the test to the front of the Scania N3 LEC.

4.1.15.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

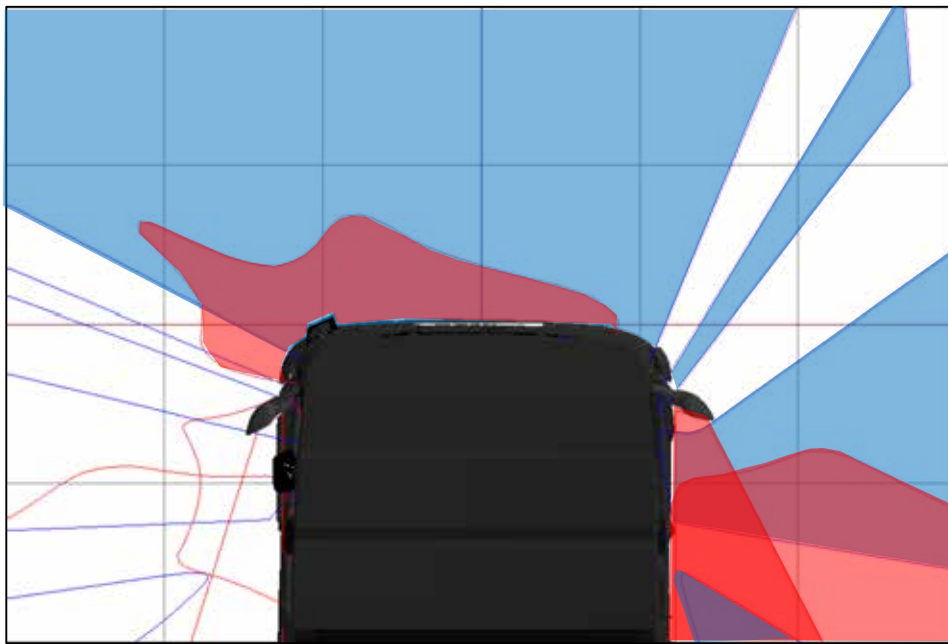


Figure 508. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 510 and Figure 511 show that the front (yellow) cyclist cannot be hidden from vision when directly adjacent to the vehicle side and the rear (blue) cyclist is also visible in the driver's view, even when adjacent to the side of the vehicle.

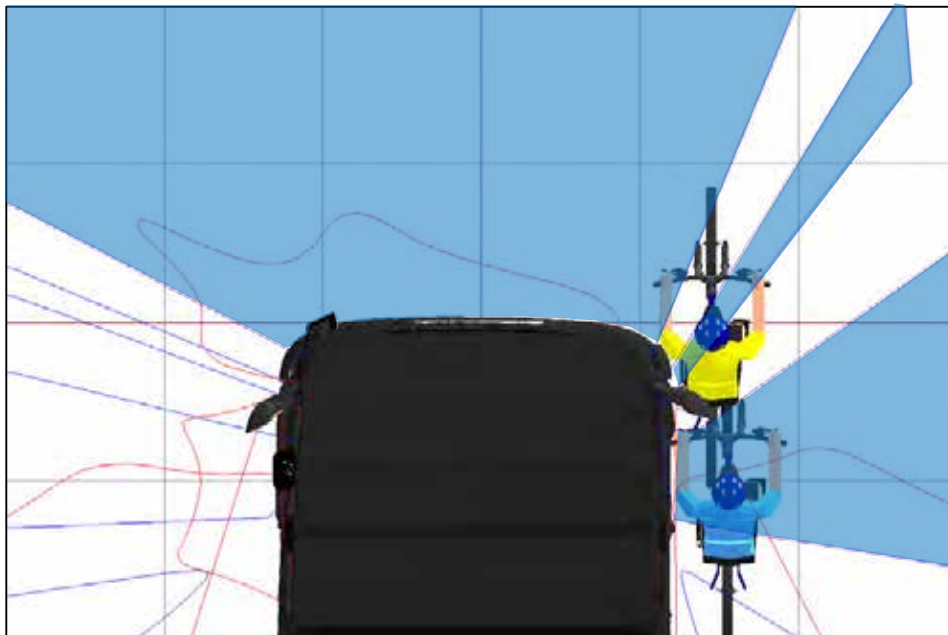


Figure 509. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist

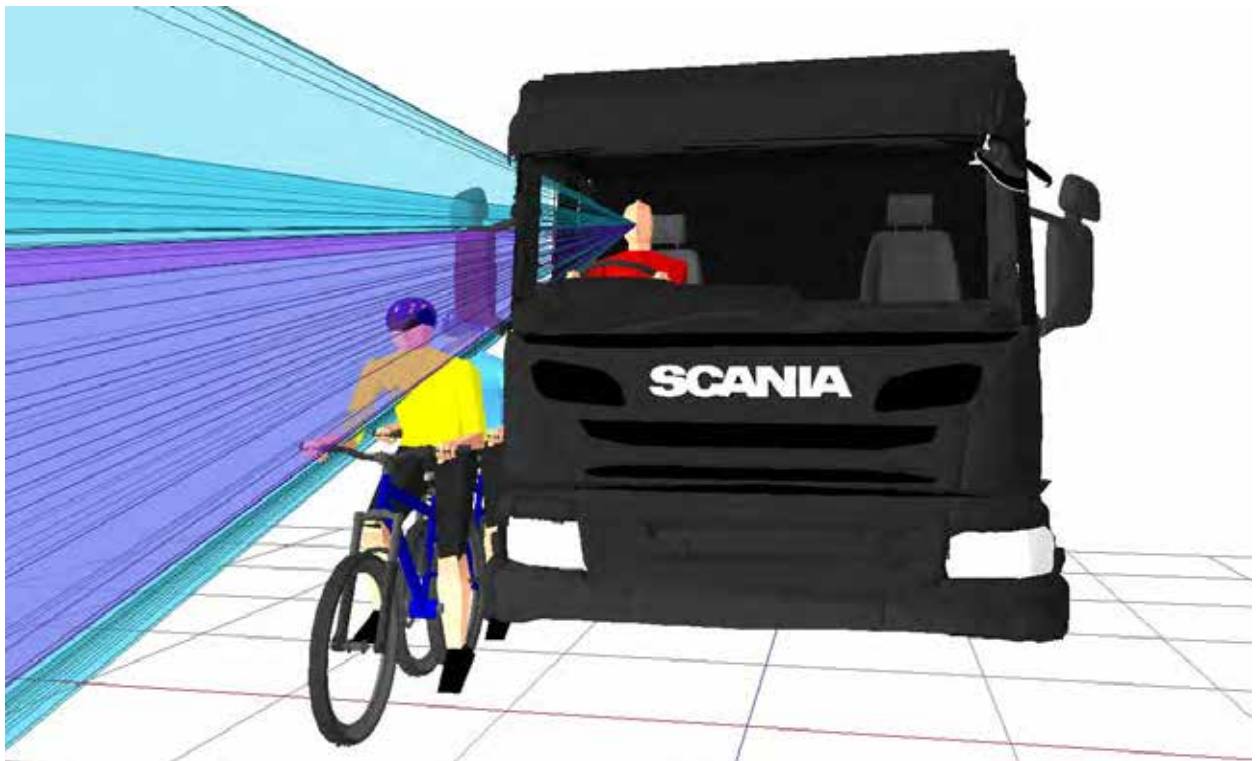


Figure 510. 3D view showing that both cyclists cannot be hidden from direct vision to the offside of the Scania N3 LEC

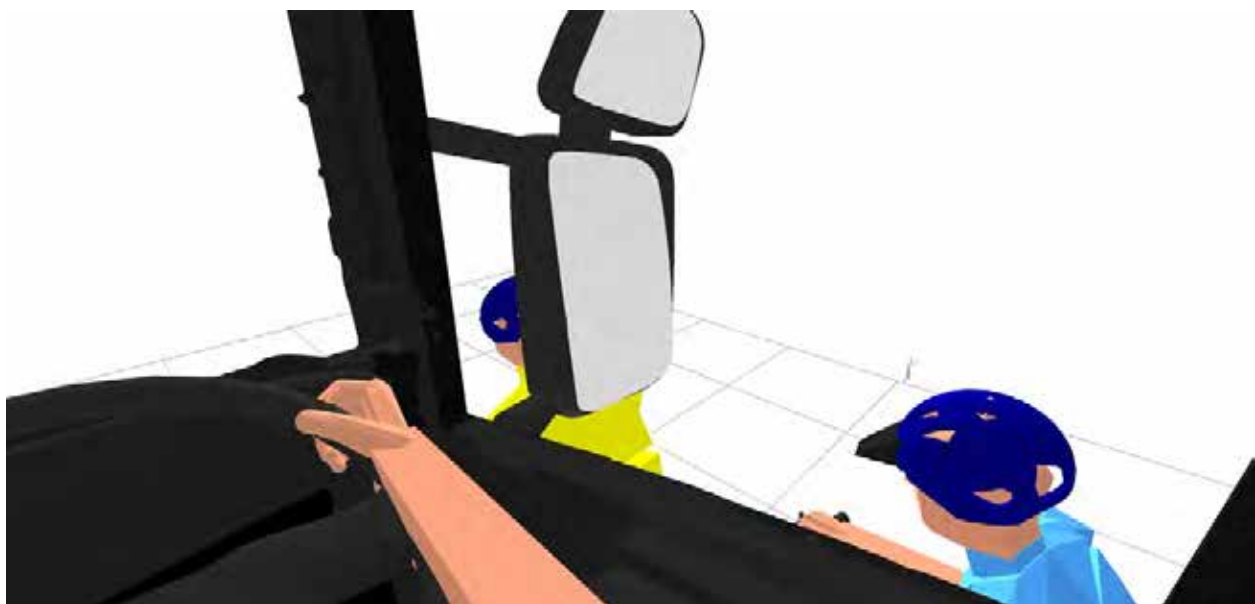


Figure 511. The view from the driver's eyes clearly shows the two cyclists are visible, even when positioned against the side of the vehicle.

For offside direct visibility of the cyclists it is clear that both cyclists are visible even when directly adjacent to the side of the cab.

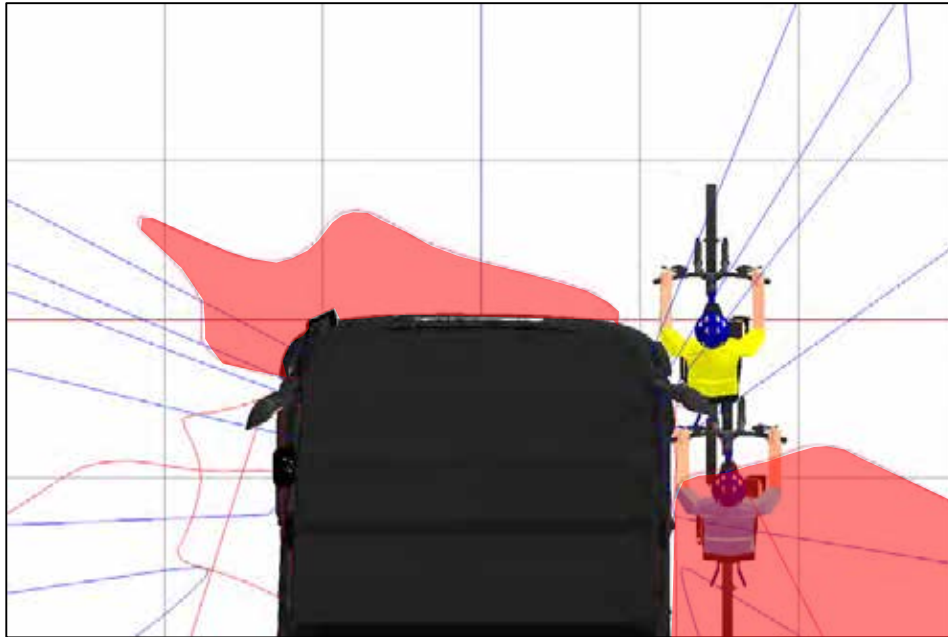


Figure 512. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist



Figure 513. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

The cyclists are visible to the driver through the use of the mirrors. Figure 513 shows that theoretically both cyclists are visible in the Class VI mirror. However, due to limitations of the projection technique, the rear cyclist (blue) would actually be hidden from view by the cab of the vehicle. However, part of the front (yellow) cyclist would be visible in the Class VI mirror including their arms and the front of the bicycle.



Figure 514. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 514 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and shoulders. The projections show that for a driver using their mirrors and direct vision, it is not possible to hide a cyclist in the positions shown to the offside of the Scania N3 LEC.

4.1.15.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

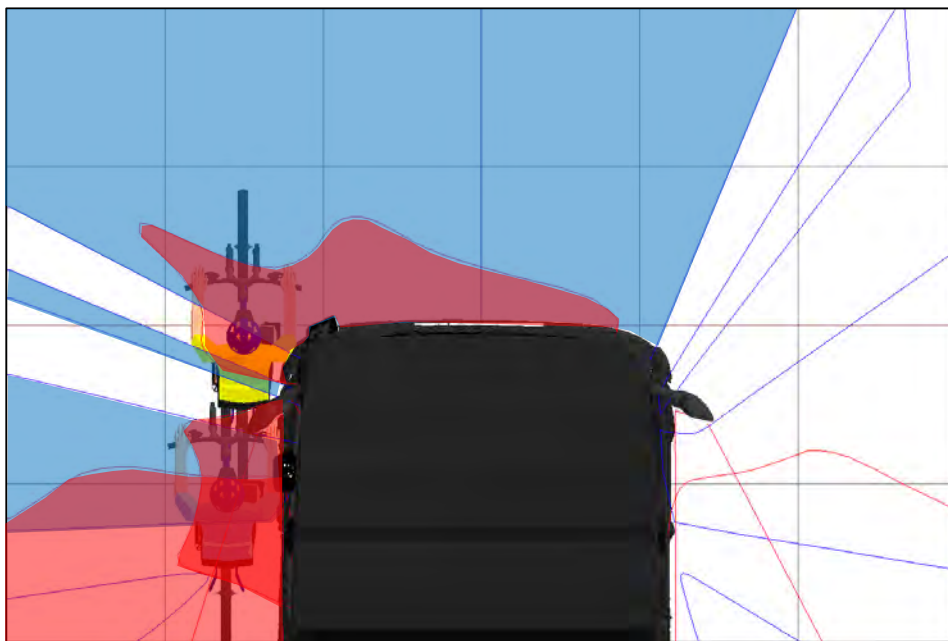


Figure 515. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 517 and Figure 518 show that the cyclists cannot be hidden from view even when directly adjacent to the cab, but with only a small portion of the cyclists visible to the driver.

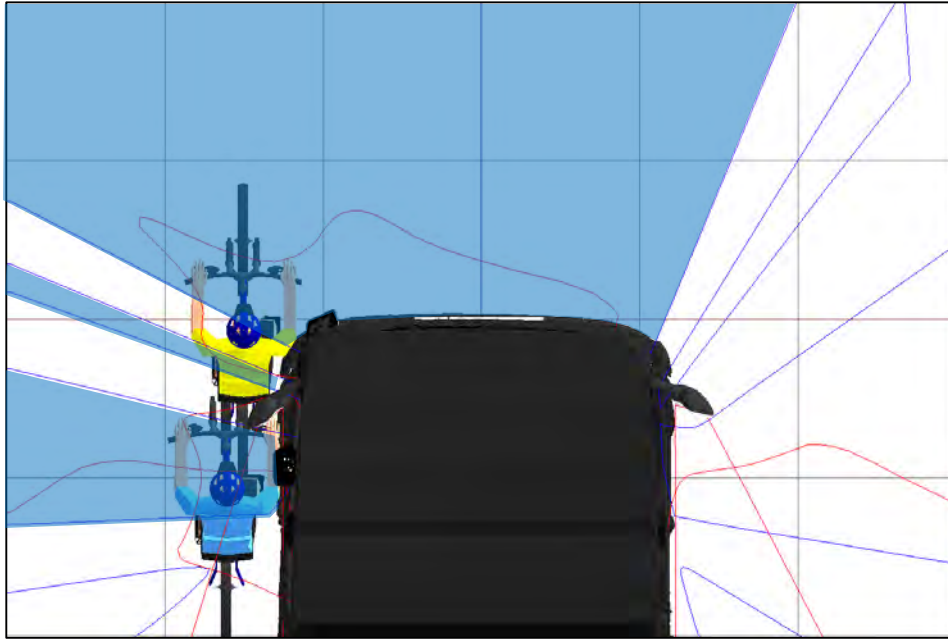


Figure 516. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

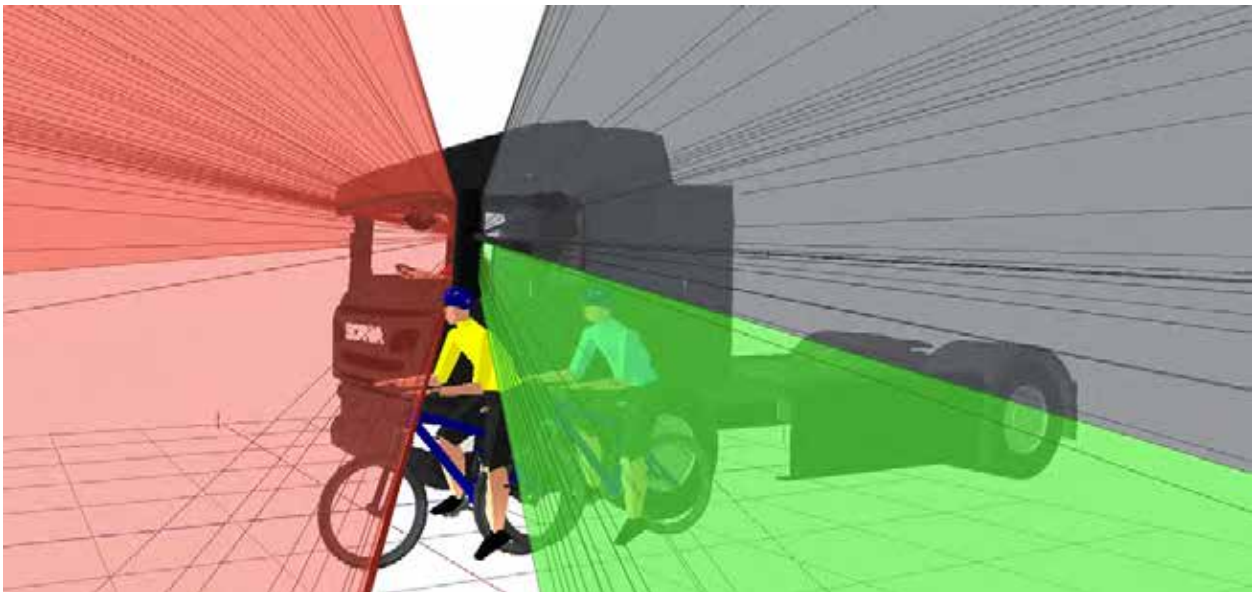


Figure 517. 3D view showing that the two human models are visible through the windscreen and the side windows

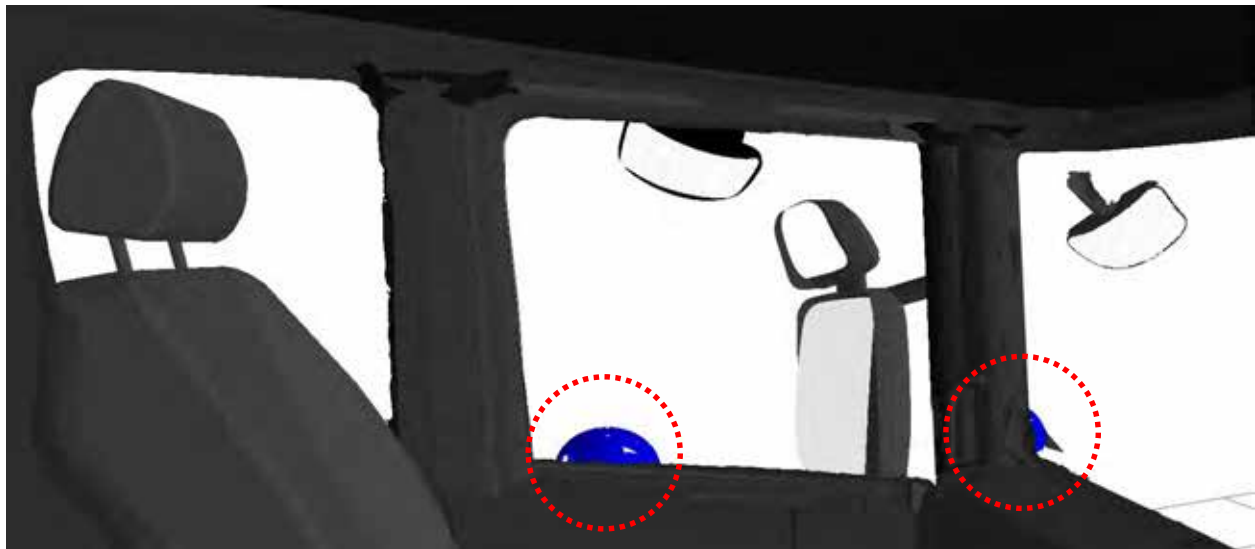


Figure 518. The view from the driver's eyes clearly shows the two cyclists are not hidden from view.

For nearside visibility both cyclists can be seen. There is only a small portion of the front (yellow) cyclist visible, and it is clear that there is a position in which the cyclist could be hidden behind the near side A-pillar if the front cyclist was moved slightly rearwards.

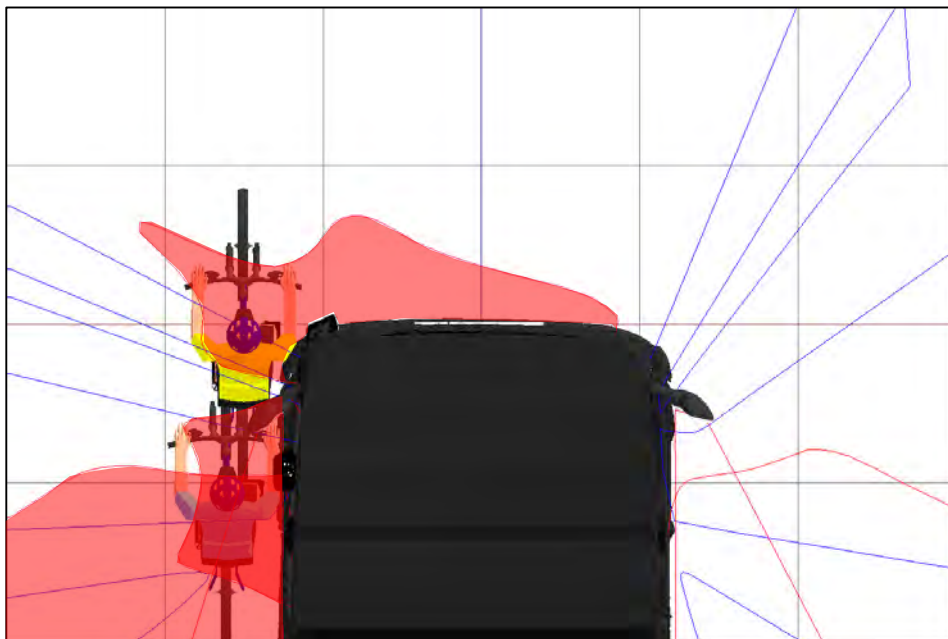


Figure 519. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

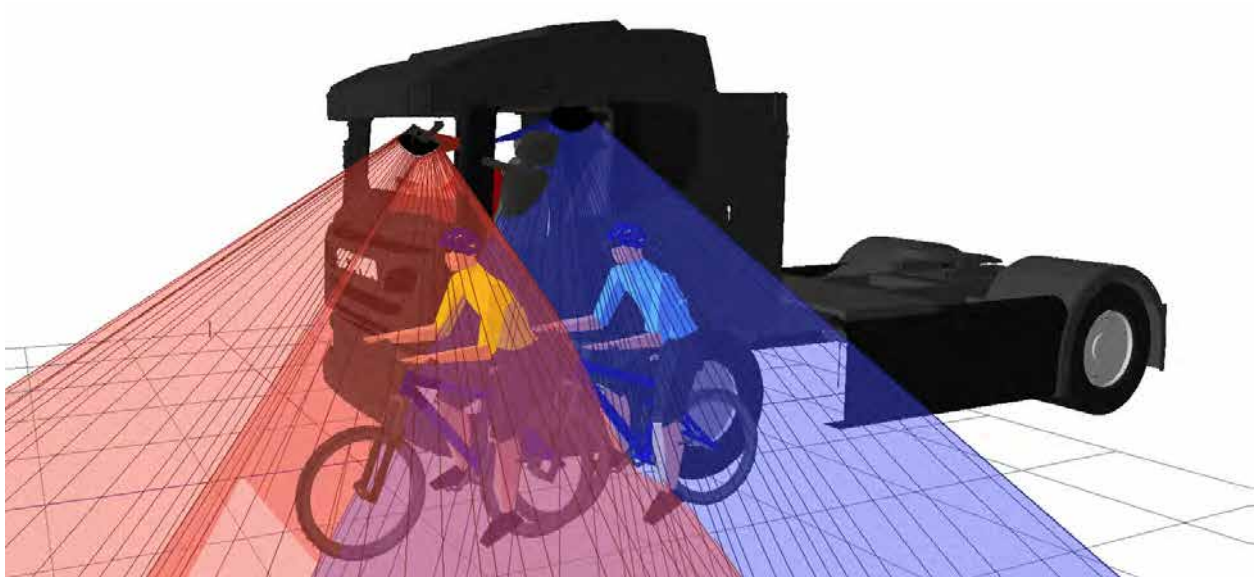


Figure 520. 3D view showing that the Front (yellow) cyclists positioned to the nearside of the vehicle is visible in the projection of the Class V and / or Class VI mirrors, and that the rear cyclist is visible in the Class V mirror

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 520 shows that the front (yellow) cyclist is visible in the Class V and Class VI mirrors. The rear (blue) cyclist is visible in both the Class V and Class IV mirrors.



Figure 521. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is visible in the projection of the Class IV mirror

The analysis shows that the cyclists on the near side of the vehicle cannot be obscured from vision.

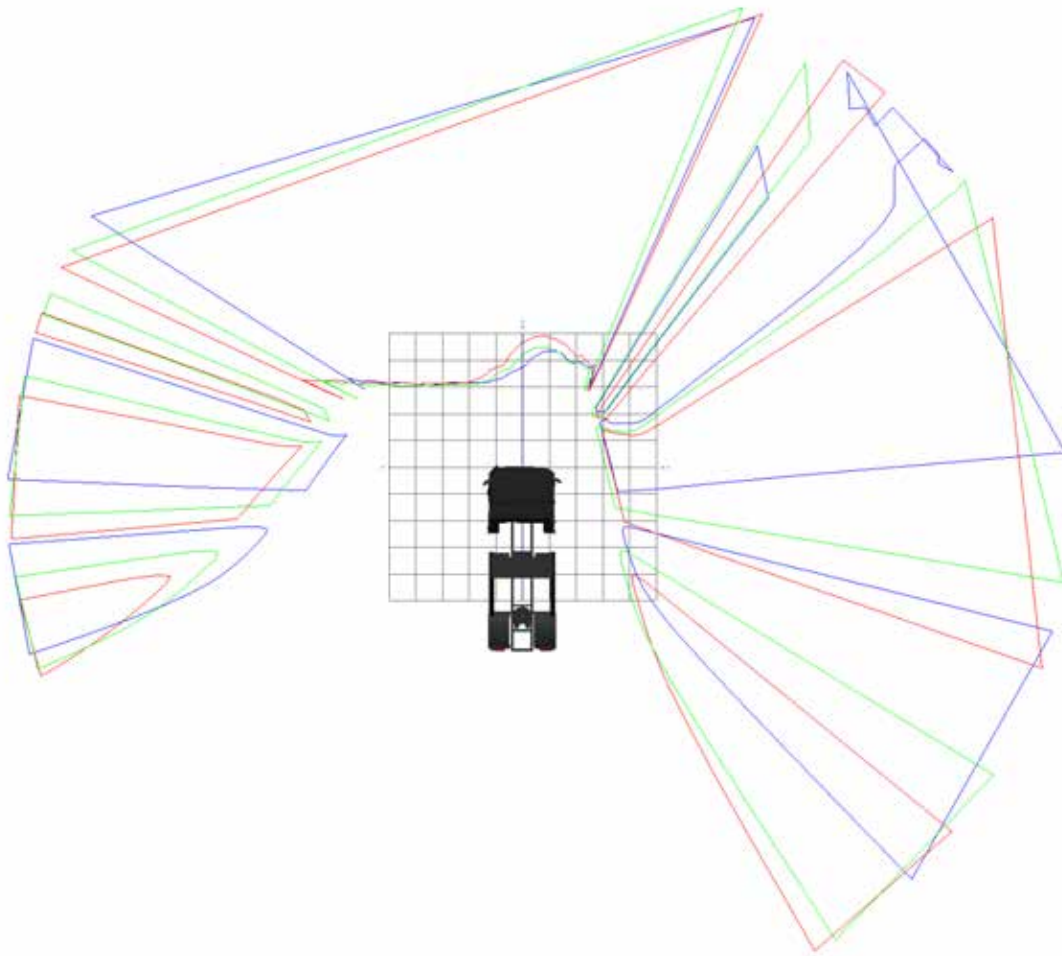
4.1.15.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

Figure 522. A plan view of the projection of the windscreen and side windows onto the ground plane for the Scania N3 LEC for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.1.16 VOLVO FM N3 DISTRIBUTION - 50TH %ILE MALE DRIVER



Figure 523. Evaluation model of Volvo FM N3 Distribution variant vehicle

4.1.16.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 524 shows a top-down view of all of the window projections for the Volvo FM N3 cab with a 50th %ile UK Male Driver. The image on the right of Figure 524 shows the areas of these projections that intersect with the ground. Figure 525 shows the same for the the mirror projections and Figure 526 shows the two combined. In this case the projections have been clipped to a radius of twenty metres. Any area outside of the coloured projections, within that twenty metre radius, is effectively a blind spot at the ground plane.

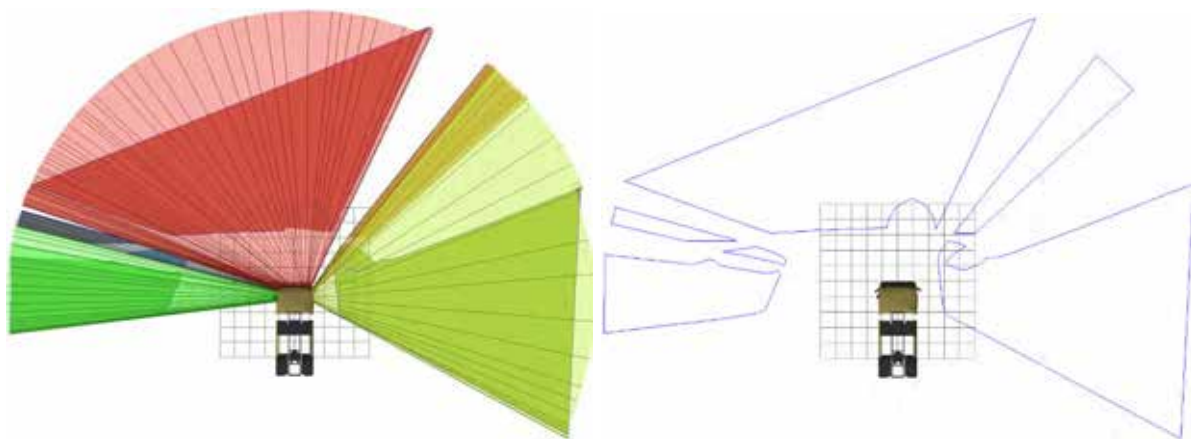


Figure 524. The projection of the windscreen and window apertures at the ground plane for the Volvo FM N3

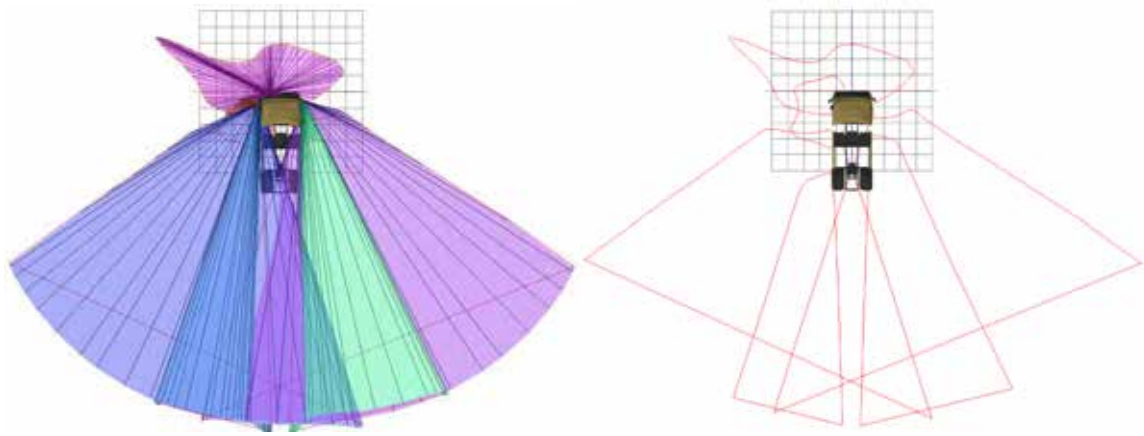


Figure 525. The projection of the mirrors at the ground plane for the Volvo FM N3

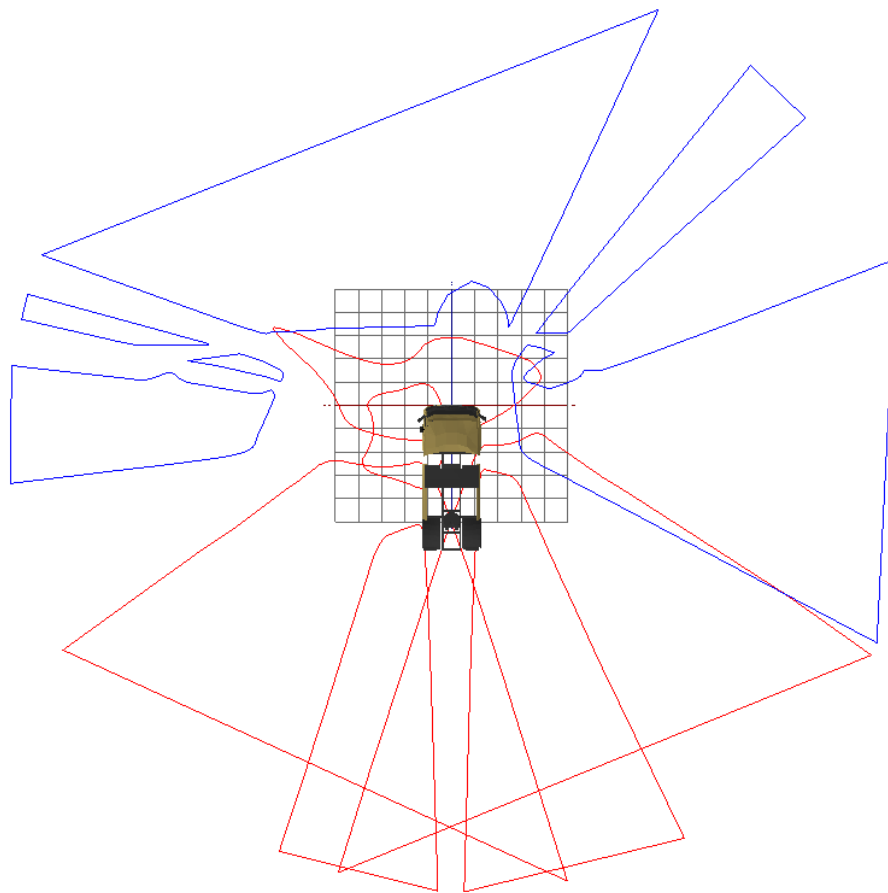


Figure 526. The combined direct and indirect vision projections at the ground plane for the Volvo FM N3

Figure 527 through Figure 531 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 532 and Figure 533 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

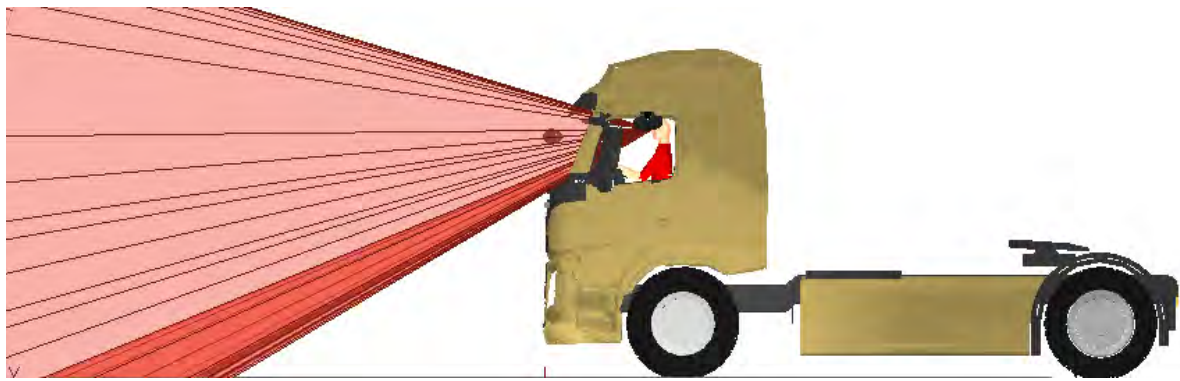


Figure 527. A side view of the windscreen aperture projection for the Volvo FM N3



Figure 528. Frontal views of the off side and near side door window projections for the Volvo FM N3



Figure 529. A side view of the Class VI mirror projection for the Volvo FM N3



Figure 530. A front view of the Class V mirror projection for the Volvo FM N3

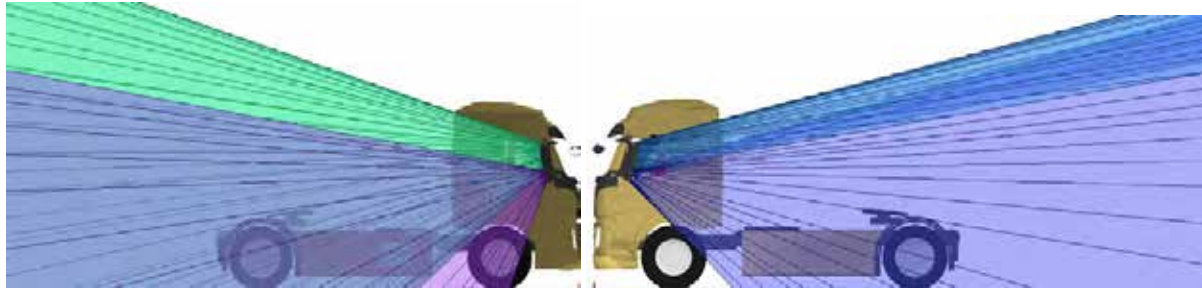


Figure 531. Side views of the combined Class II and Class IV mirror projections for the Volvo FM N3

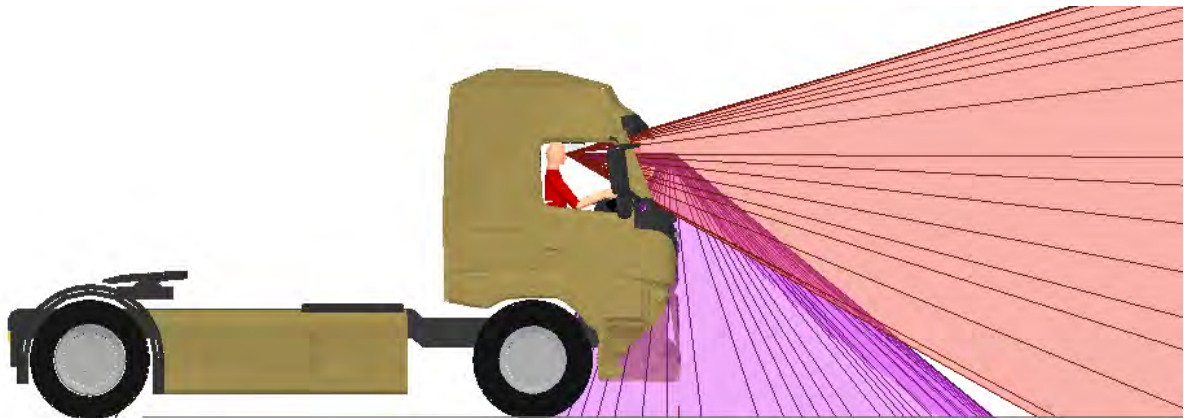


Figure 532. Combined projection of the windscreen and Class VI mirror to the front of the Volvo FM N3

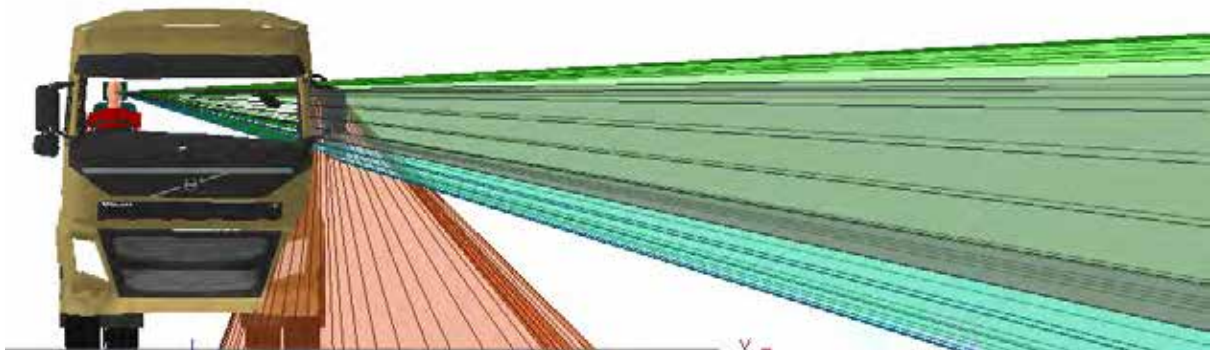


Figure 533. Combined projection of the near side windows and Class V mirror to the side of the Volvo FM N3

4.1.16.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 534 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.



Figure 534. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 526. Figure 535 and Figure 536 show that there is almost no space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.



Figure 535. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

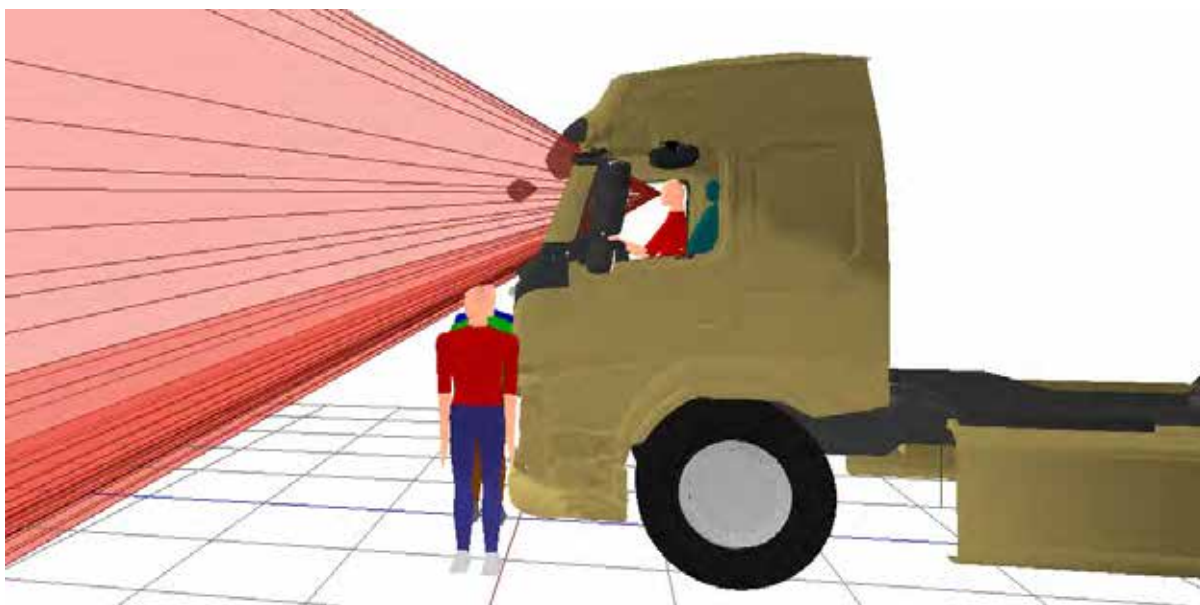


Figure 536. 3D view showing that the left (red) and centre (green) pedestrians cannot be hidden, but the right (blue) pedestrian can stand up to 191mm in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture

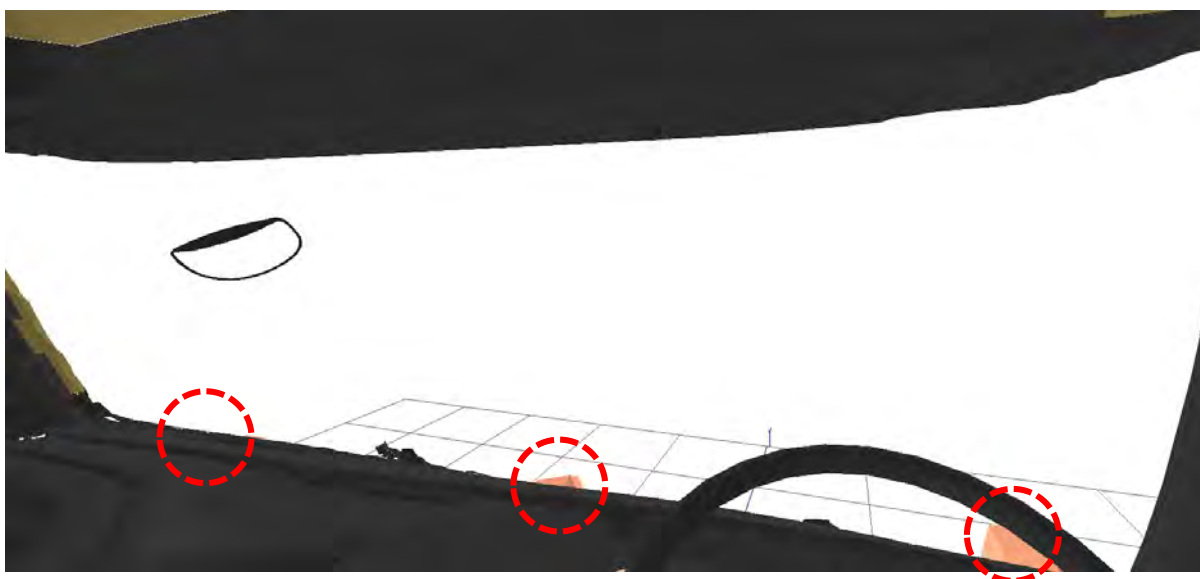


Figure 537. The view from the driver's eyes shows that the left (red), and centre (green) pedestrians are just visible, and the right (blue) pedestrian is effectively hidden, though may be visible through the centre of the steering wheel depending on its design.

For forwards visibility of the pedestrians it is only possible to hide the right (blue) pedestrian from the driver's direct vision. The right (blue) pedestrian is positioned at 191mm from the front of the vehicle and is hidden by the steering wheel. Steering wheel adjustment and the design of the steering wheel itself will impact upon this result. The left (red) pedestrian and central (green) pedestrian cannot be hidden even when touching the front of the vehicle. Thus it is possible for a pedestrian of 50th %ile UK male height or shorter to be hidden from direct vision when positioned to the front right of the Volvo FM N3.

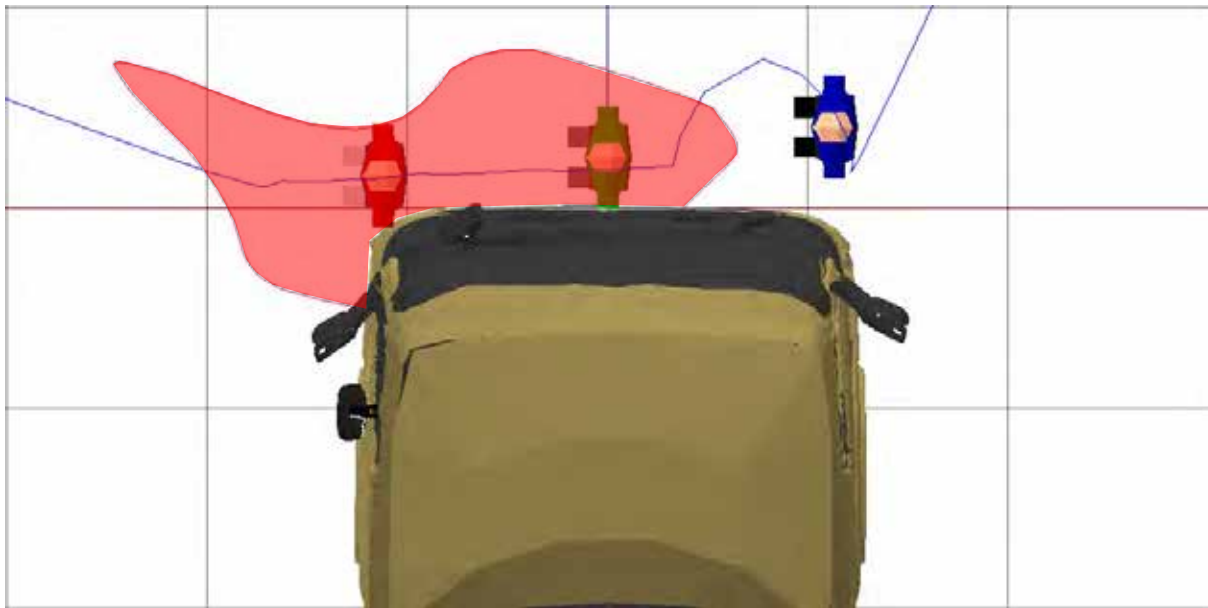


Figure 538. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

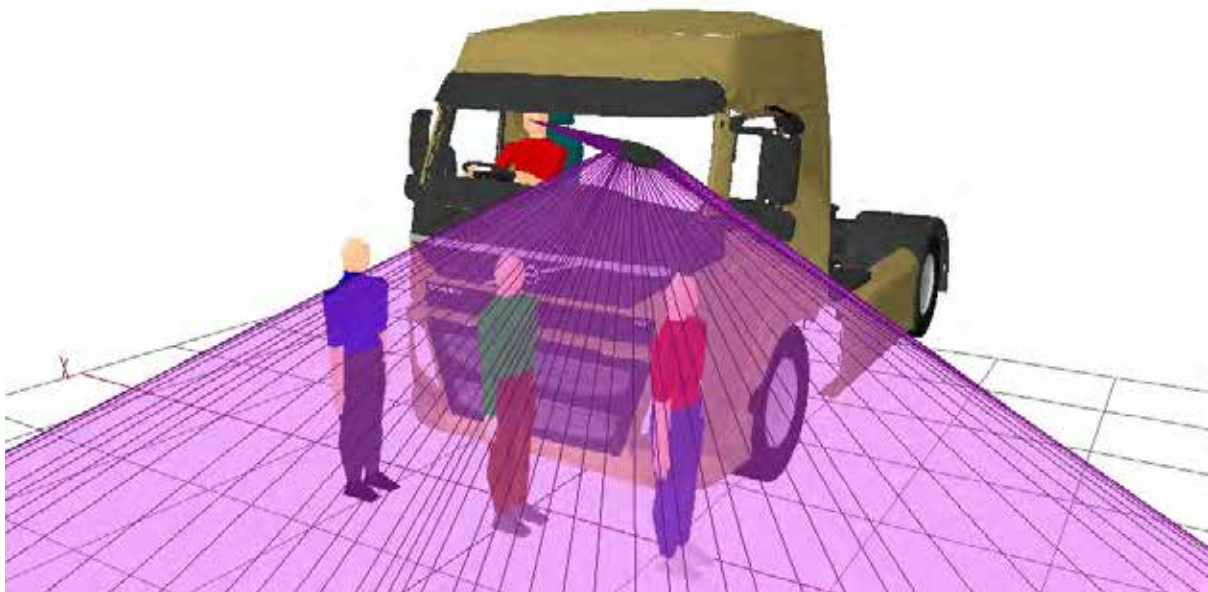


Figure 539. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though one of the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 539 shows that the pedestrian to the left (red) and centre (green) would be completely visible and the pedestrian to the right (blue) would be visible from the neck down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide the pedestrian models that have been tested to the front of the Volvo FM N3.

4.1.16.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

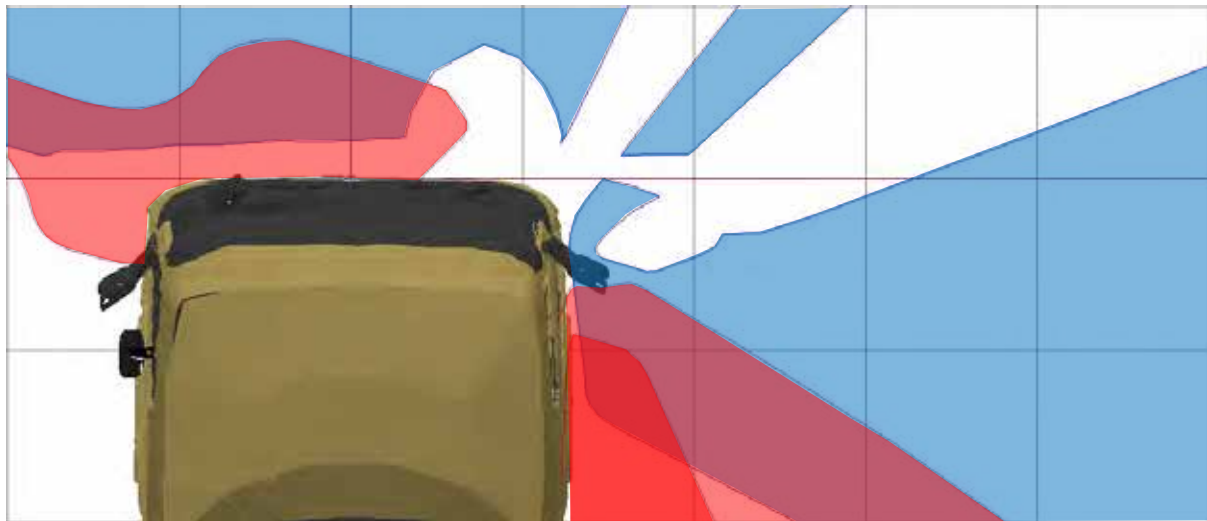


Figure 540. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

From Figure 540 it is clear that the visible areas at a height representative of a cyclist are closer to the vehicle than those taken at ground level shown in Figure 526. Figure 541, Figure 542 and Figure 543 show that whilst there is a small gap between the offside of the vehicle and the near edges of the visible areas, there is insufficient space in which a cyclist could be hidden from direct view.

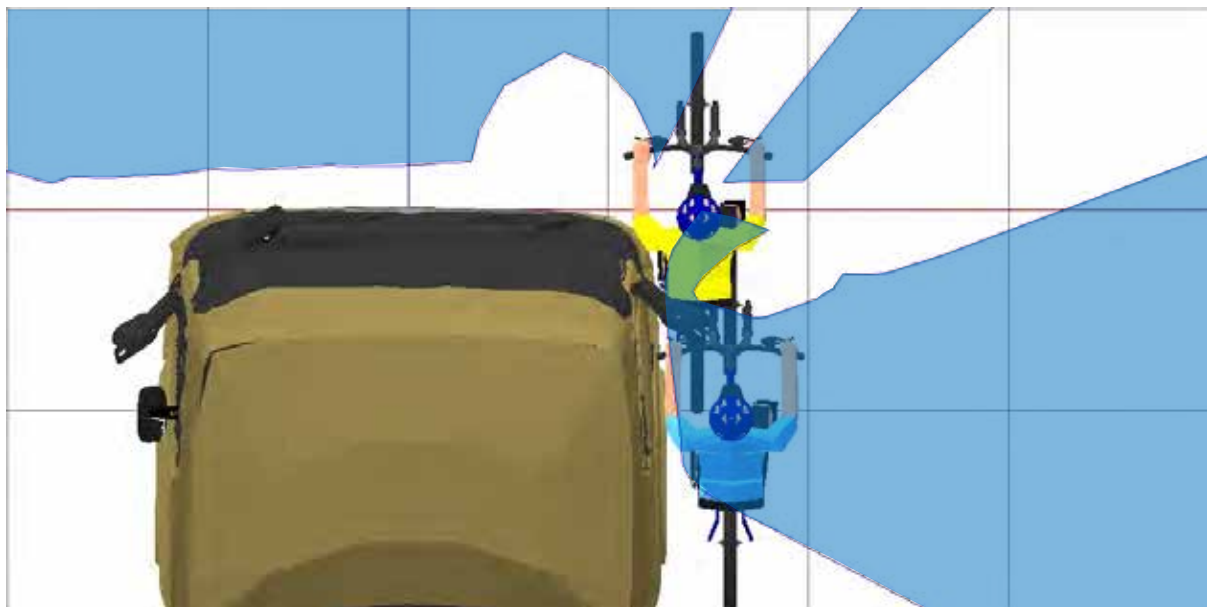


Figure 541. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist

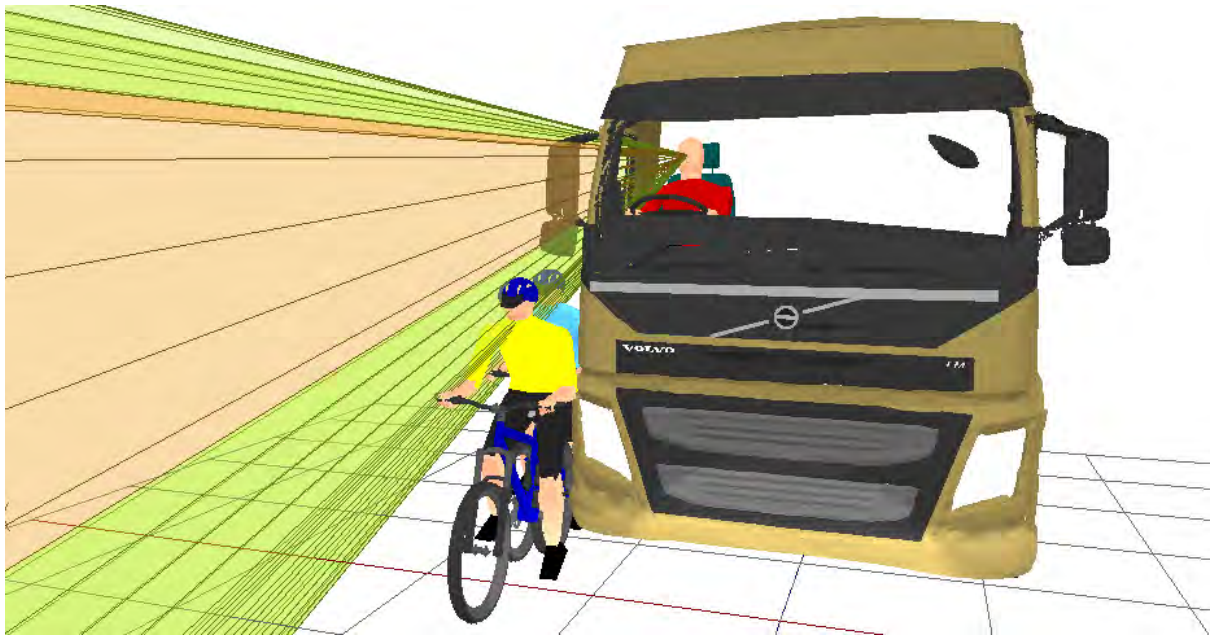


Figure 542. 3D view showing that both cyclists cannot be hidden from direct vision to the offside of the Volvo FM N3

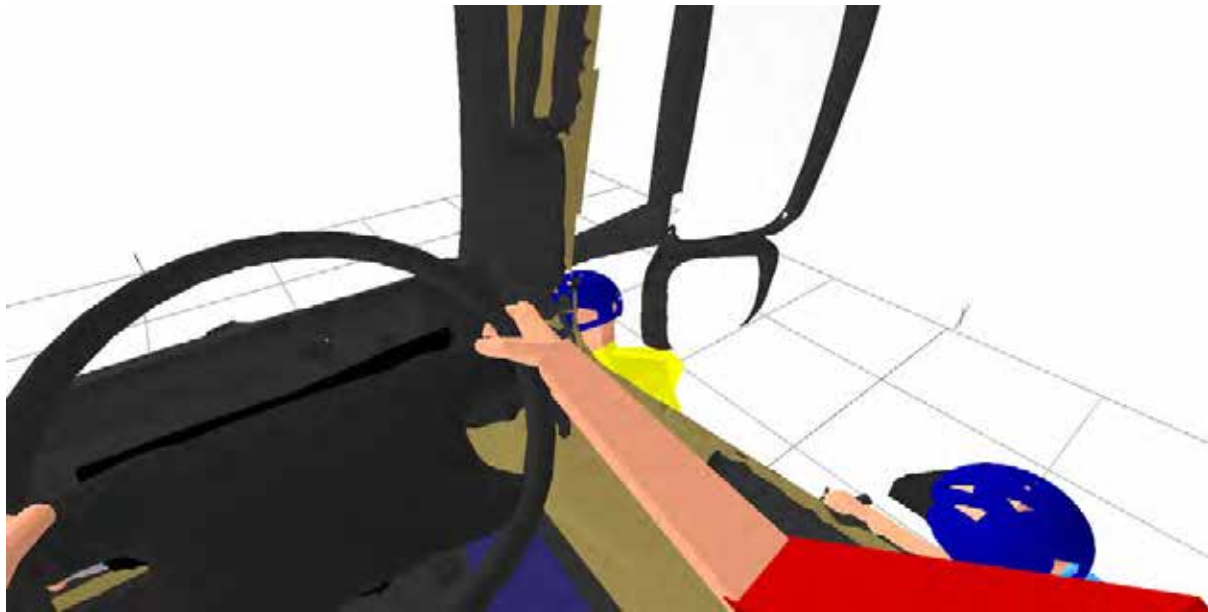


Figure 543. The view from the driver's eyes clearly shows the two cyclists are visible, even when positioned against the side of the vehicle.

For offside visibility of the cyclists there is no blind spot that could obscure a cyclist. Figure 543 shows that even with the cyclists touching the side of the cab they would still be visible to the driver.

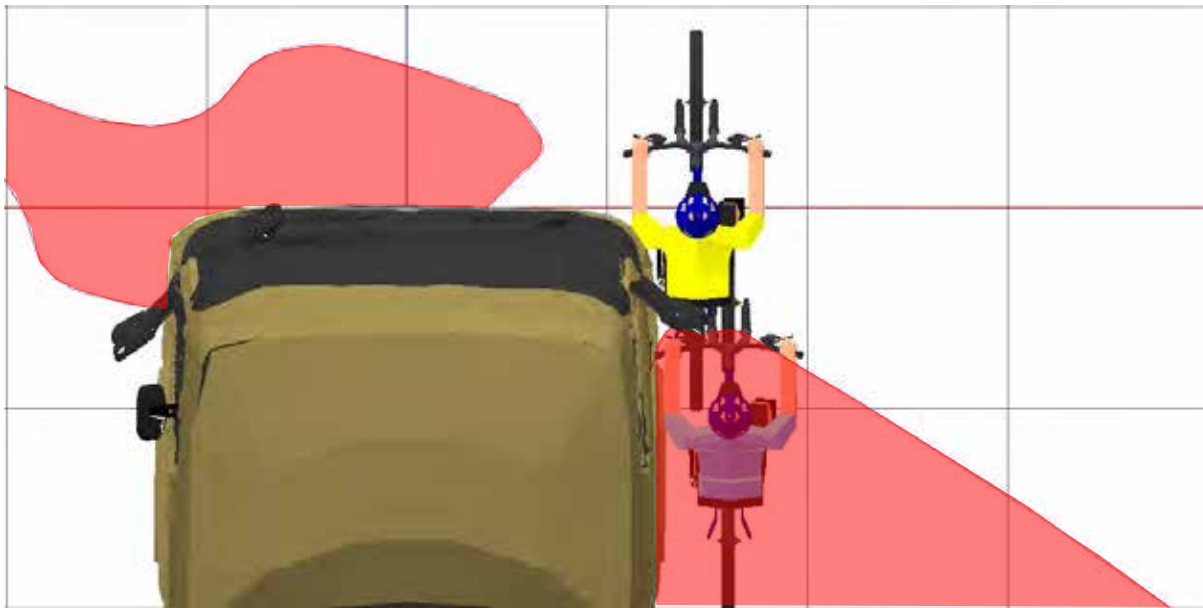


Figure 544. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist



Figure 545. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

In addition to being visible in direct vision the cyclists are also visible in the mirrors. Figure 545 shows that part of the front (yellow) cyclist would also be visible in the Class VI mirror including their arms, lower legs and the front of the bicycle.

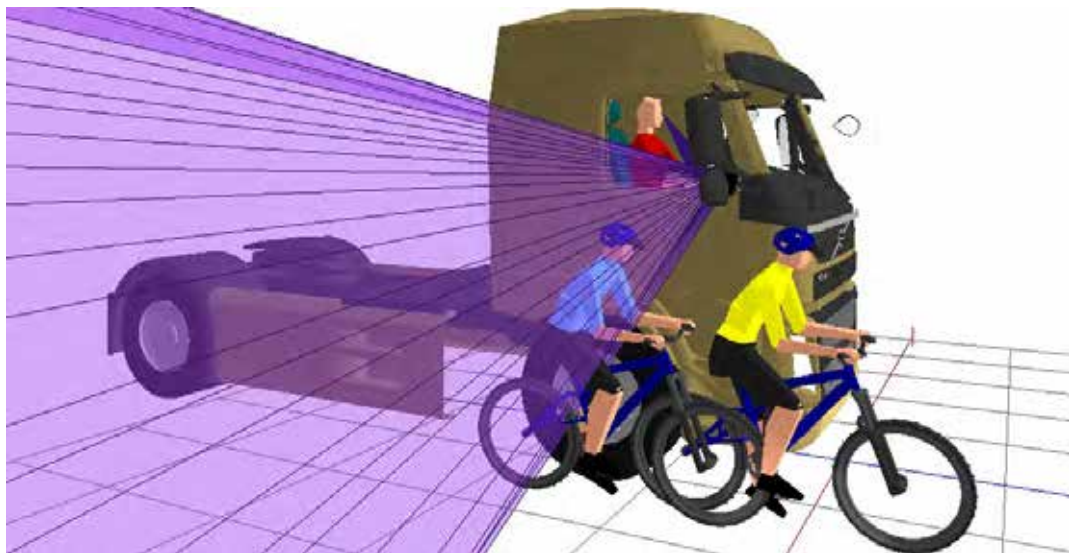


Figure 546. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 546 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and torso, upper arms and thighs. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the offside of the Volvo FM N3.

4.1.16.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

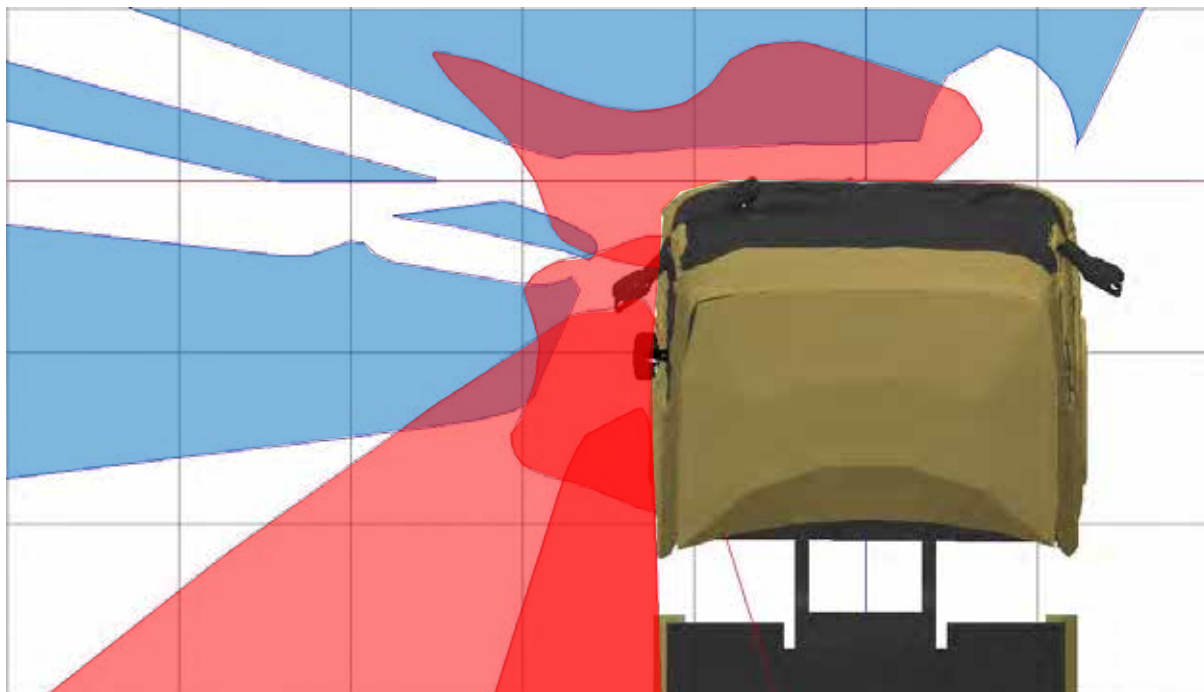


Figure 547. The areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 548 and Figure 549 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

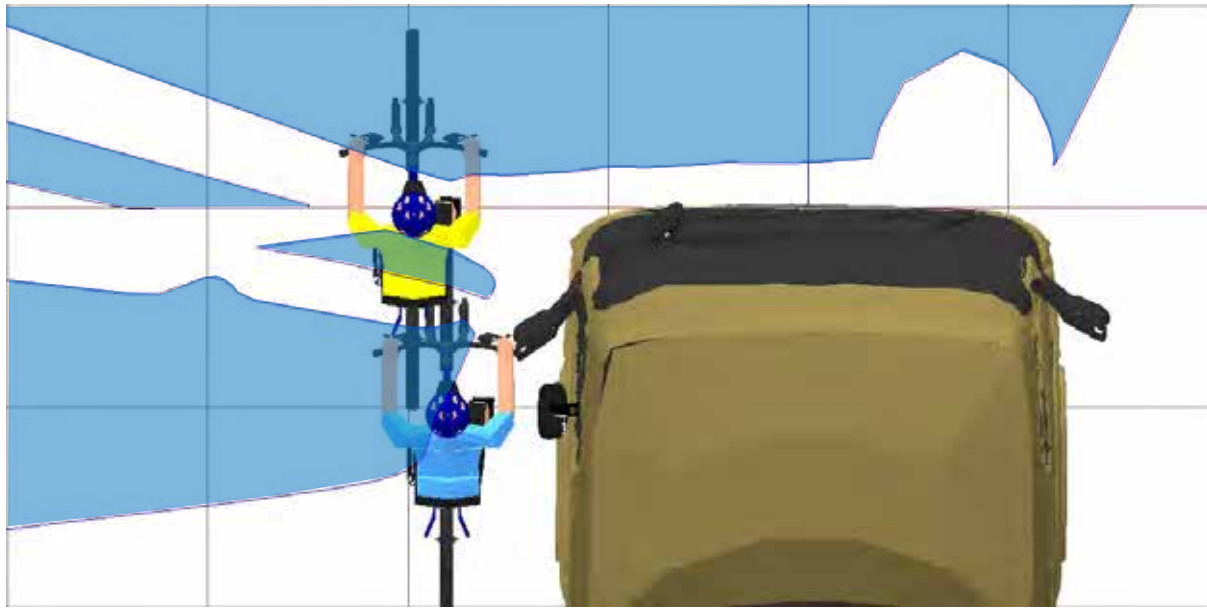


Figure 548. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

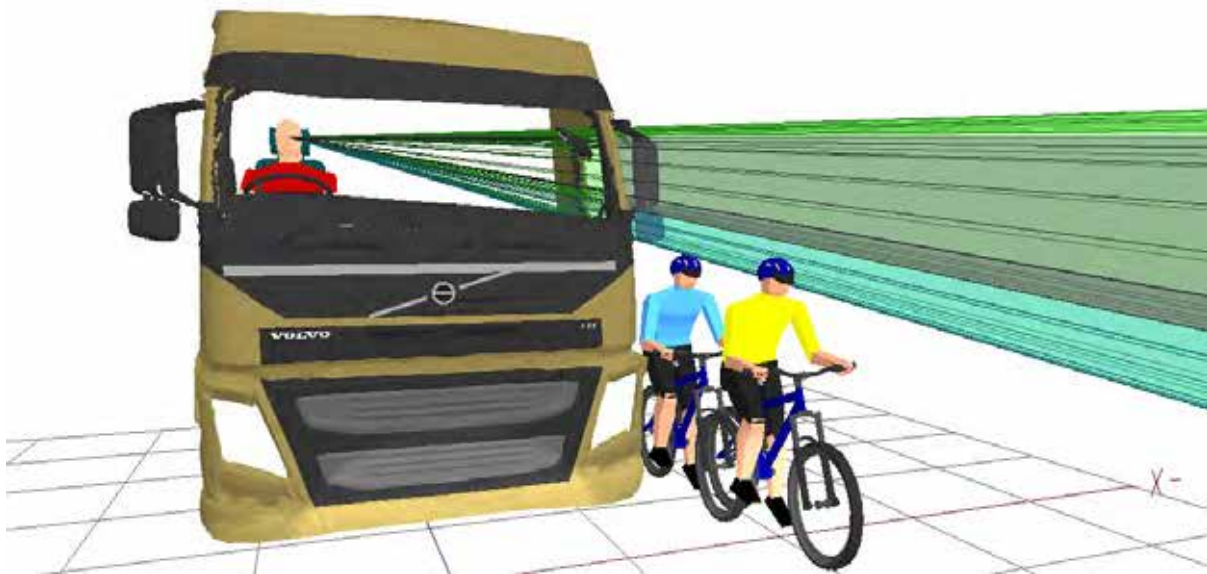


Figure 549. 3D view showing that the two human models can be positioned 354mm (yellow) and 186mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture

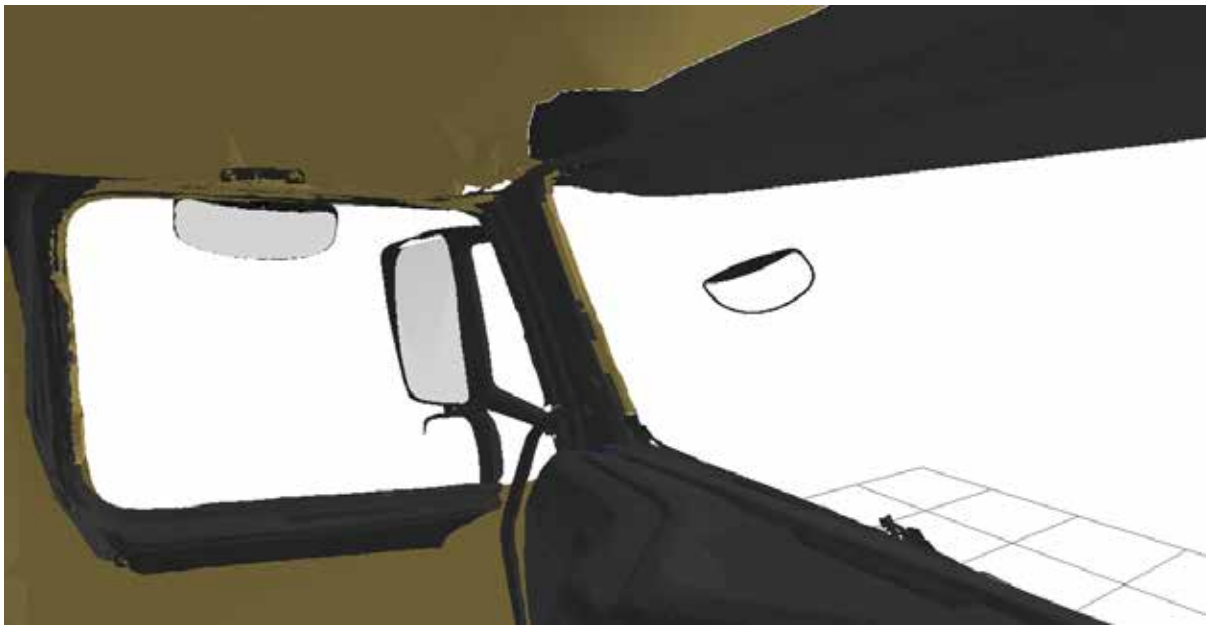


Figure 550. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 354mm from the side of the vehicle, the rear (blue) cyclist is positioned at 186mm from the side of the vehicle. In this configuration the front cyclist is easier to obscure than the rear cyclist, contrary to many of the other vehicle assessed (e.g. DAF CF N3, Figure 70). This is due to the front cyclist falling into the A-pillar blind spot.

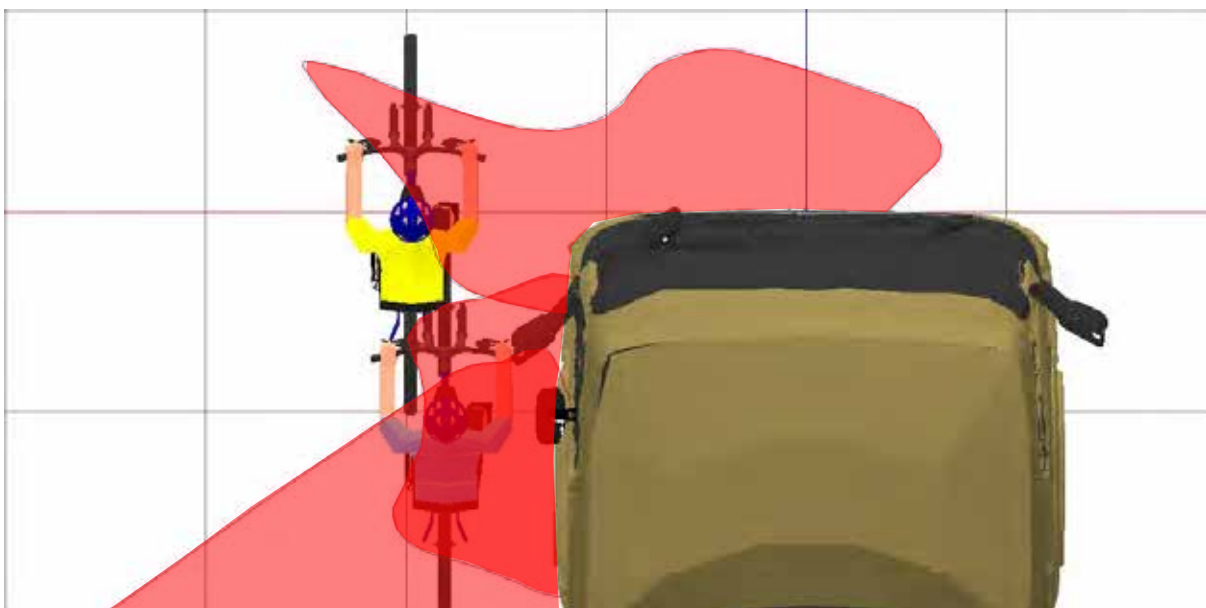


Figure 551. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

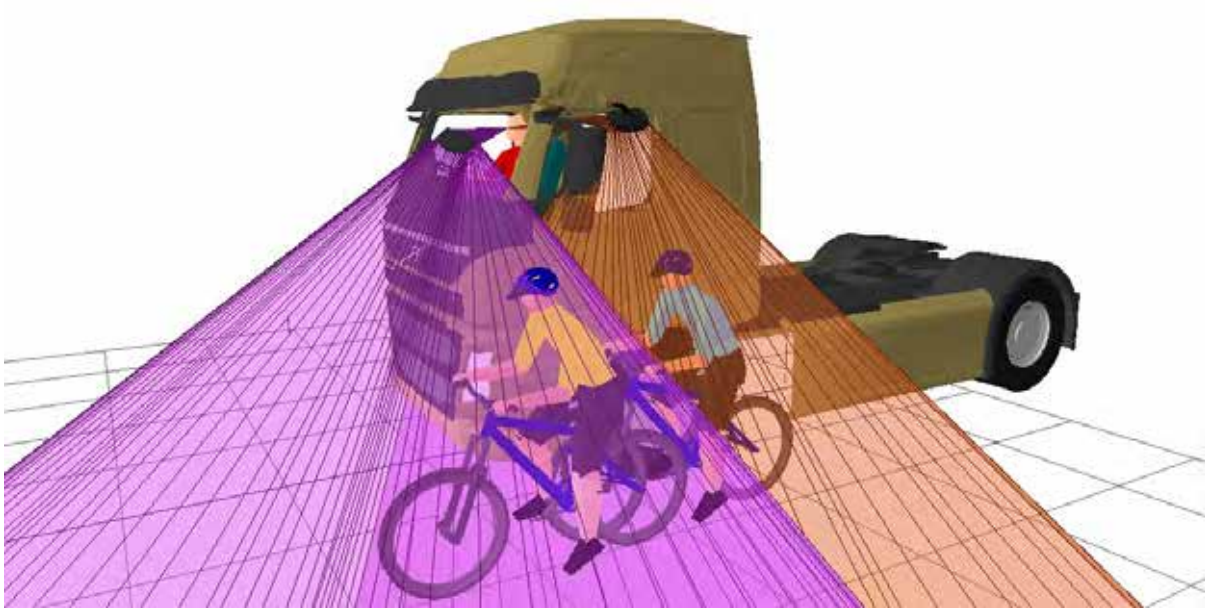


Figure 552. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 552 shows that both are visible in the Class V and Class VI mirrors. The front (yellow) cyclist is completely visible in the Class VI mirror and from the chest down in the Class V mirror. Part of the rear (blue) cyclist's front wheel is visible in the Class VI and completely visible in the Class V mirror.



Figure 553. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is visible in the projection of the Class IV mirror

Figure 553 shows that the rear of the two cyclists (blue) is also visible in the projection of the nearside Class IV mirror. The cyclist would only be partially visible including the head and back of the torso of the rider. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the nearside of the Volvo FM N3.

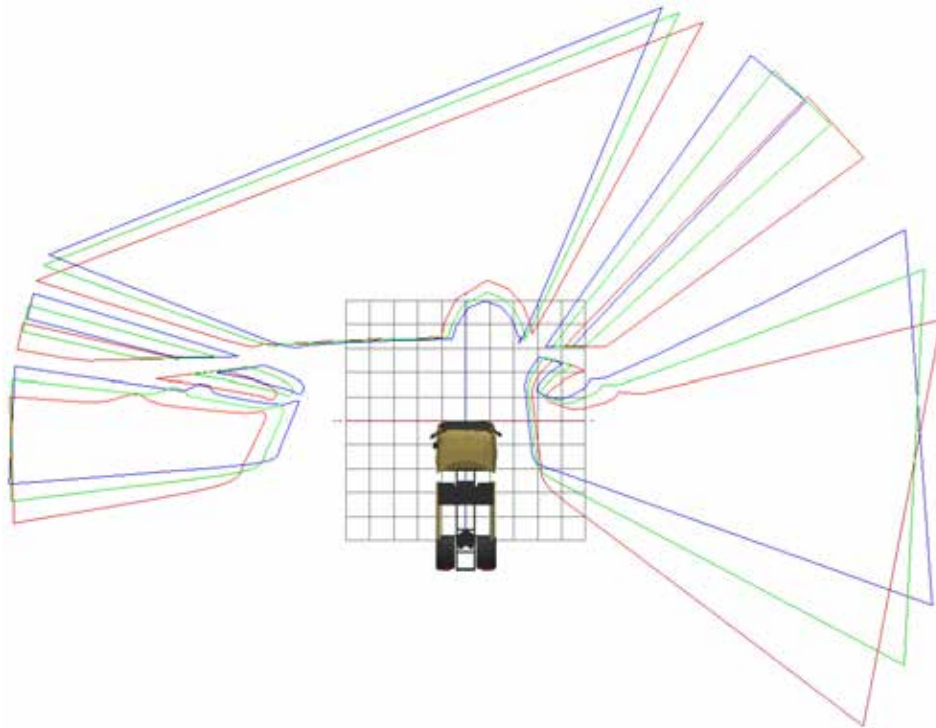
4.1.16.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

Figure 554. A plan view of the projection of the windscreen and side windows onto the ground plane for the Volvo FM N3 for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.1.17 VOLVO FMX N3G CONSTRUCTION - 50TH %ILE MALE DRIVER



Figure 555. Evaluation model of Volvo FMX N3G Construction variant vehicle

4.1.17.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 556 shows a top-down view of all of the window projections for the Volvo FMX N3G cab with a 50th %ile UK Male Driver. The image on the right of Figure 556 shows the areas of these projections that intersect with the ground. Figure 557 shows the same for the the mirror projections and Figure 558 shows the two combined. In this case the projections have been clipped to a radius of twenty metres. Any area outside of the coloured projections, within that twenty metre radius, is effectively a blind spot at the ground plane.

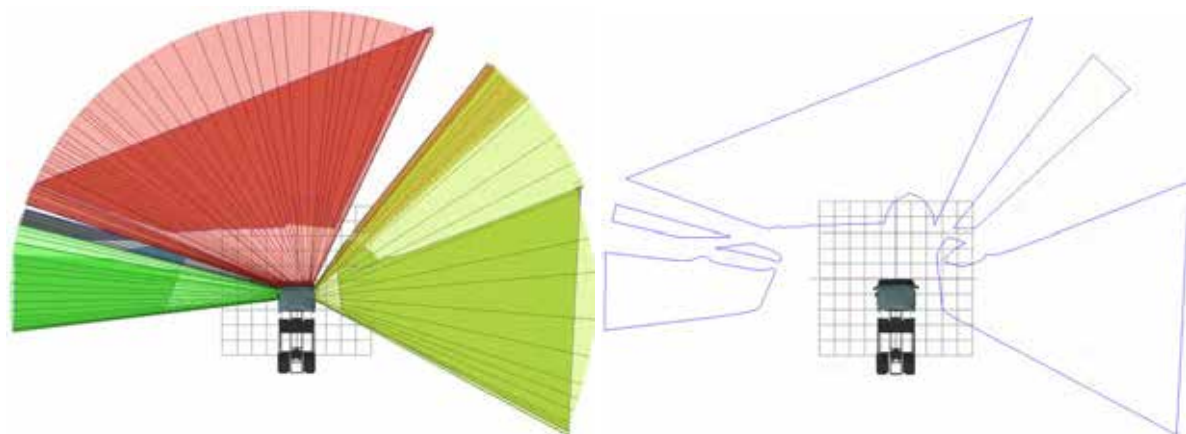


Figure 556. The projection of the windscreen and window apertures at the ground plane for the Volvo FMX N3G

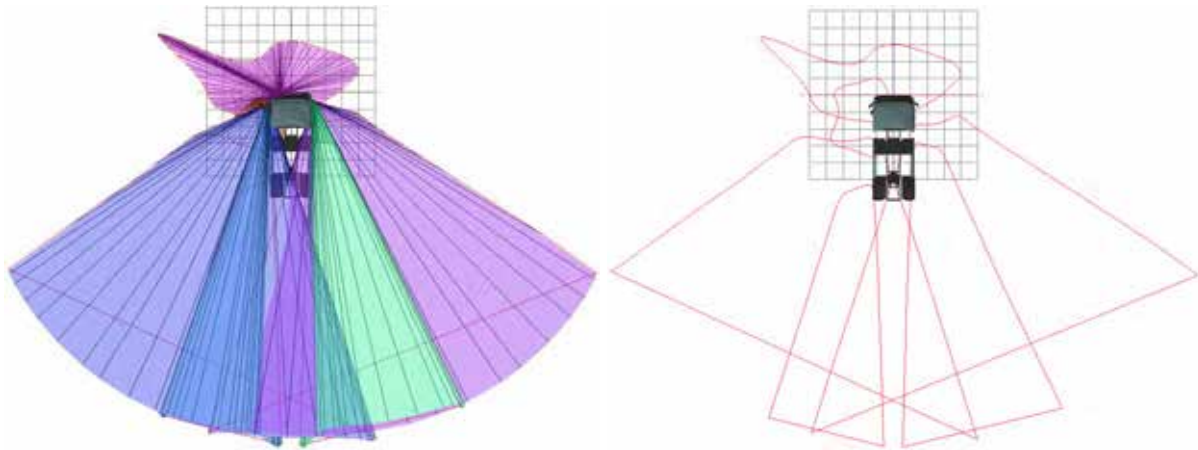


Figure 557. The projection of the mirrors at the ground plane for the Volvo FMX N3G

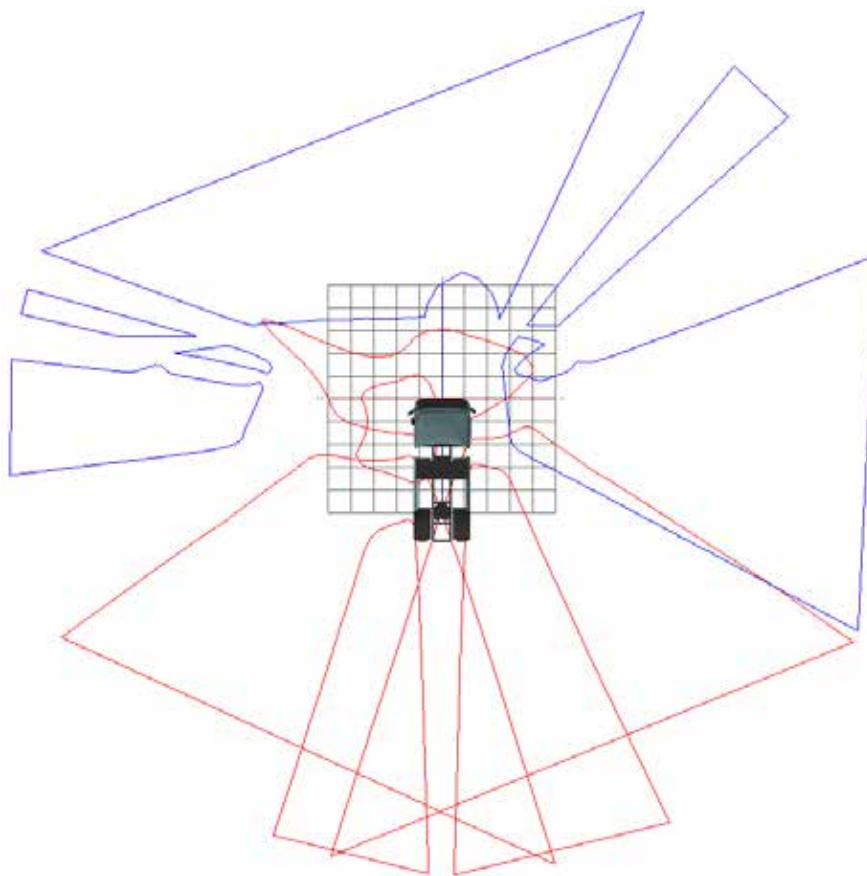


Figure 558. The combined direct and indirect vision projections at the ground plane for the Volvo FMX N3G

Figure 559 through Figure 563 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 564 and Figure 565 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

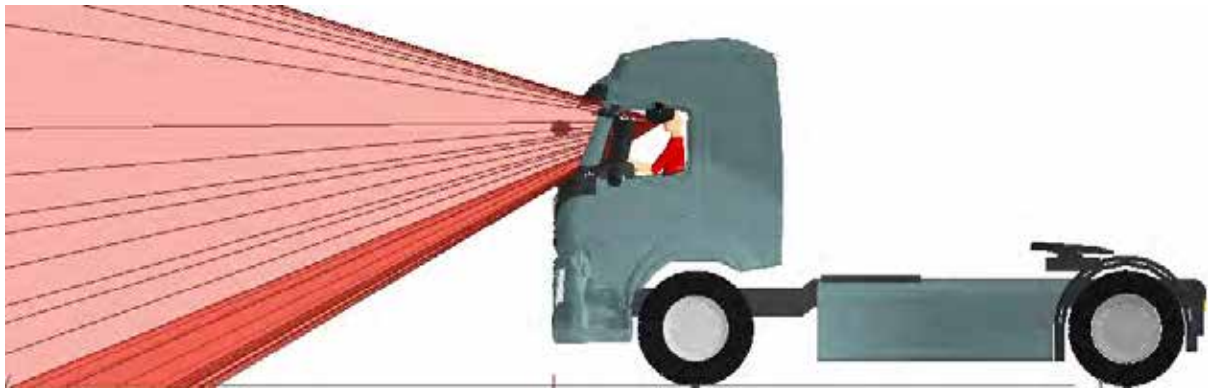


Figure 559. A side view of the windscreen aperture projection for the Volvo FMX N3G



Figure 560. Frontal views of the off side and near side door window projections for the Volvo FMX N3G

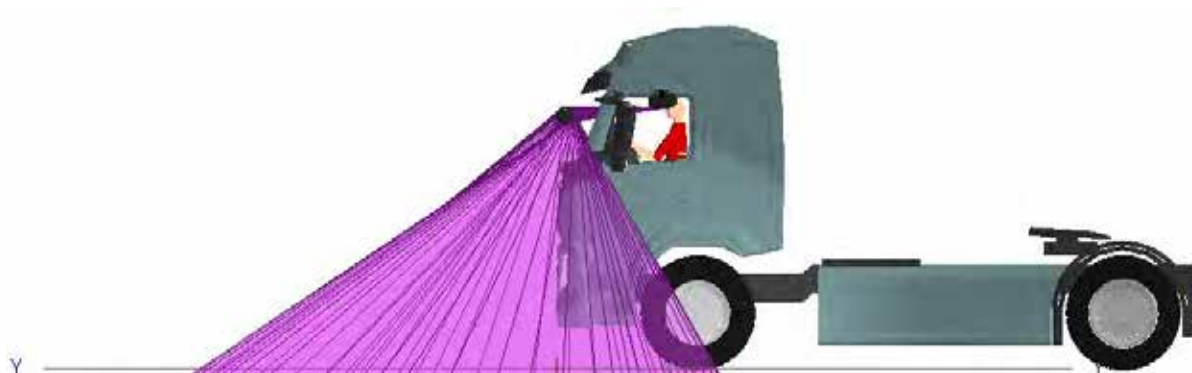


Figure 561. A side view of the Class VI mirror projection for the Volvo FMX N3G



Figure 562. A front view of the Class V mirror projection for the Volvo FMX N3G

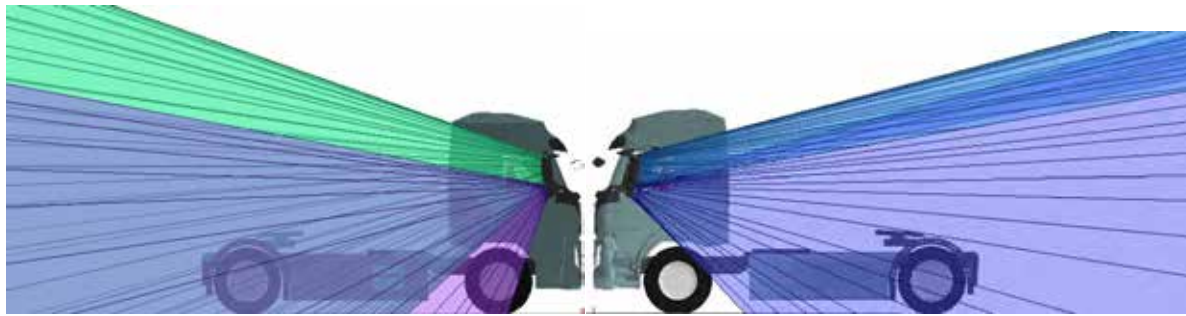


Figure 563. Side views of the combined Class II and Class IV mirror projections for the Volvo FMX N3G

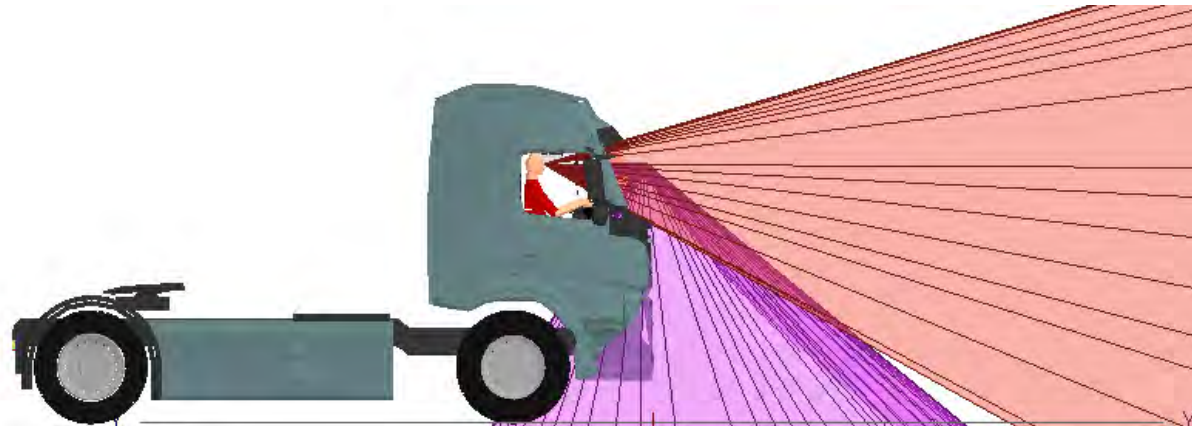


Figure 564. Combined projection of the windscreen and Class VI mirror to the front of the Volvo FMX N3G

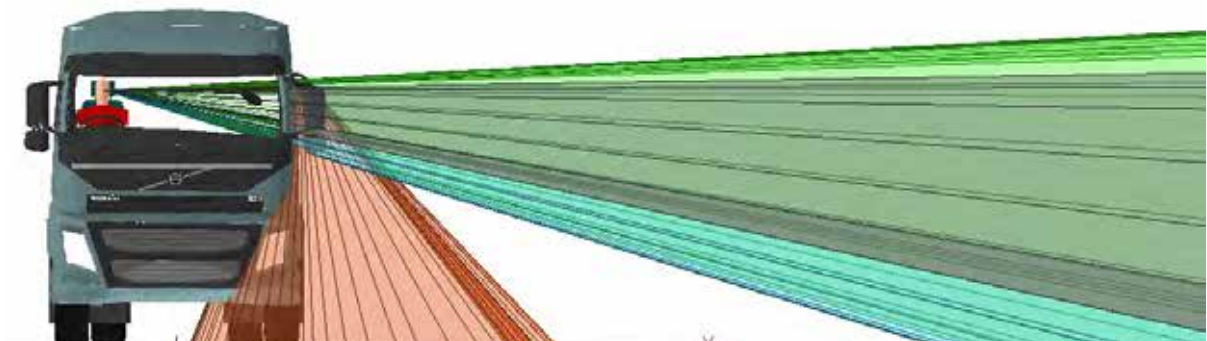


Figure 565. Combined projection of the near side windows and Class V mirror to the side of the Volvo FMX N3G

4.1.17.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 566 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.



Figure 566. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 558. Figure 567 and Figure 568 show that there is space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.

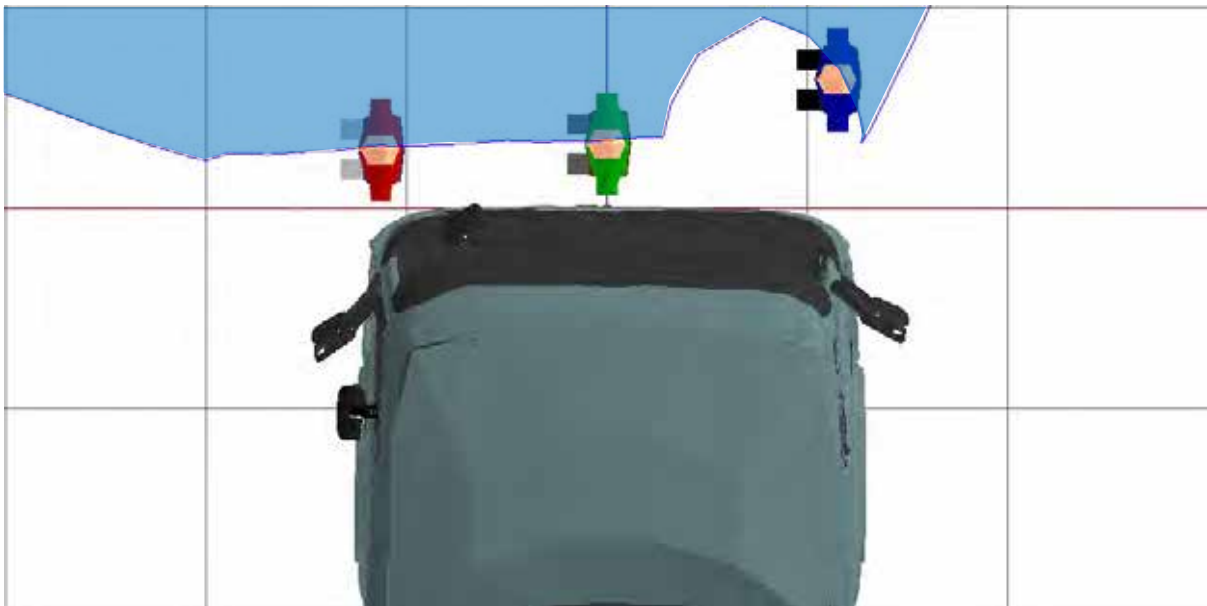


Figure 567. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

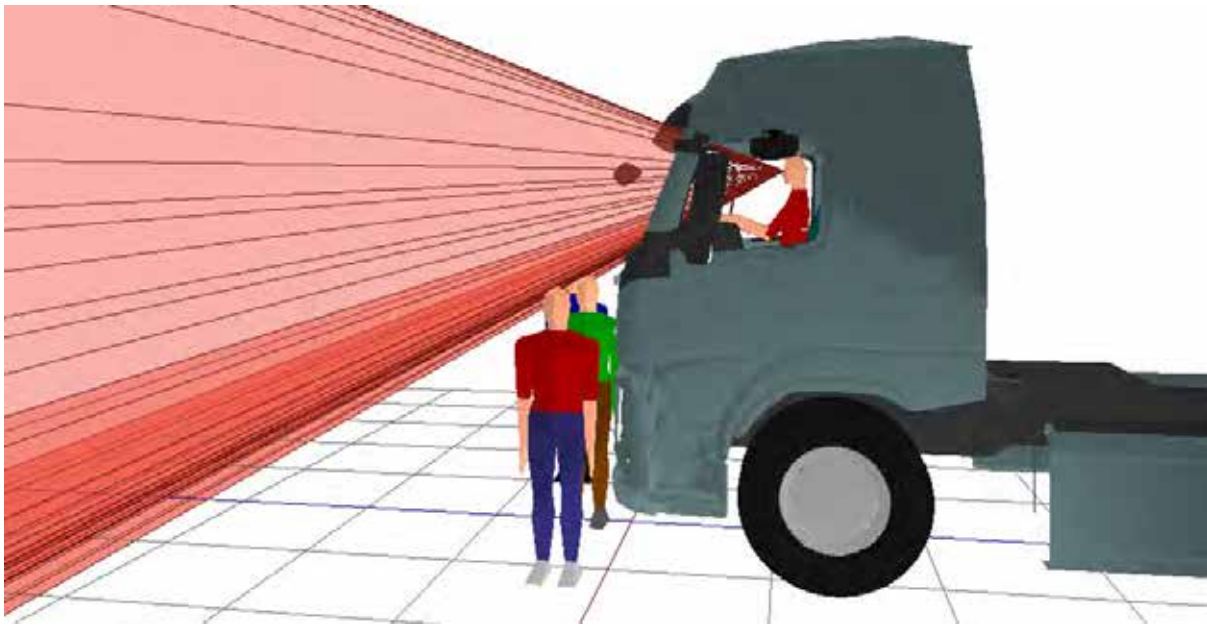


Figure 568. 3D view showing that the three human models can stand 447mm (blue), 71mm (green) and 124mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 569. The view from the driver's eyes shows that all three pedestrians are hidden from view, though the right (blue) pedestrian may be visible through the centre of the steering wheel depending on its design.

For forwards visibility of the pedestrians all three can be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 447mm from the front of the vehicle, the left (red) pedestrian is positioned at 124mm from the front of the vehicle and the central (green) pedestrian is positioned at 71mm from the front of the vehicle. The projections show that it is possible for a pedestrian of 50th %ile UK male height or shorter to be hidden from direct vision in these locations. As with the Volvo FM N3 the greatest obscuration is exacerbated by the steering wheel and affects pedestrians to the front right of the cab. Steering wheel adjustment and the design of the steering wheel itself will impact upon this result. It is also important to note the increase in the blind spot to direct vision due to the increased height of the cab of the Volvo FMX N3G

over the FM N3. The maximum distance has increased from 191mm (see Figure 536) to 447mm from the front of the cab in which a pedestrian can be hidden.

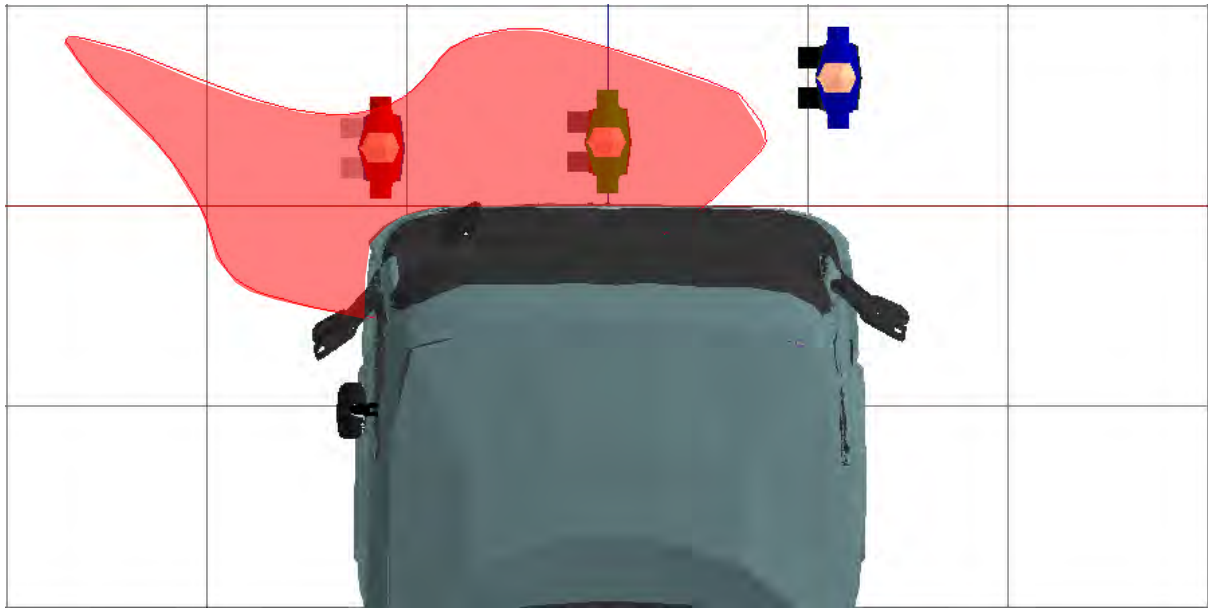


Figure 570. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

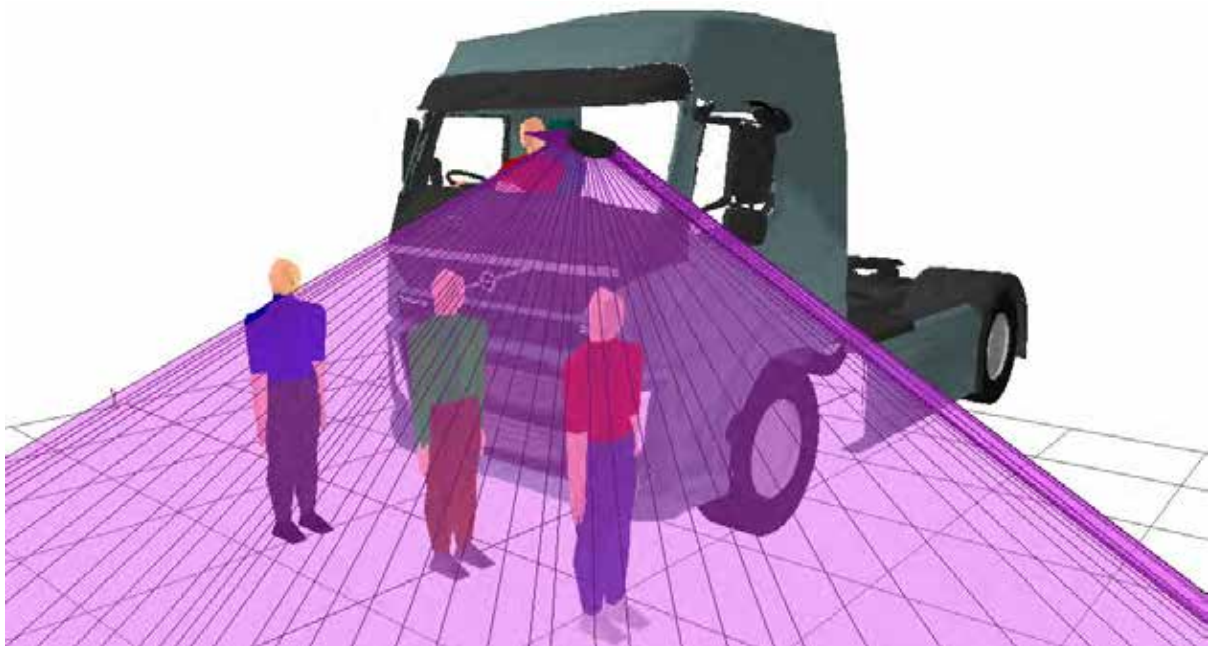


Figure 571. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 571 shows that the pedestrian to the left (red) and centre (green) would be completely visible and the pedestrian to the right (blue) would be visible from the neck down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide the pedestrian models that have been tested to the front of the Volvo FMX N3G.

4.1.17.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST



Figure 572. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

From Figure 572 it is clear that the visible areas at a height representative of a cyclist are closer to the vehicle than those taken at ground level shown in Figure 558. Figure 573, Figure 574 and Figure 575 show that whilst there is a small gap between the offside of the vehicle and the near edges of the visible areas, there is insufficient space in which a cyclist could be hidden from direct view.

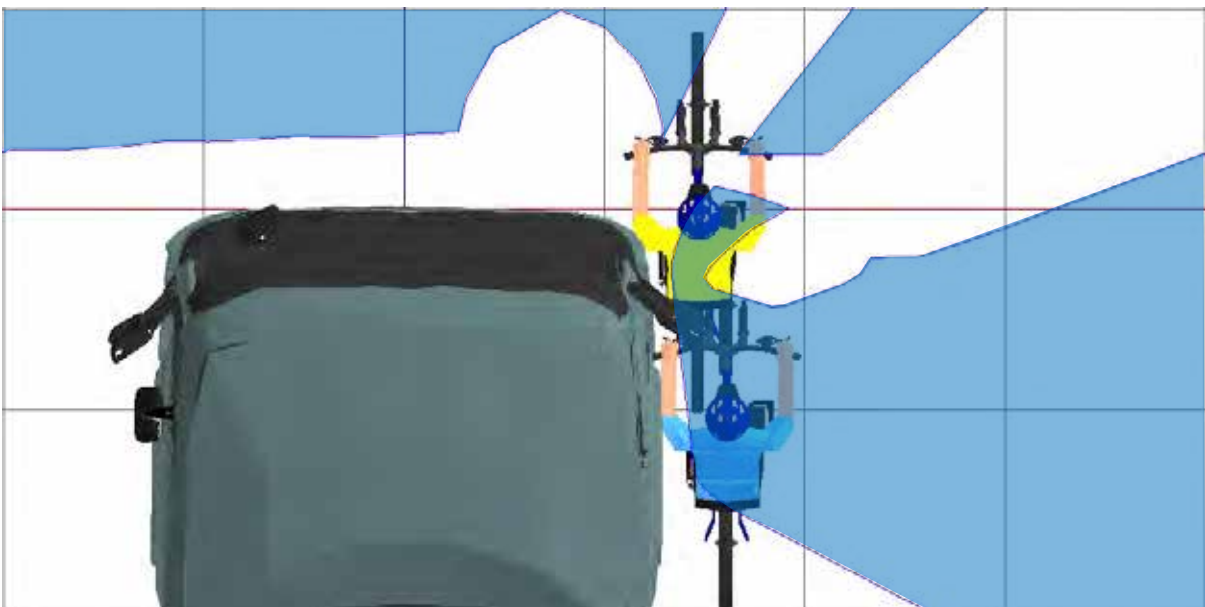


Figure 573. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist

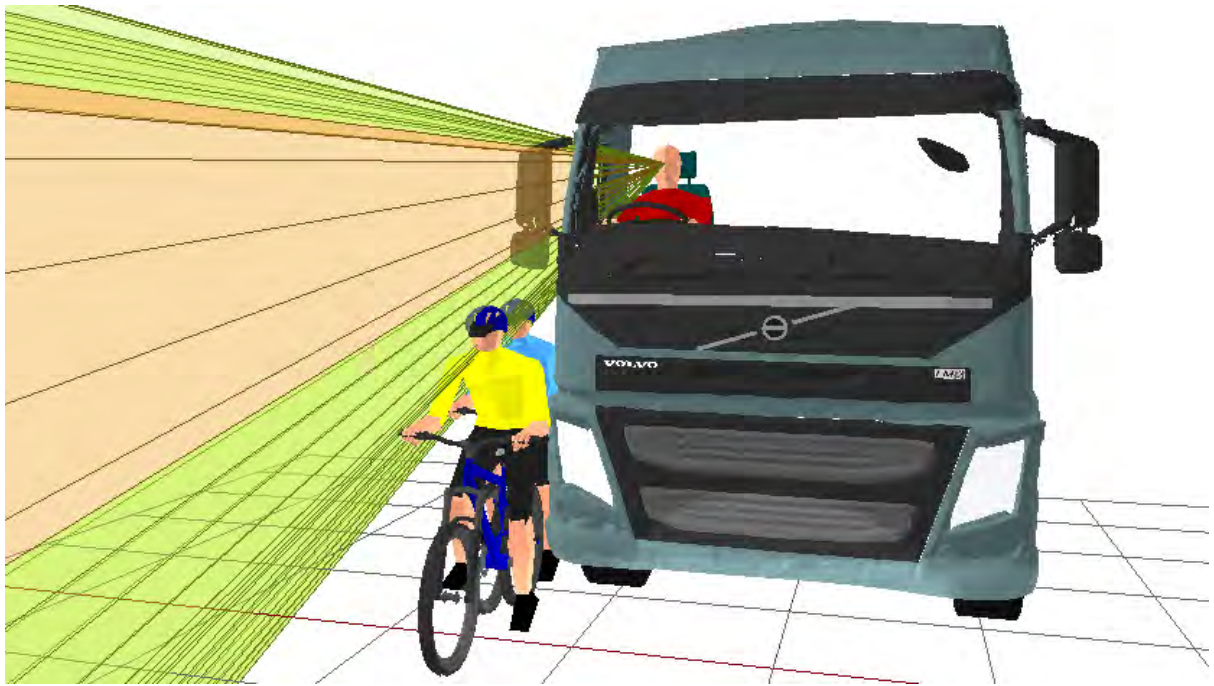


Figure 574. 3D view showing that both cyclists cannot be hidden from direct vision to the offside of the Volvo FMX N3G

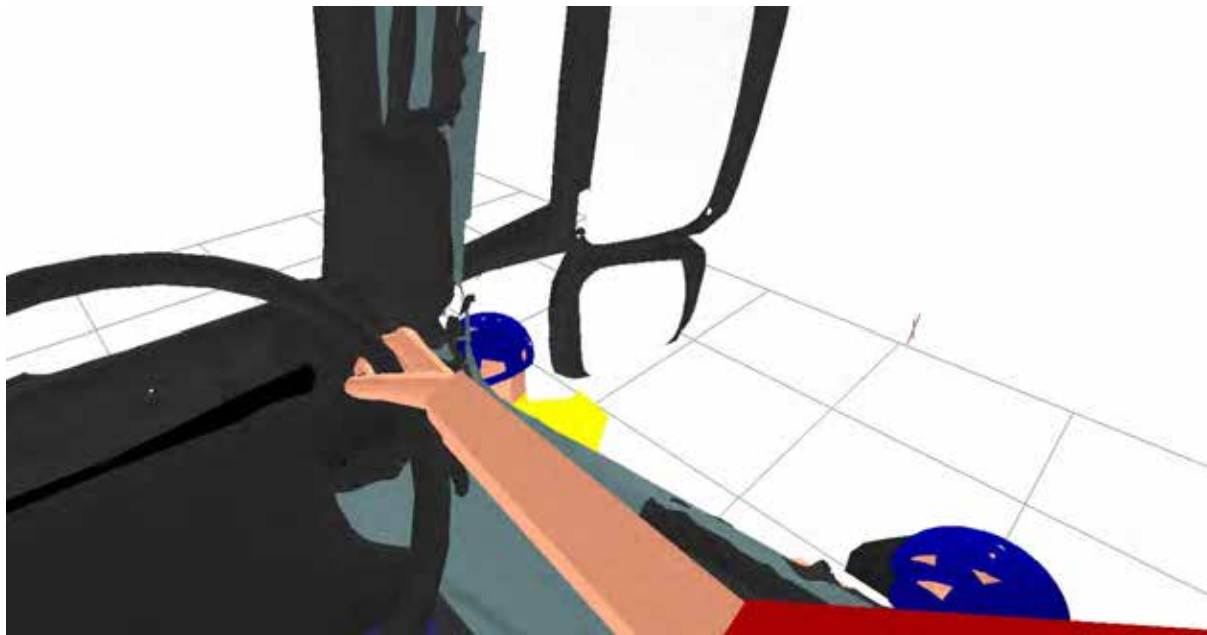


Figure 575. The view from the driver's eyes clearly shows the two cyclists are visible, even when positioned against the side of the vehicle.

For offside visibility of the cyclists there is no blind spot that could obscure a cyclist. Figure 575 shows that even with the cyclists touching the side of the cab they would still be visible to the driver.

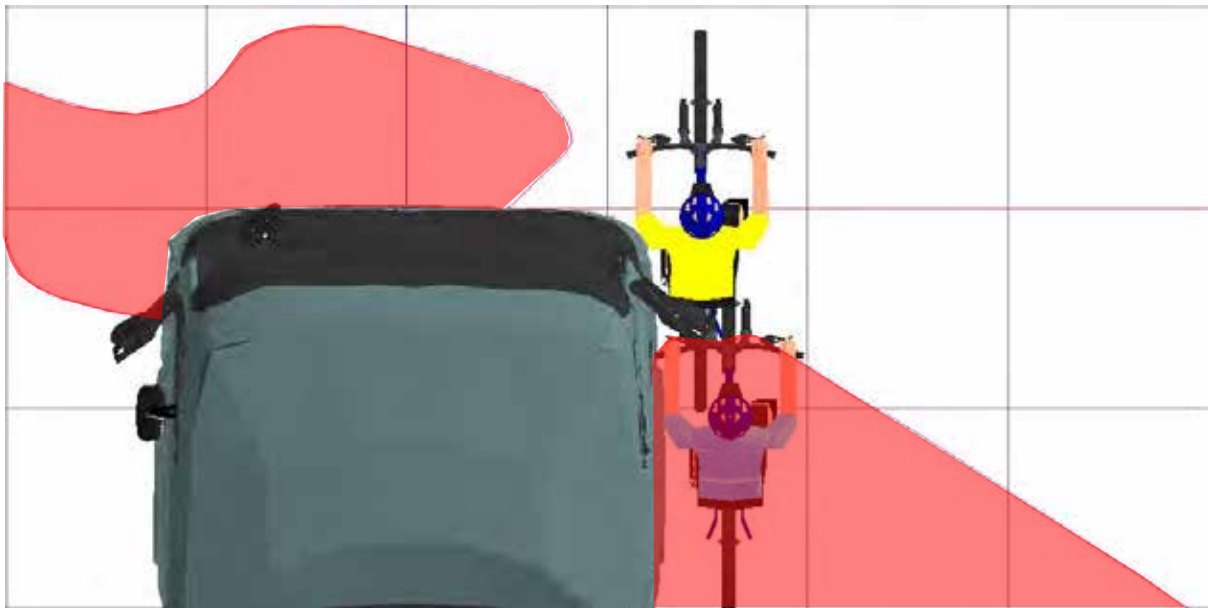


Figure 576. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist



Figure 577. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

In addition to being visible in direct vision the cyclists are also visible in the mirrors. Figure 577 shows that part of the front (yellow) cyclist would also be visible in the Class VI mirror including their left arm, lower legs and the front of the bicycle.

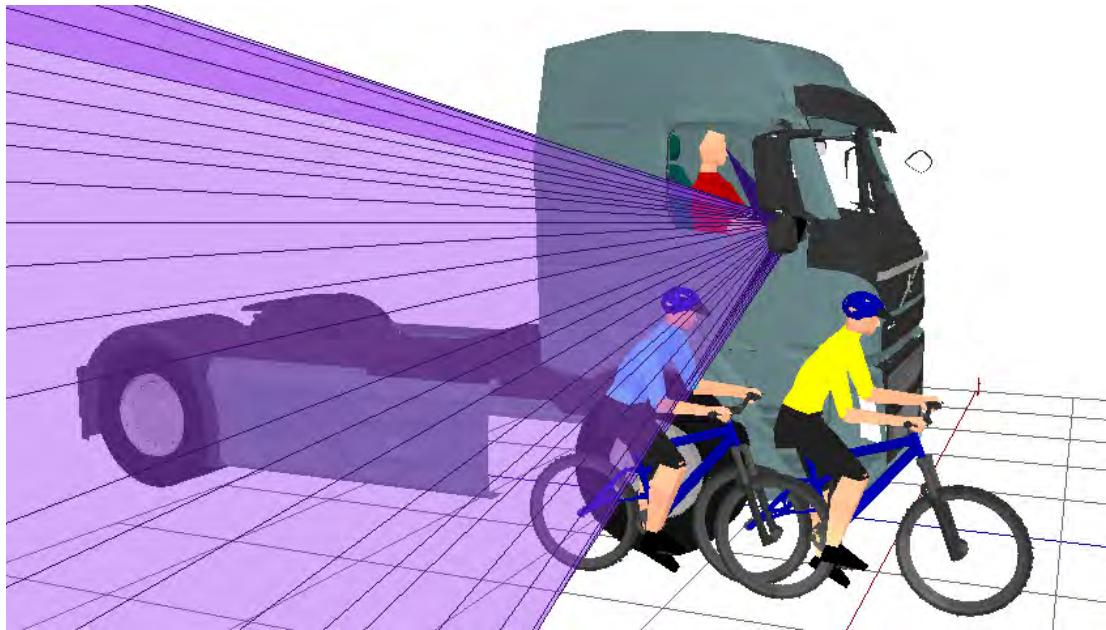


Figure 578. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 578 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and torso, upper arms and thighs. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the offside of the Volvo FMX N3G.

4.1.17.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

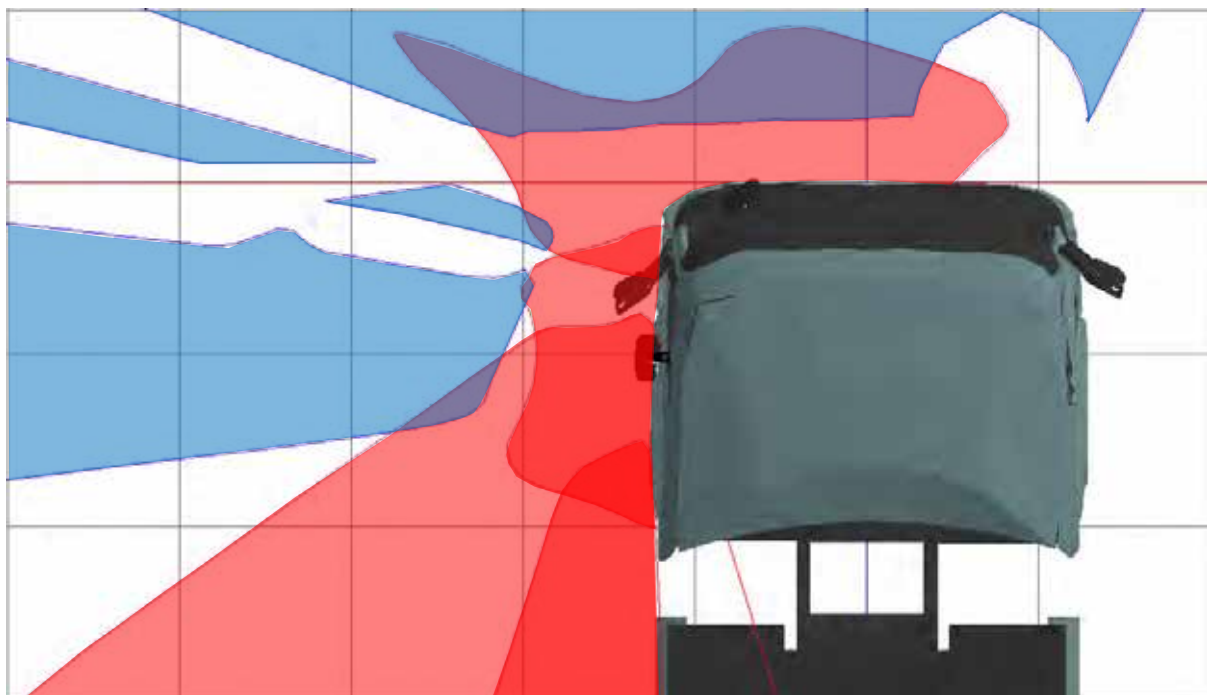


Figure 579. The areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 580 and Figure 581 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

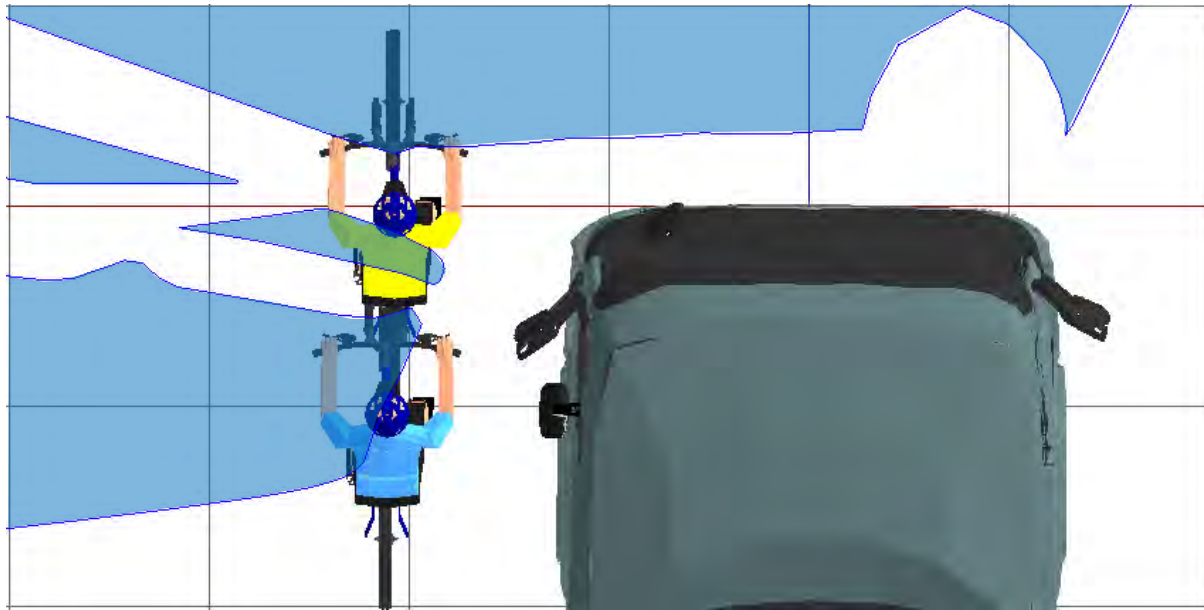


Figure 580. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist



Figure 581. 3D view showing that the two human models can be positioned 462mm (yellow) and 526mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 582. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 462mm from the side of the vehicle, the rear (blue) cyclist is positioned at 526mm from the side of the vehicle. As seen in the forward vision assessment there is an increase in the blind spot to direct vision due to the increased height of the cab of the Volvo FMX N3G over the FM N3. The maximum distance has increased from 354mm (see Figure 549) to 526mm from the side of the cab in which a cyclist can be hidden.



Figure 583. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

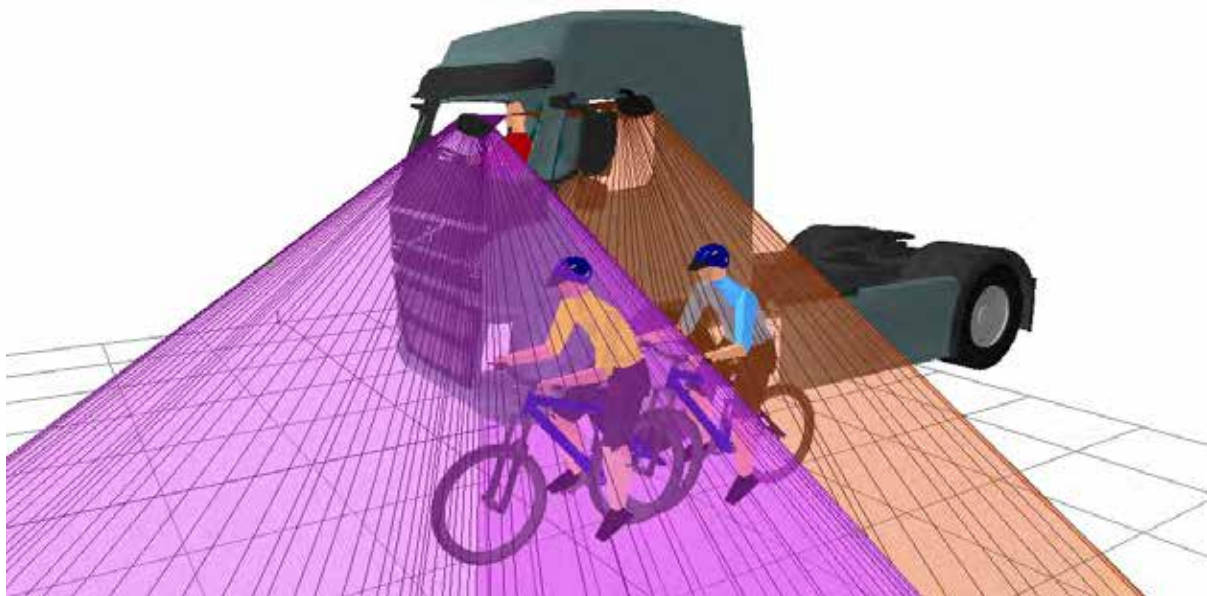


Figure 584. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 584 shows that both are visible in the Class V and Class VI mirrors. The front (yellow) cyclist is completely visible in the Class VI mirror and from the chest down in the Class V mirror. The rear (blue) cyclist's front wheel is visible in the Class VI and visible from the neck down in the Class V mirror.

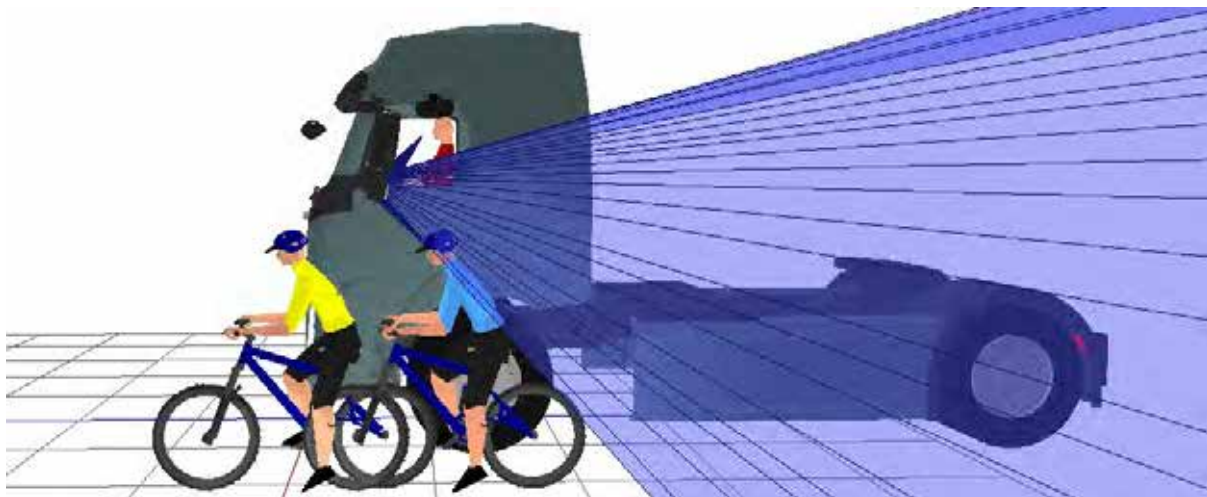


Figure 585. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is visible in the projection of the Class IV mirror

Figure 585 shows that the rear of the two cyclists (blue) is also visible in the projection of the nearside Class IV mirror. The cyclist would only be partially visible including part of the head, back of the torso of the rider. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the nearside of the Volvo FMX N3G.

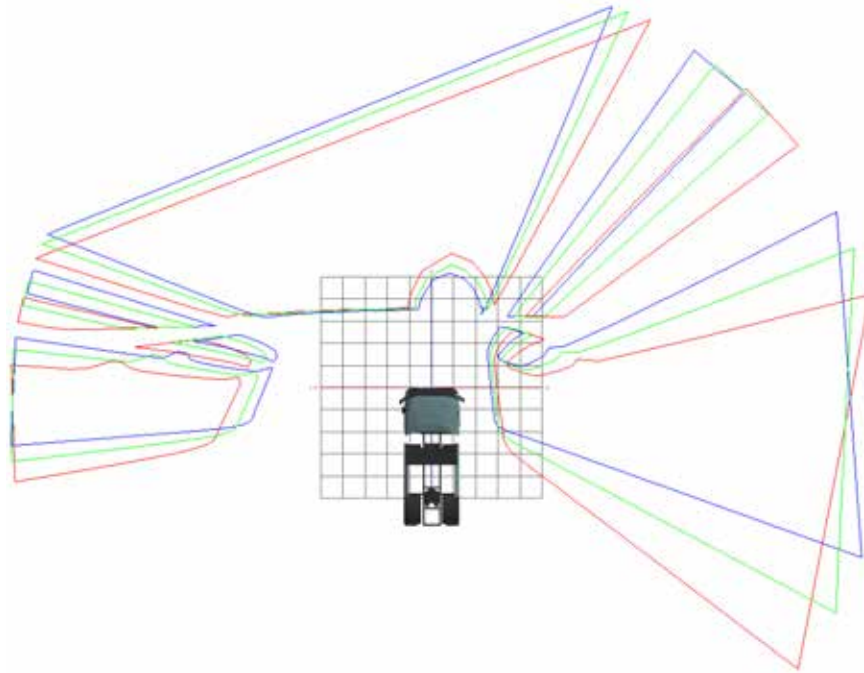
4.1.17.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

Figure 586. A plan view of the projection of the windscreen and side windows onto the ground plane for the Volvo FMX N3G for a range of driver eye positions. Red=smallest driver (5th %ile UK female stature), Green=average sized driver (50th %ile UK male stature), and Blue=tallest driver (95th %ile UK male stature).

4.1.18 VOLVO FH N3 DISTRIBUTION - 50TH %ILE MALE DRIVER



Figure 587. Evaluation model of Volvo FH N3 Distribution variant vehicle

4.1.18.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 588 shows a top-down view of all of the window projections for the Volvo FH N3 cab with a 50th %ile UK Male Driver. The image on the right of Figure 588 shows the areas of these projections that intersect with the ground. Figure 589 shows the same for the the mirror projections and Figure 590 shows the two combined. In this case the projections have been clipped to a radius of twenty metres. Any area outside of the coloured projections, within that twenty metre radius, is effectively a blind spot at the ground plane.

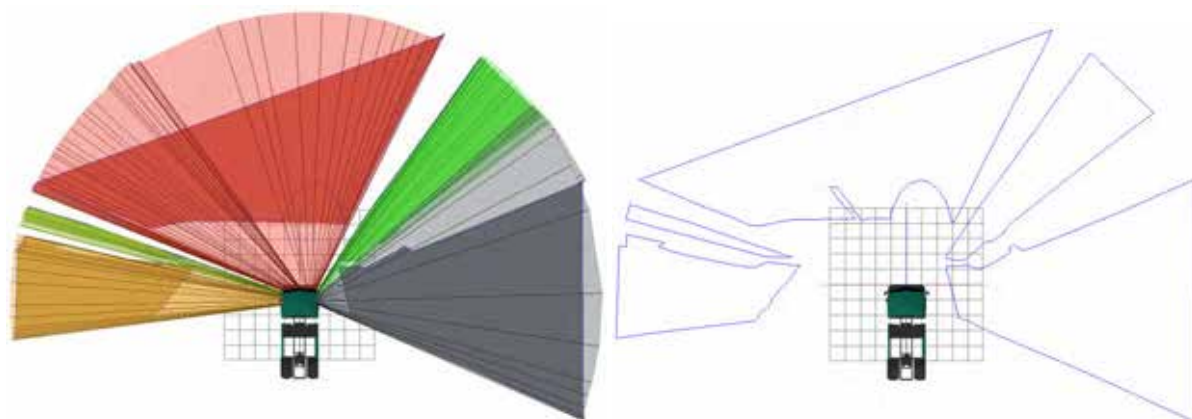


Figure 588. The projection of the windscreen and window apertures at the ground plane for the Volvo FH N3

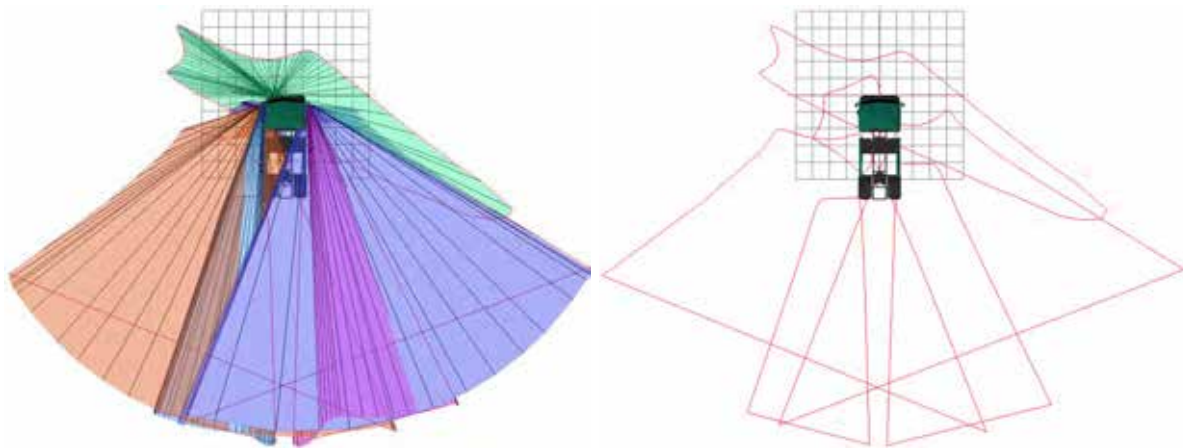


Figure 589. The projection of the mirrors at the ground plane for the Volvo FH N3

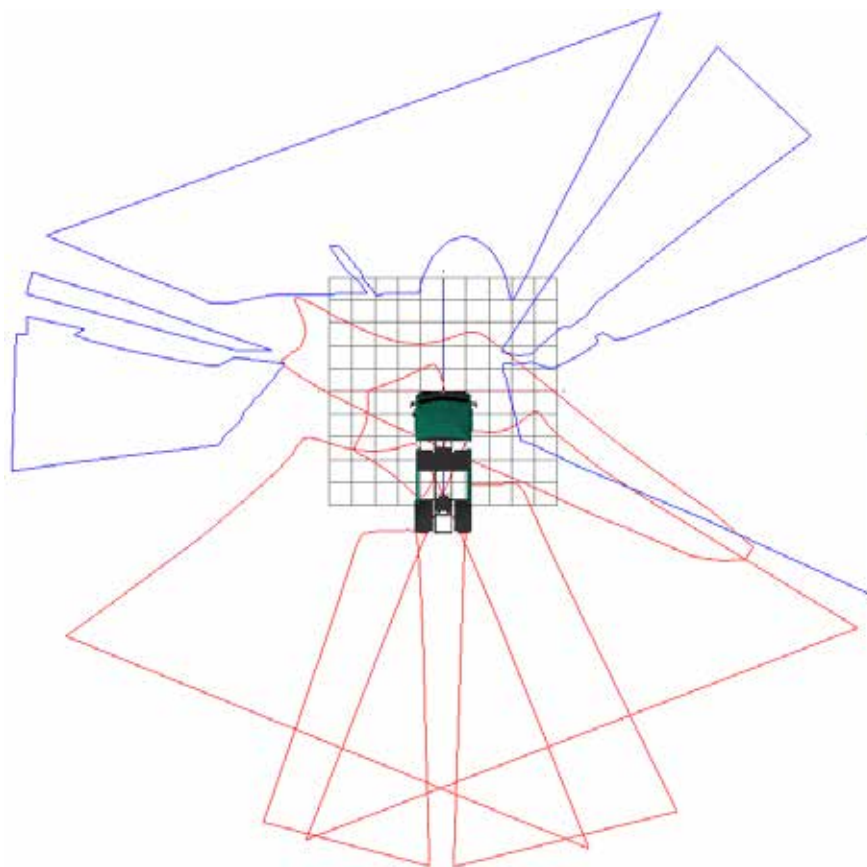


Figure 590. The combined direct and indirect vision projections at the ground plane for the Volvo FH N3

Figure 591 through Figure 595 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 596 and Figure 597 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.



Figure 591. A side view of the windscreen aperture projection for the Volvo FH N3



Figure 592. Frontal views of the off side and near side door window projections for the Volvo FH N3

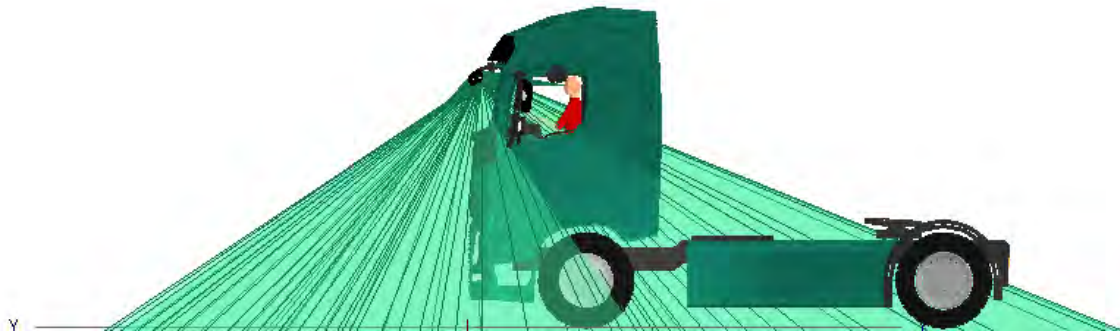


Figure 593. A side view of the Class VI mirror projection for the Volvo FH N3



Figure 594. A front view of the Class V mirror projection for the Volvo FH N3



Figure 595. Side views of the combined Class II and Class IV mirror projections for the Volvo FH N3

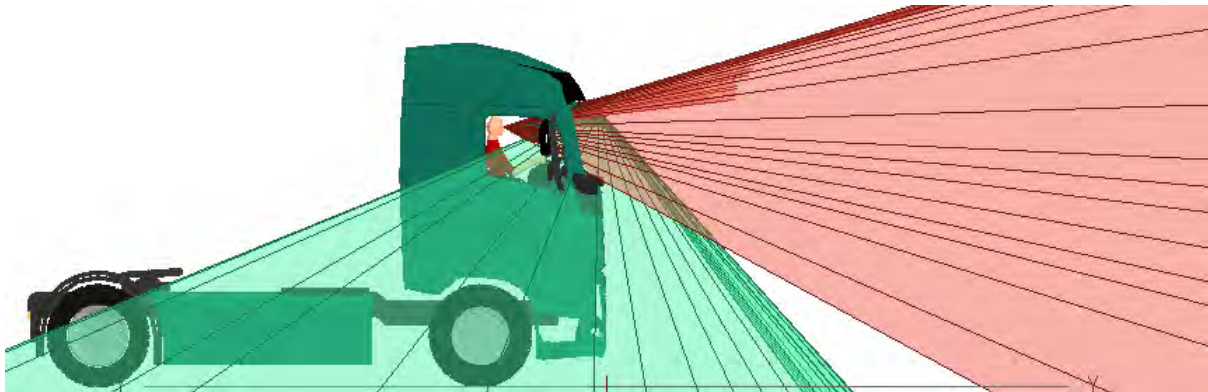


Figure 596. Combined projection of the windscreen and Class VI mirror to the front of the Volvo FH N3

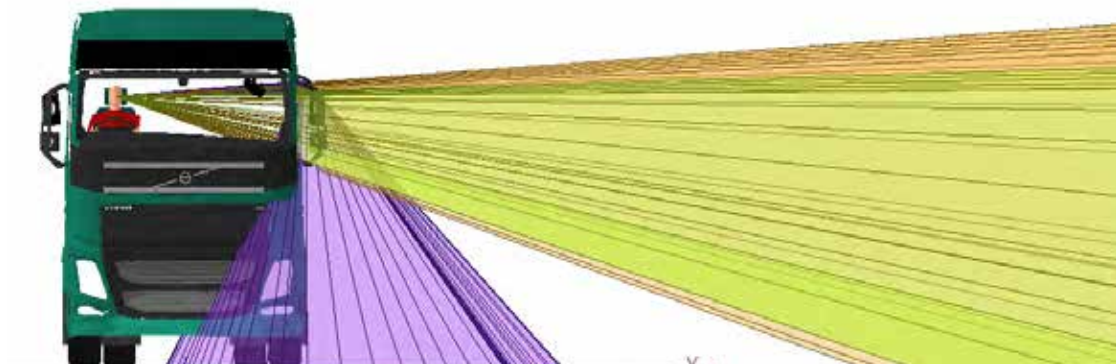


Figure 597. Combined projection of the near side windows and Class V mirror to the side of the Volvo FH N3

4.1.18.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 598 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.

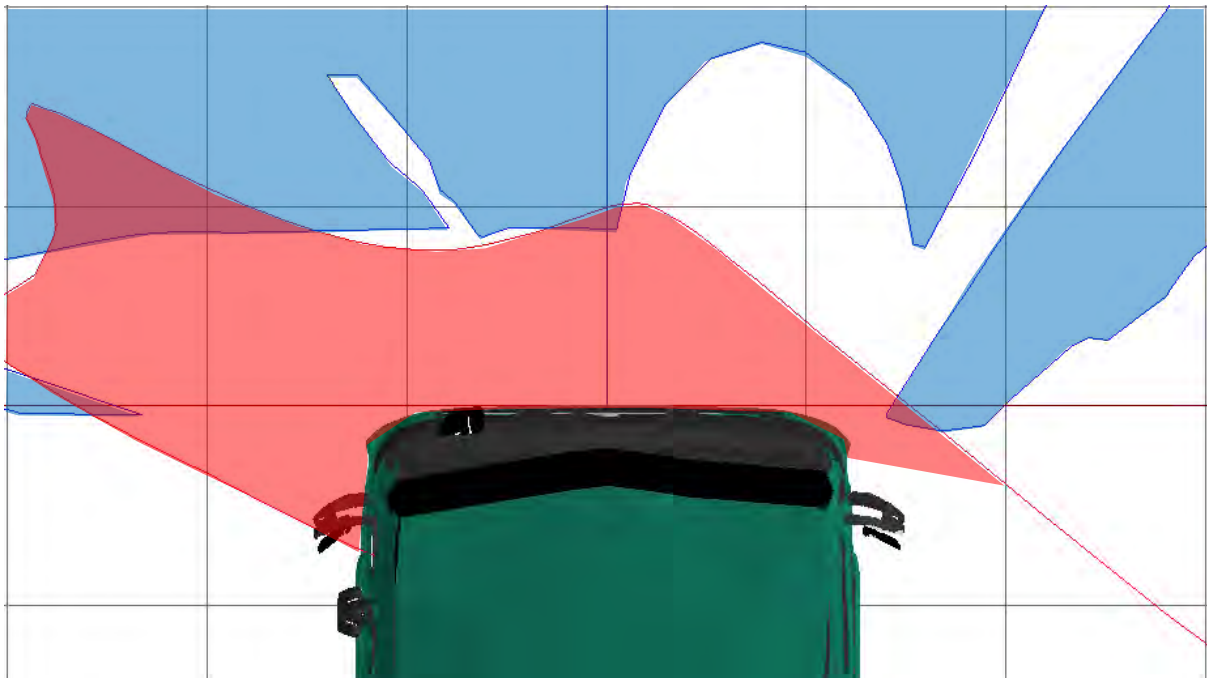


Figure 598. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 590. However Figure 599 and Figure 600 show that there is a clear space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.

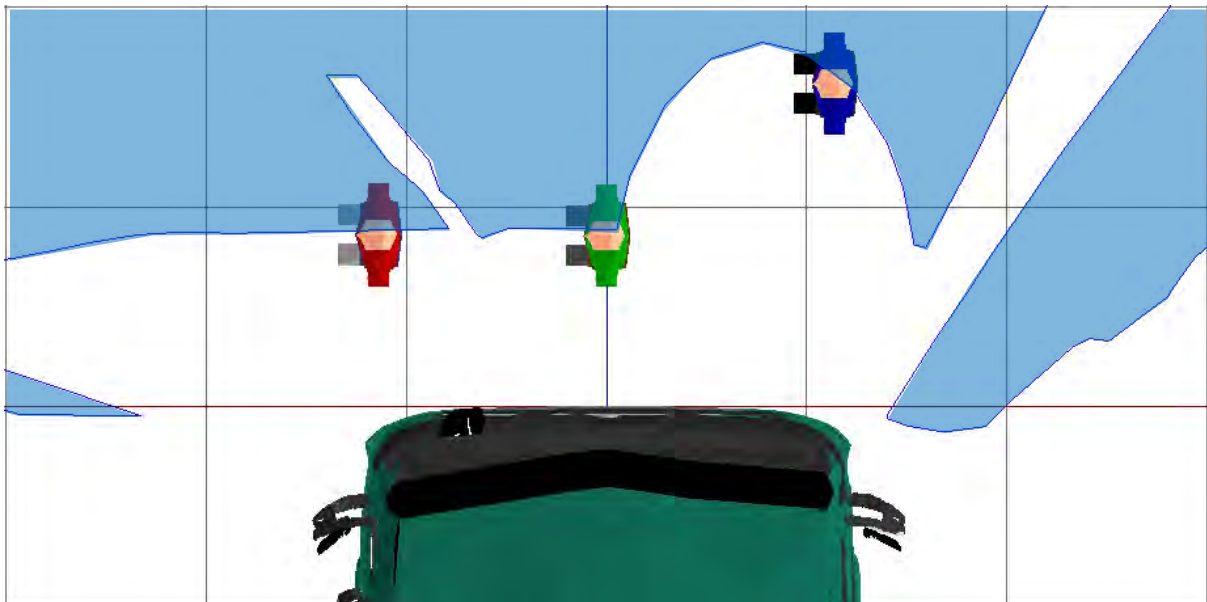


Figure 599. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

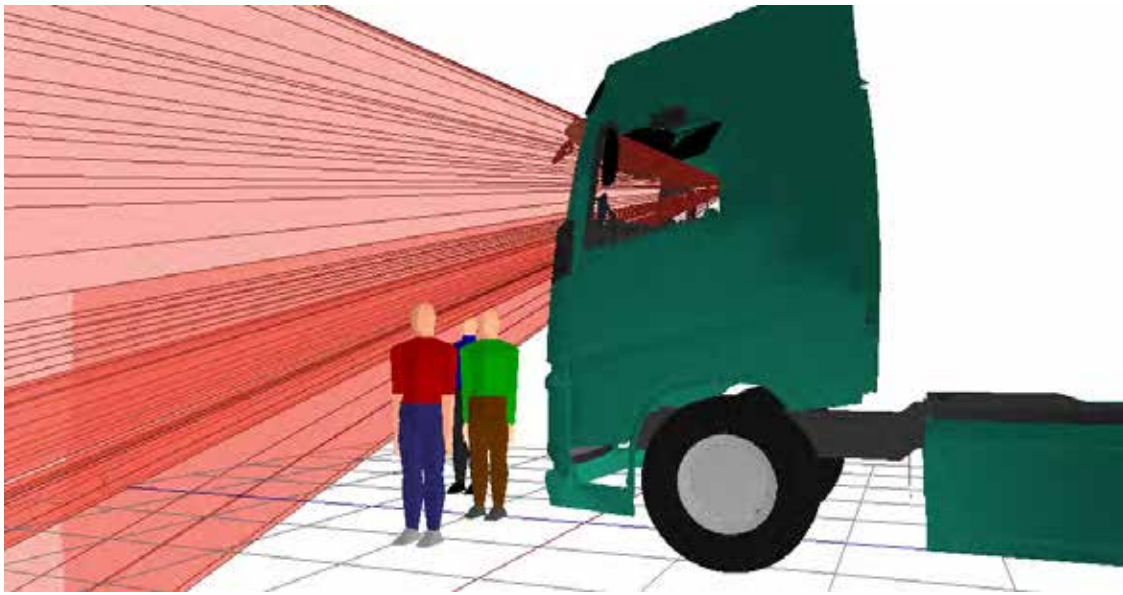


Figure 600. 3D view showing that the three human models can stand 1404mm (blue), 621mm (green) and 652mm (red) in front of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 601. The view from the driver's eyes shows that all three pedestrians are hidden from view, though the right (blue) pedestrian may be visible through the centre of the steering wheel depending on its design.

For forwards visibility of the pedestrians all three can be hidden from the driver's direct vision. The right (blue) pedestrian is positioned at 1404mm from the front of the vehicle, the left (red) pedestrian is positioned at 652mm from the front of the vehicle and the central (green) pedestrian is positioned at 621mm from the front of the vehicle. The greatest obscuration is exacerbated by the steering wheel and affects pedestrians to the front right of the cab. Steering wheel adjustment and the design of the steering wheel itself will impact upon this result. The projections show that it is clearly possible for a pedestrian of 50th %ile UK male height or shorter to be hidden from direct vision in these locations.

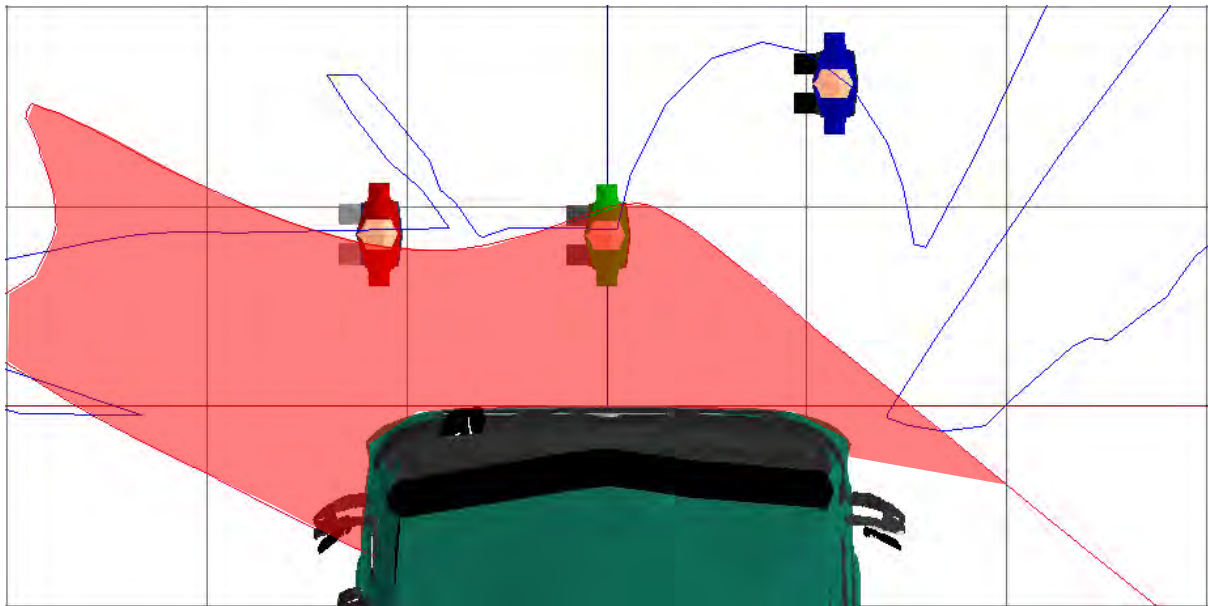


Figure 602. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

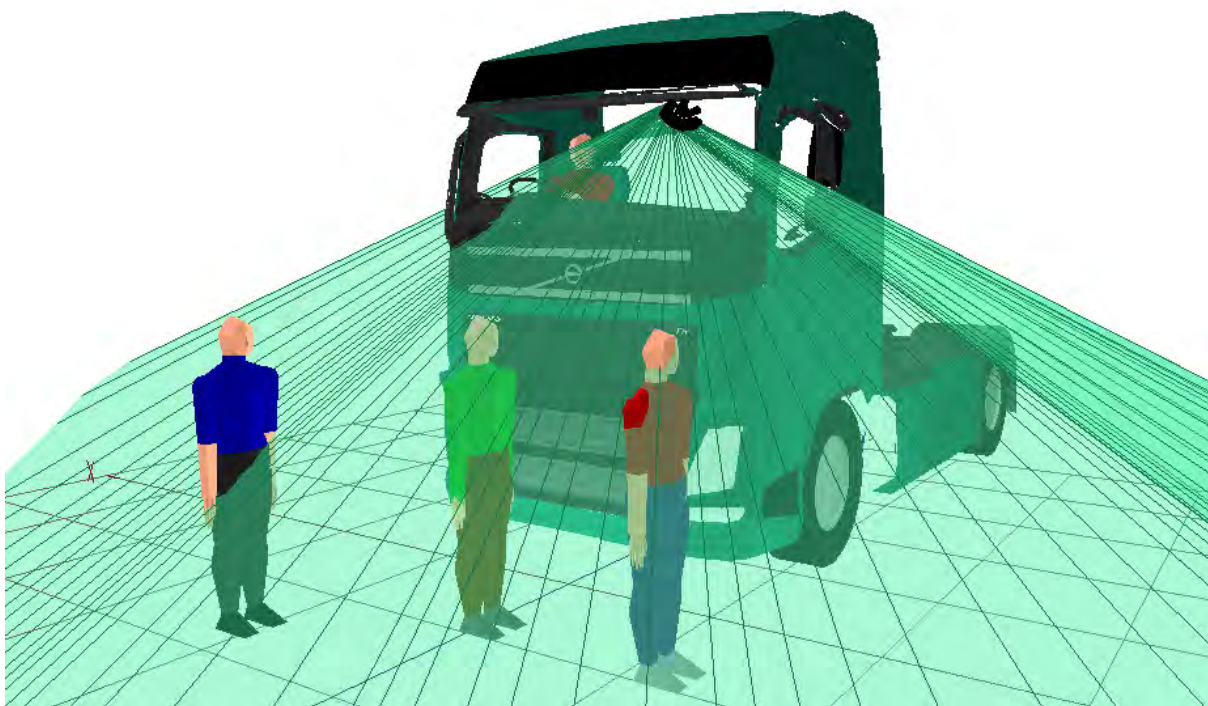


Figure 603. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

Though the three pedestrians can be hidden from direct view to the front of the vehicle all three are visible in the Class VI mirror. Figure 603 shows that the pedestrian to the centre (green) would be completely visible, the pedestrian to the left (red) would be visible all bar the top of their head, and the pedestrian to the right (blue) would be visible from the waist down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide the pedestrian models that have been tested to the front of the Volvo FH N3.

4.1.18.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

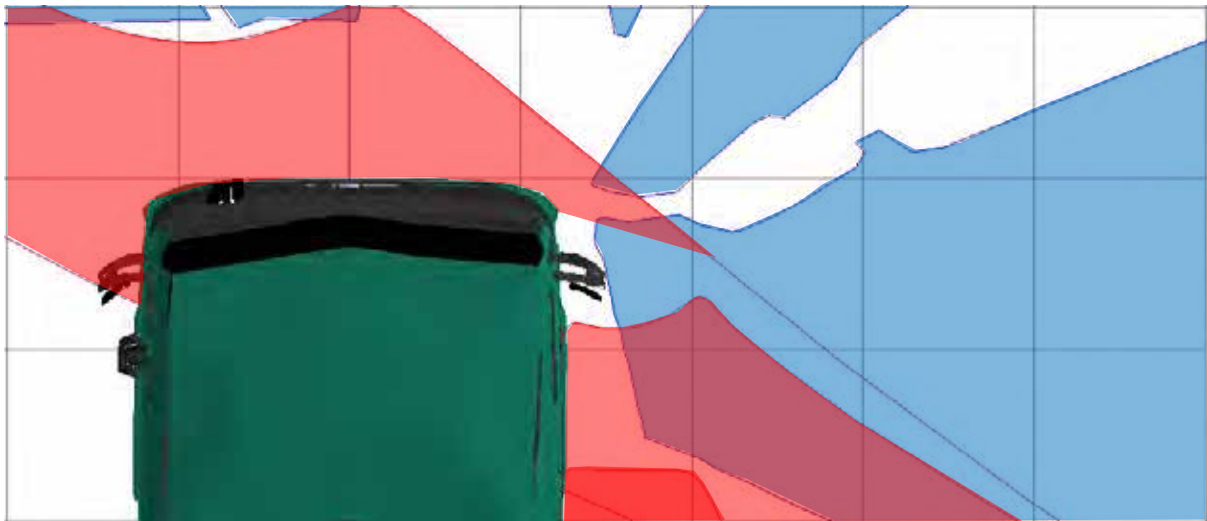


Figure 604. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

From Figure 604 it is clear that the visible areas at a height representative of a cyclist are closer to the vehicle than those taken at ground level shown in Figure 590. Figure 605, Figure 606 and Figure 607 show that it is just not possible to hide a cyclist from direct vision.

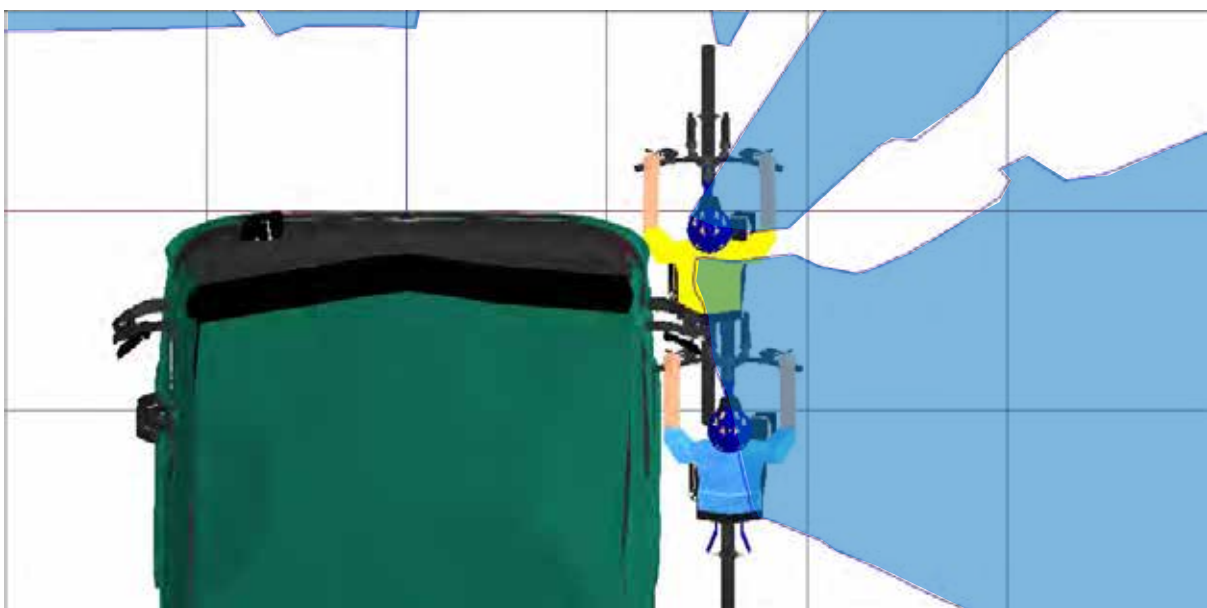


Figure 605. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist

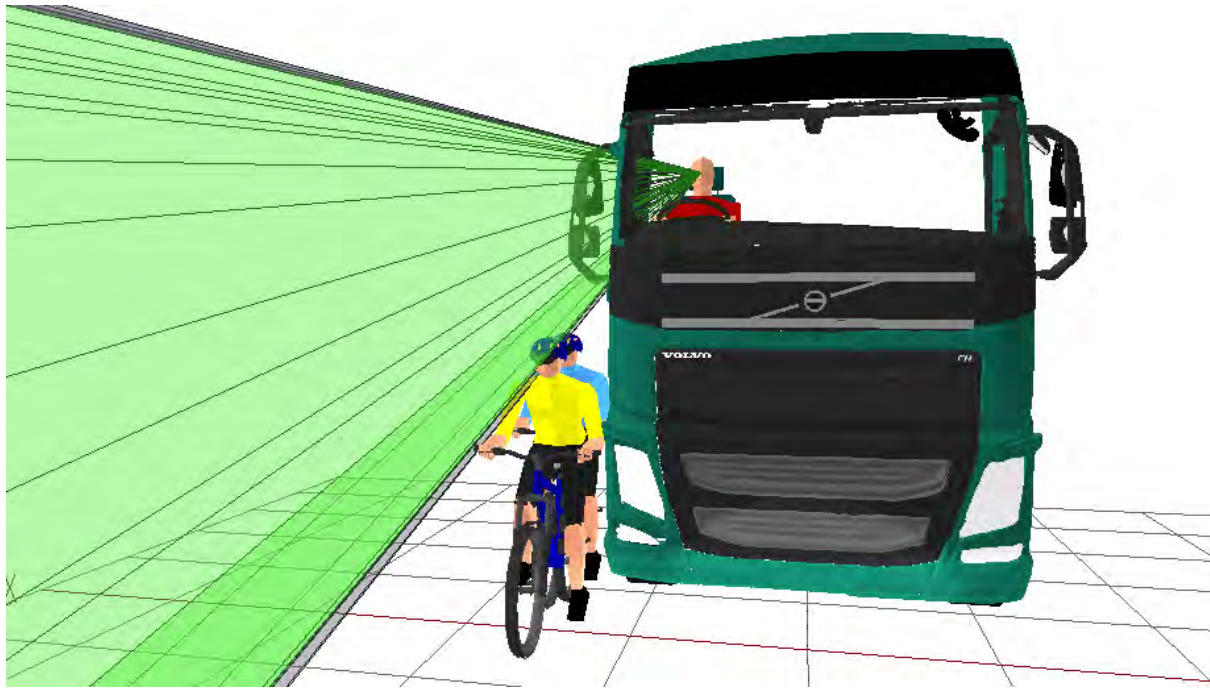


Figure 606. 3D view showing that both cyclists cannot be hidden from direct vision to the offside of the Volvo FH N3

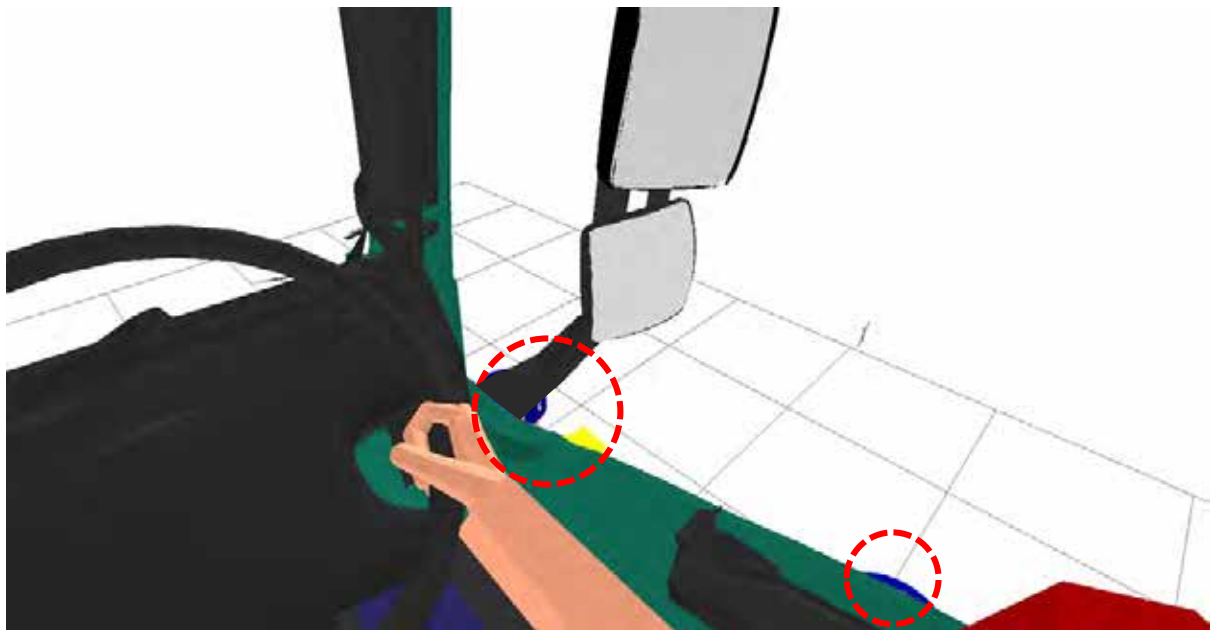


Figure 607. The view from the driver's eyes clearly shows the two cyclists are just visible, even when positioned against the side of the vehicle.

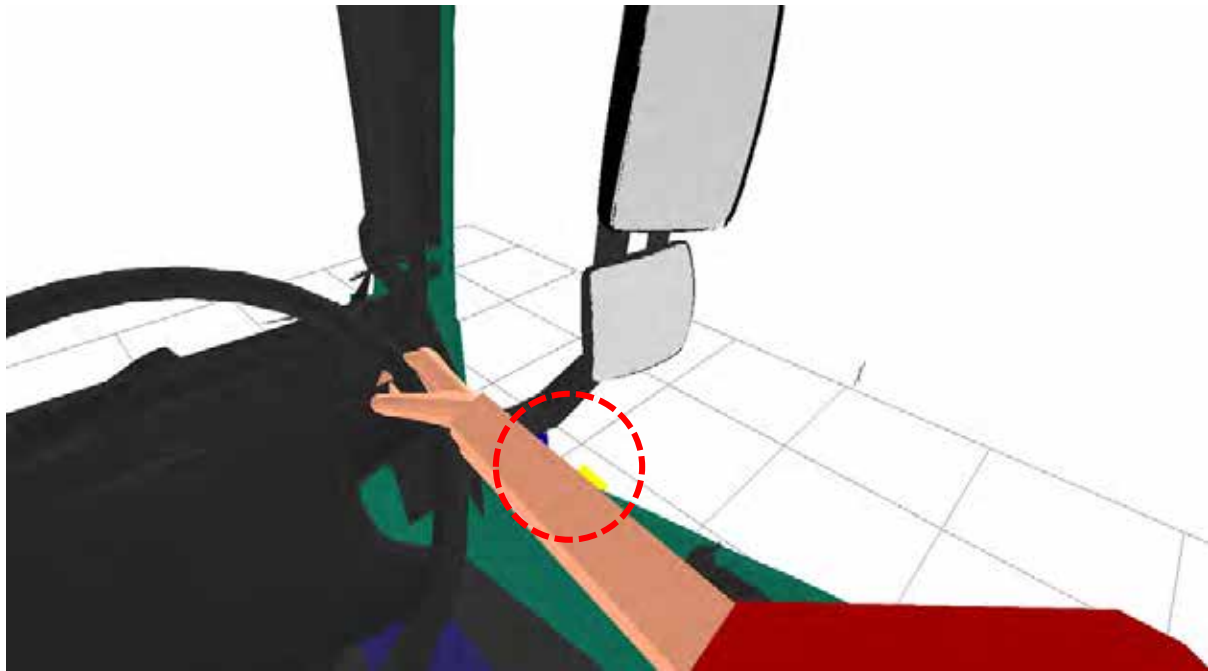


Figure 608. The view from the driver's eyes shows that whilst the cyclists should be visible the driver's own arm may obscure the view.

For offside visibility of the cyclists there is no blind spot that could obscure a cyclist. Figure 607 shows that even with the cyclists touching the side of the cab they would still be visible to the driver. However, Figure 608 also shows that the driver's own arm in the standard driving posture may obscure the view of the cyclists. Whilst it is important to recognise this potential issue, it is unlikely that a cyclist would get so close to the cab and a cyclist positioned at a more realistic distance away would be clearly visible.



Figure 609. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

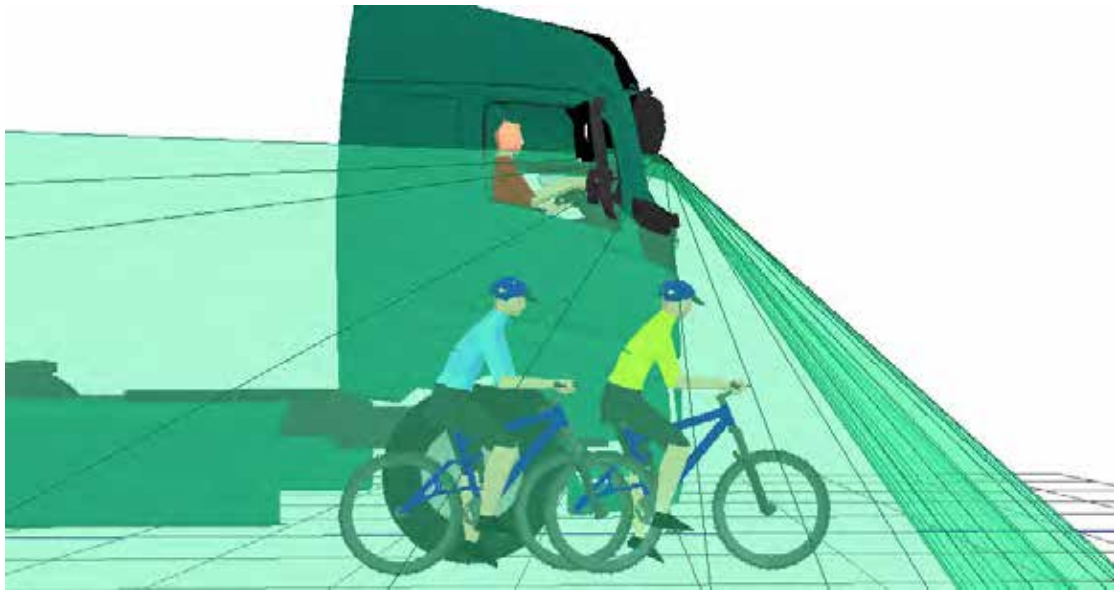


Figure 610. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

In addition to the two cyclists being visible through direct vision to the offside of the vehicle both are also visible in the Class IV and Class VI mirrors. Figure 610 shows that theoretically both cyclists are also visible in the Class VI mirror. However, due to limitations of the projection technique, the rear cyclist (blue) would actually be hidden from view by the cab of the vehicle. Part of the front (yellow) cyclist would be visible in the Class VI mirror including their arms and the front of the bicycle.

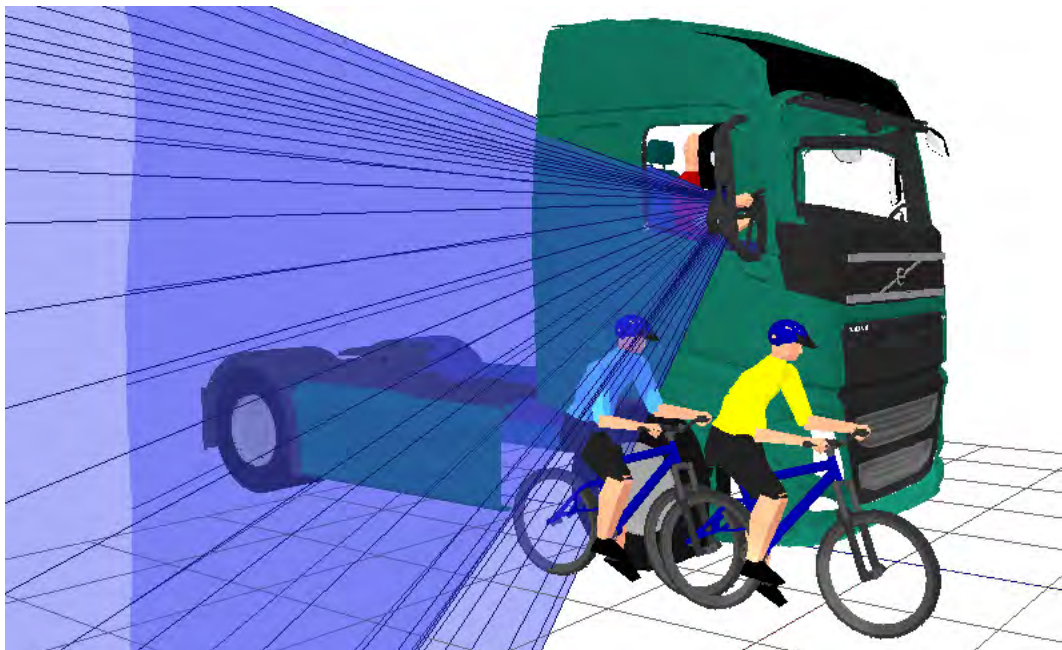


Figure 611. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 611 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and upper body. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the offside of the Volvo FH N3.

4.1.18.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

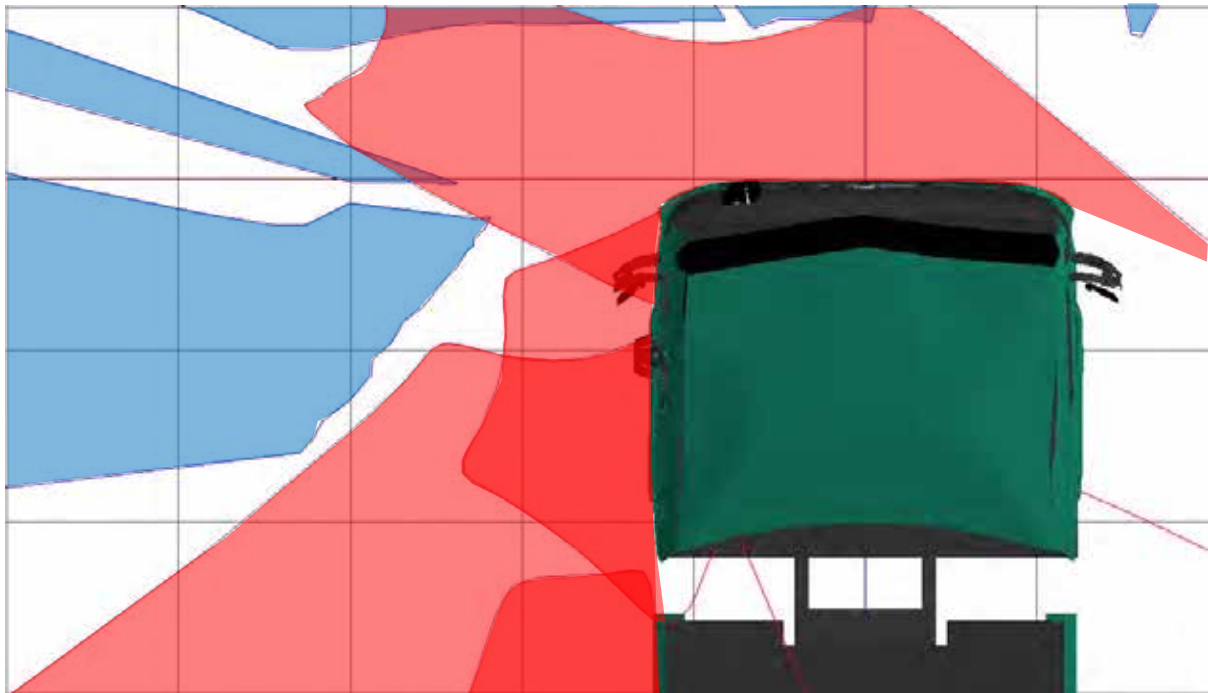


Figure 612. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 613 and Figure 614 show that there is a clear space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

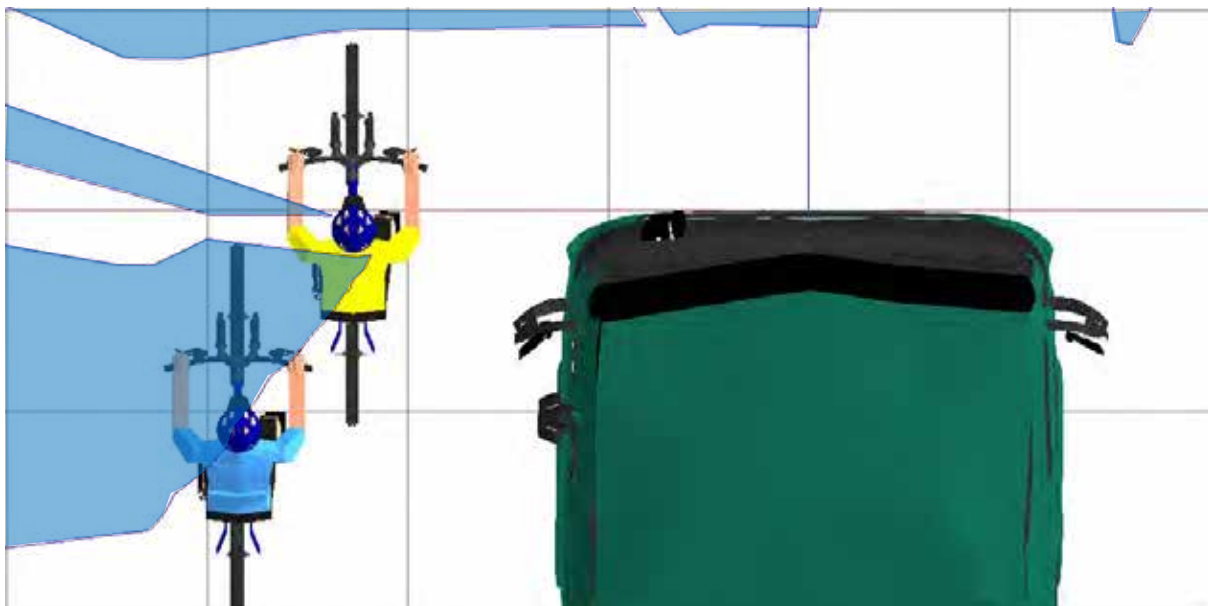


Figure 613. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

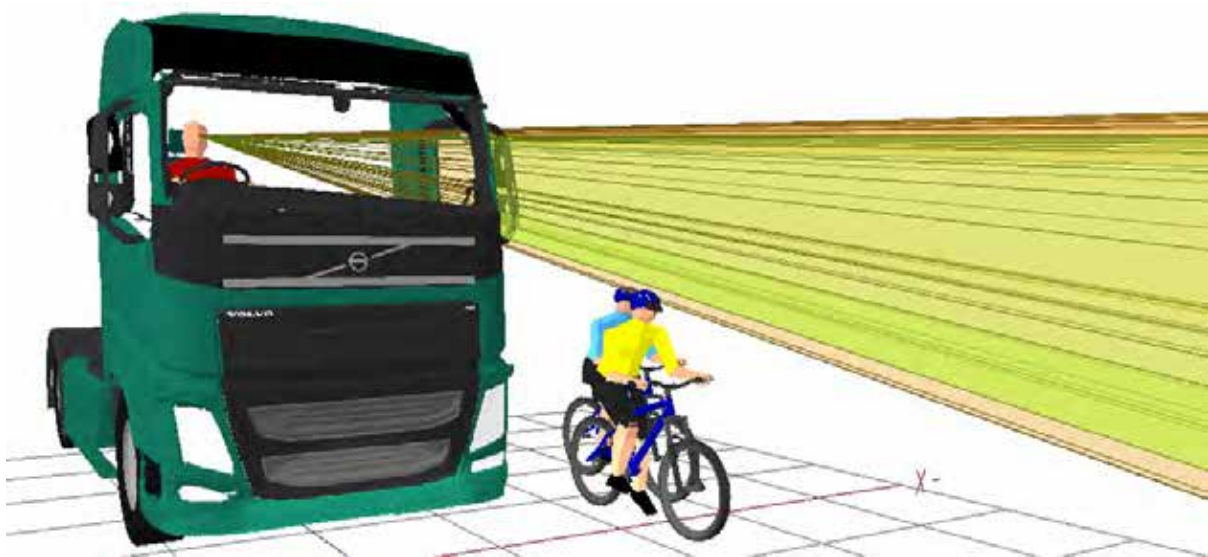


Figure 614. 3D view showing that the two human models can be positioned 725mm (yellow) and 1255mm (blue) to the side of the vehicle without being seen through direct vision by the driver in the standardised driving posture



Figure 615. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility of the cyclists both can be hidden from the driver's direct vision. The front (yellow) cyclist is positioned at 725mm from the side of the vehicle, the rear (blue) cyclist is positioned at 1255mm from the side of the vehicle. The additional height of the cab makes the blind spot in direct vision significantly greater than that seen for the Volvo FM and FMX.

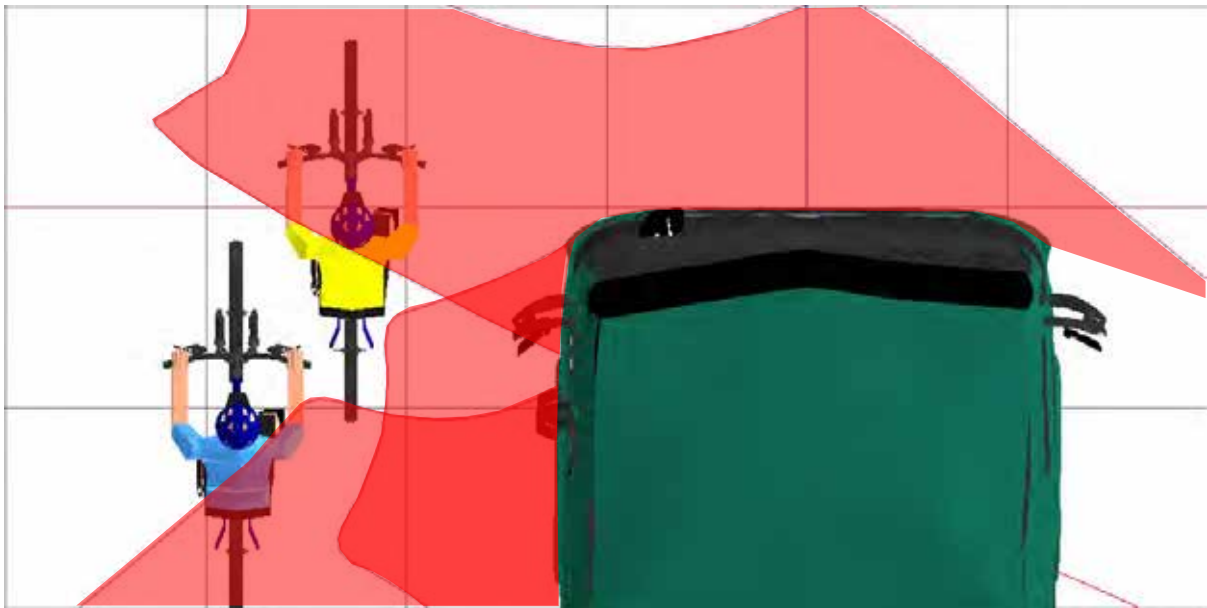


Figure 616. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist



Figure 617. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

Though the two cyclists can be hidden from direct view to the nearside of the vehicle Figure 617 shows that both are visible in the Class V and Class VI mirrors. The front (yellow) cyclist is almost completely visible in the Class VI mirror. The front (yellow) would also be visible from the waist down in the Class V mirror. The rear (blue) cyclist has the front wheel of their bicycle visible in the Class VI mirror and their right leg, lower left leg and the wheels and lower part of their bicycle visible in the Class V.



Figure 618. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is barely visible in the projection of the Class IV mirror

Figure 618 shows that a small portion of the back of the rear of the two cyclists (blue) is also visible in the projection of the nearside Class IV mirror. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the nearside of the Volvo FH N3.

4.1.18.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

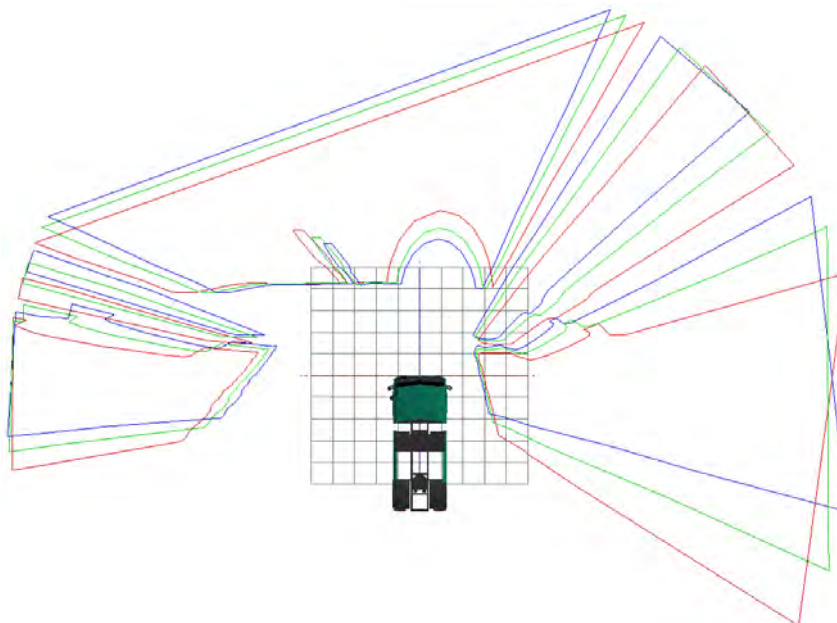


Figure 619. A plan view of the projection of the windscreen and side windows onto the ground plane for the Volvo FH N3 for a range of driver eye positions. Red=smallest driver (5th%ile UK female stature), Green=average sized driver (50th%ile UK male stature), and Blue=tallest driver (95th%ile UK male stature).

4.1.19 VOLVO FE N3 LOW ENTRY CAB - 50TH %ILE MALE DRIVER



Figure 620. Evaluation model of Volvo FE N3 LEC variant vehicle

4.1.19.1 APERTURE PROJECTIONS

The following projections illustrate the extent of direct and indirect vision afforded to the driver via windows or via mirrors. Figure 621 shows a top-down view of all of the window projections for the Volvo FE N3 LEC cab with a 50th %ile UK Male Driver. The image on the right of Figure 621 shows the areas of these projections that intersect with the ground. Figure 622 shows the same for the the mirror projections and Figure 623 shows the two combined. In this case the projections have been clipped to a radius of twenty metres. Any area outside of the coloured projections, within that twenty metre radius, is effectively a blind spot at the ground plane.

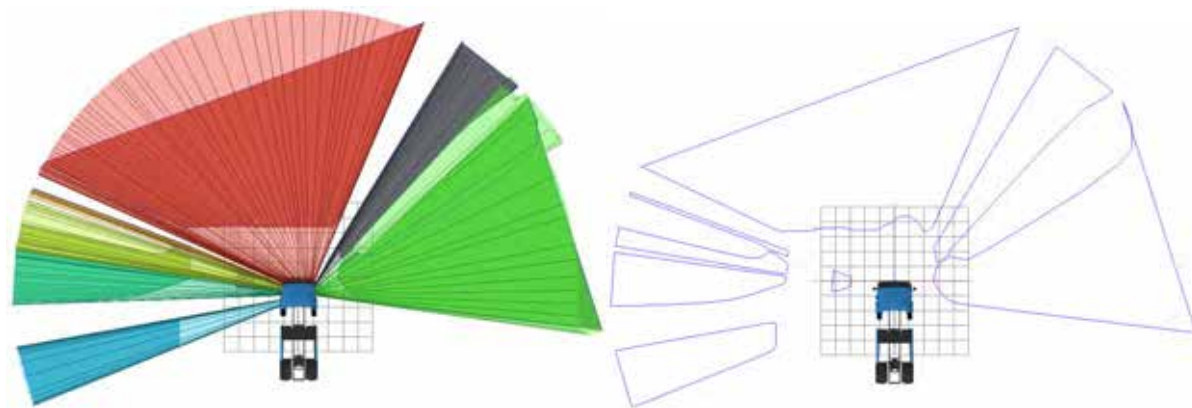


Figure 621. The projection of the windscreen and window apertures at the ground plane for the Volvo FE N3 LEC

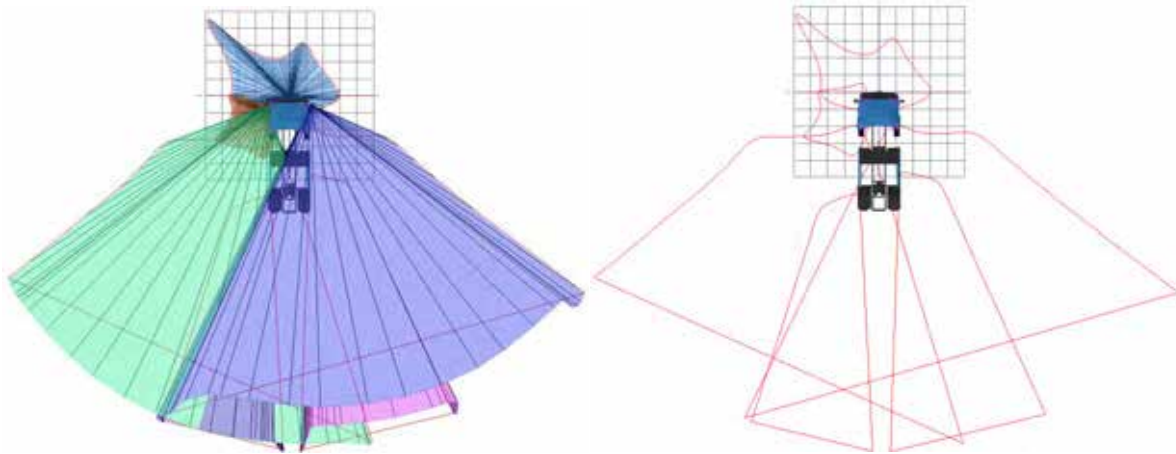


Figure 622. The projection of the mirrors at the ground plane for the Volvo FE N3 LEC

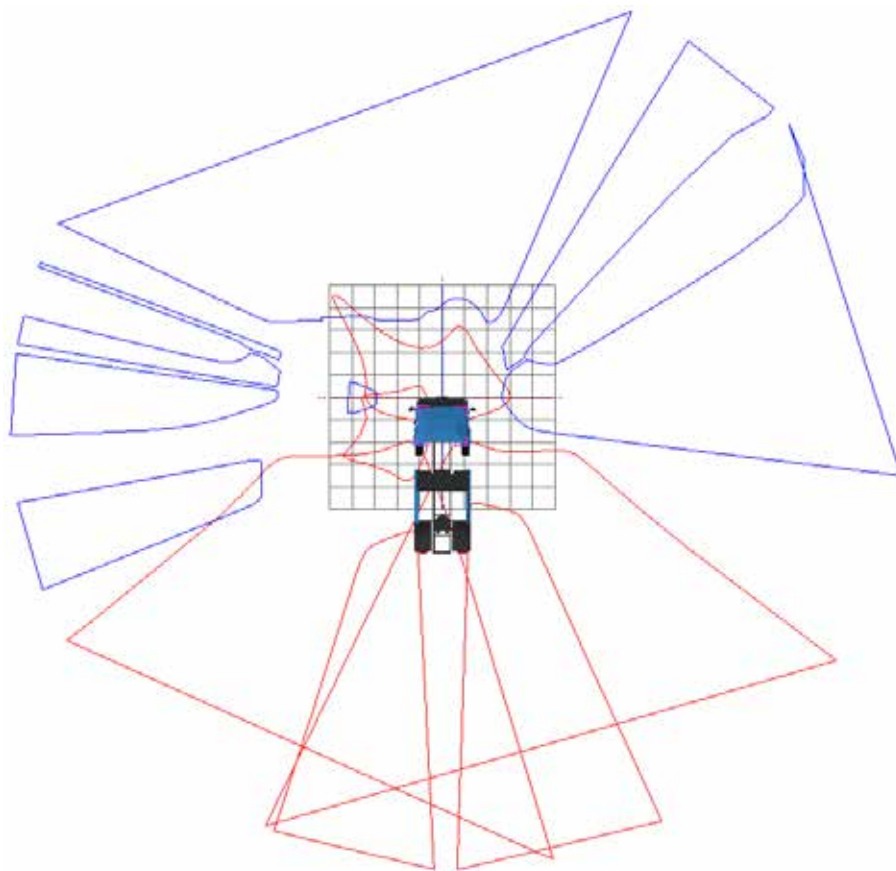


Figure 623. The combined direct and indirect vision projections at the ground plane for the Volvo FE N3 LEC

Figure 624 through Figure 628 illustrate the shape of the projections, extending from the driver's eye point through the window aperture or reflected via the surface of the mirror. The images can be interpreted such that anything inside the projections would be visible to the driver, anything not inside the projection would not be visible without the driver moving. Figure 629 and Figure 630 show the interaction of window and mirror projections to highlight fields of view to the front and side of the vehicle.

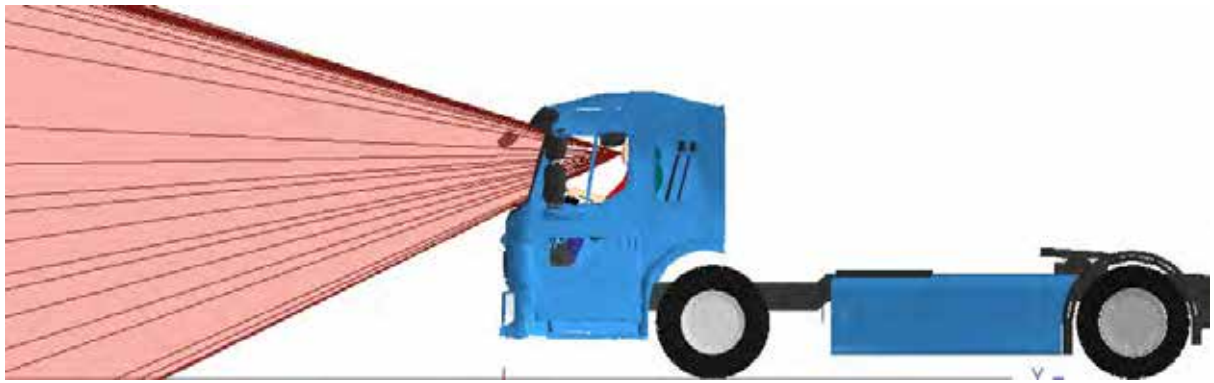


Figure 624. A side view of the windscreen aperture projection for the Volvo FE N3 LEC

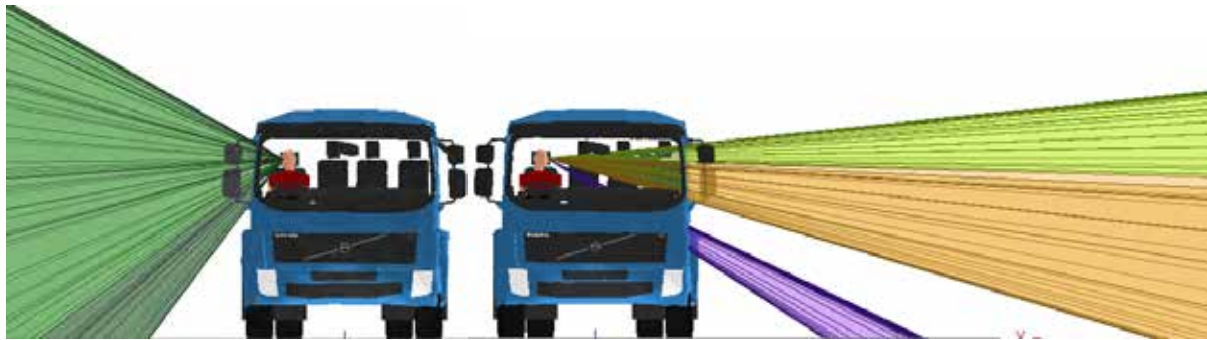


Figure 625. Frontal views of the off side and near side door window projections for the Volvo FE N3 LEC



Figure 626. A side view of the Class VI mirror projection for the Volvo FE N3 LEC



Figure 627. A front view of the Class V mirror projection for the Volvo FE N3 LEC



Figure 628. Side views of the combined Class II and Class IV mirror projections for the Volvo FE N3 LEC

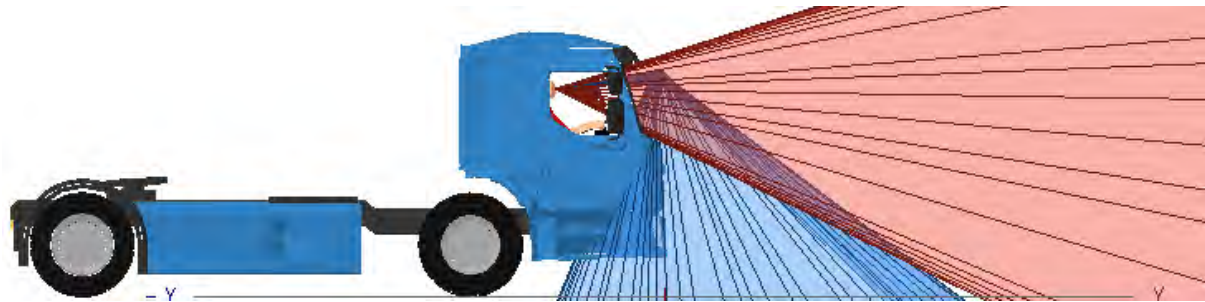


Figure 629. Combined projection of the windscreen and Class VI mirror to the front of the Volvo FE N3 LEC

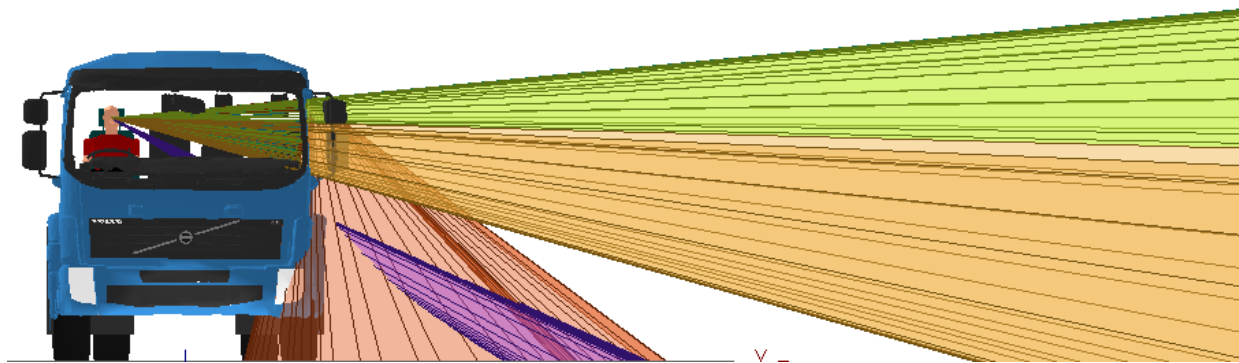


Figure 630. Combined projection of the near side windows and Class V mirror to the side of the Volvo FE N3 LEC

4.1.19.2 FORWARD VISIBILITY – PEDESTRIAN

Figure 631 shows the visible areas in proximity to the cab taken at a height equivalent to the stature of a 50th %ile UK male (1755mm). The intersection of the projections through the windscreen and front most side windows and this plane are shown shaded in blue. The intersection of the projections via the Class VI mirror and this plane is shown shaded in red.



Figure 631. Image showing the areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and part of the side windows, the red areas the projection of the Class VI mirror, at a height above the ground that equals the stature of a 50th%ile UK male pedestrian

From the figure it is clear that the visible areas at a height representative of a pedestrian are closer to the vehicle than those taken at ground level shown in Figure 623. In fact the projections actually touch the vehicle. Figure 632 and Figure 633 show that there no space between the front of the vehicle and the near edge of the visible area in which a pedestrian could be hidden from direct view.



Figure 632. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the windscreen at a height that equals the stature of a 50th%ile UK male pedestrian

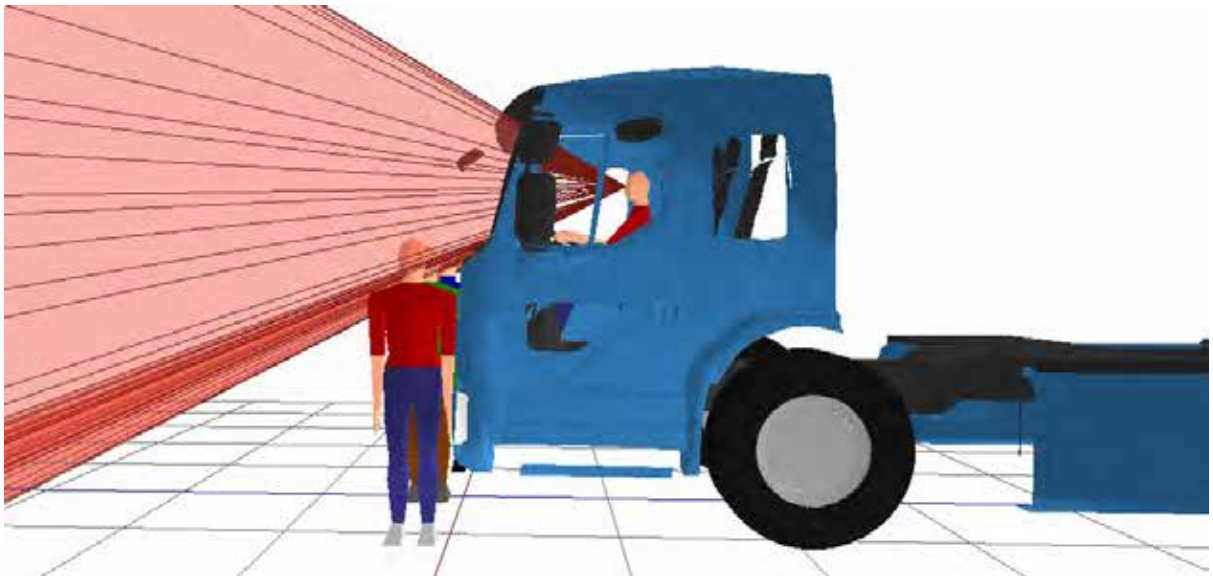


Figure 633. 3D view showing that all three pedestrians can be seen through direct vision by the driver in the standardised driving posture

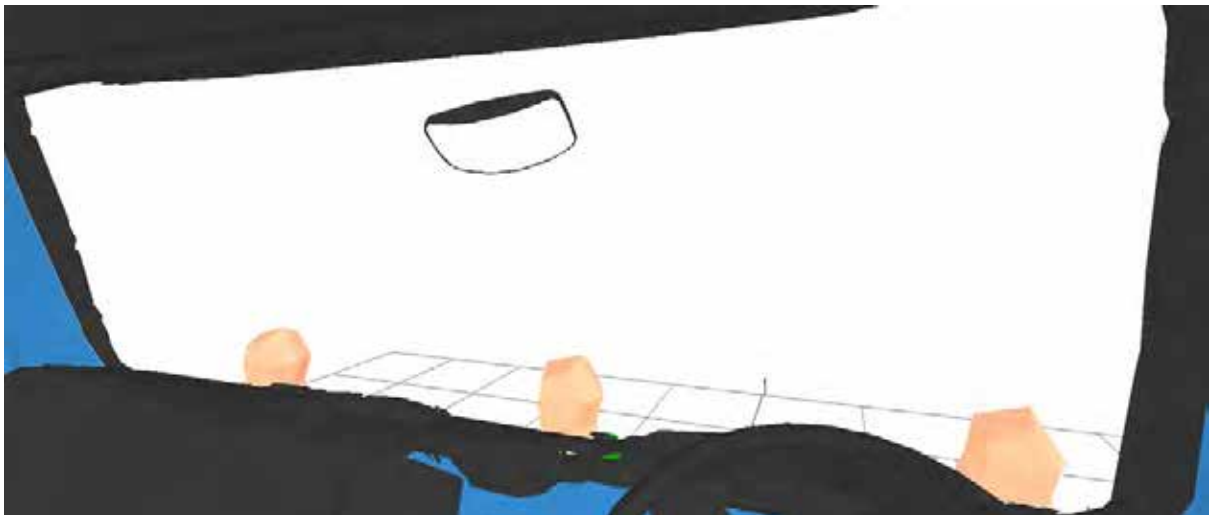


Figure 634. The view from the driver's eyes shows that the left (red), centre (green) and the right (blue) pedestrians are all clearly visible.

For forwards visibility of the pedestrians none of the three pedestrians can be hidden from view, even when they are touching the front of the vehicle. Thus it is not possible for a pedestrian of 50th %ile UK male height or shorter to be hidden from direct vision when positioned to the front right of the Volvo FE N3 LEC.

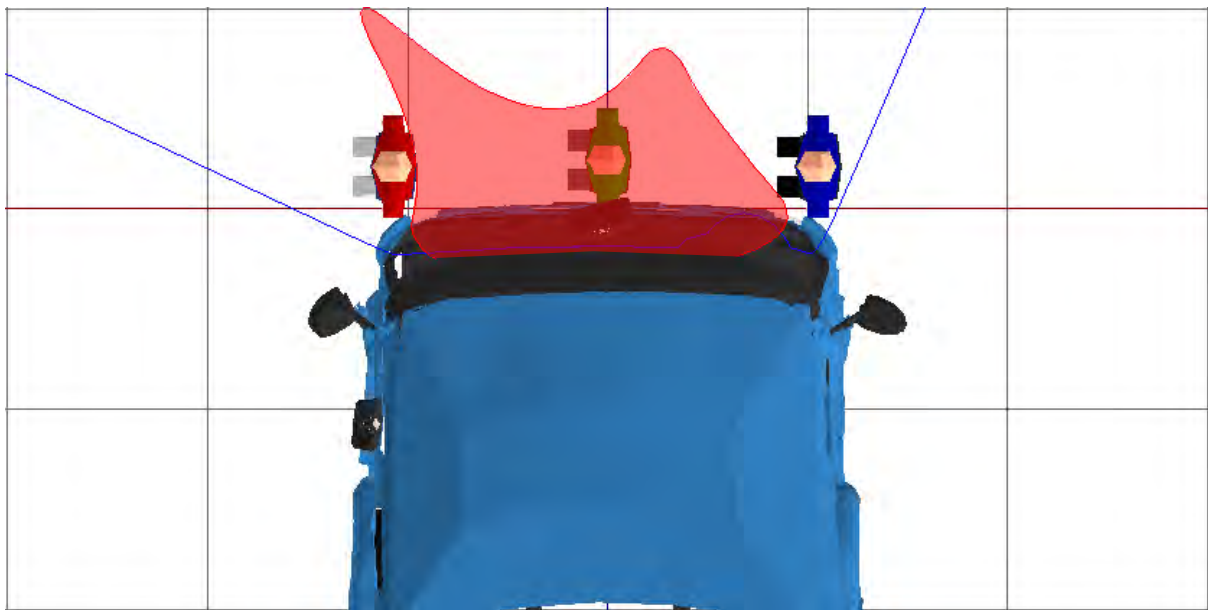


Figure 635. A plan view of the three human models that represent a pedestrian walking in front of a stationary vehicle and the projection of the Class VI mirror at a height that equals the stature of a 50th%ile UK male pedestrian

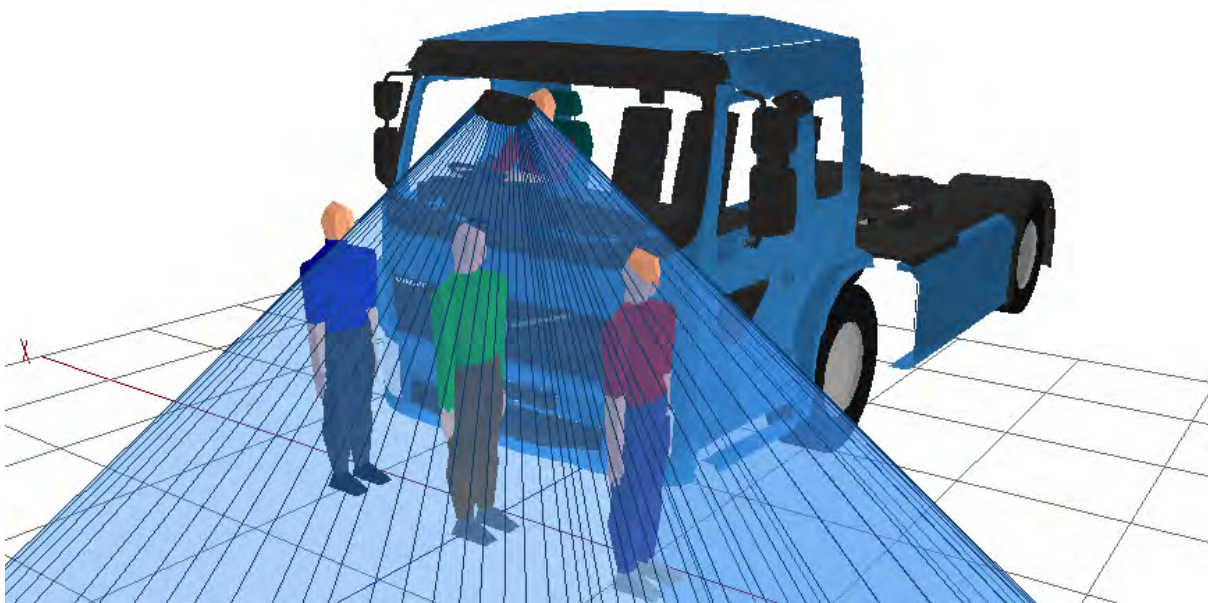


Figure 636. 3D view showing that all three pedestrians positioned to the front of the vehicle are visible in the projection of the Class VI mirror

In addition to being visible through direct vision the three pedestrians are also visible in the Class VI mirror. Figure 636 shows that the pedestrian to the centre (green) would be completely visible, the pedestrian to the left (red) would be visible apart from the top of their head, and the right (blue) would be visible from the neck down. Thus, for a driver using both direct vision and their mirrors, it is not possible to hide the pedestrian models that have been tested to the front of the Volvo FE N3 LEC.

4.1.19.3 OFFSIDE (DRIVER SIDE) VISIBILITY – CYCLIST

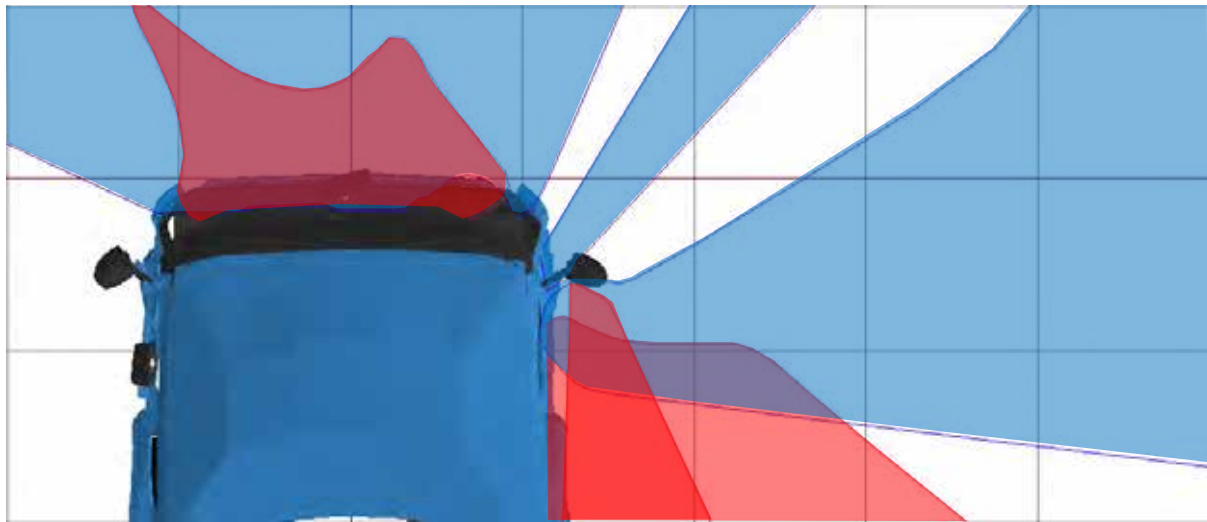


Figure 637. Image showing the areas of intersection of the projections of the driver's field of view through windows and mirrors. The blue areas show the projection of the windscreen and the offside windows, the red areas show the projection of the Class II, Class IV and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

From Figure 637 it is clear that the visible areas at a height representative of a cyclist are closer to the vehicle than those taken at ground level shown in Figure 623. As seen previously the projections actually touch the vehicle. Figure 638, Figure 639 and Figure 640 show that the cyclists to the offside cannot be hidden from direct view.

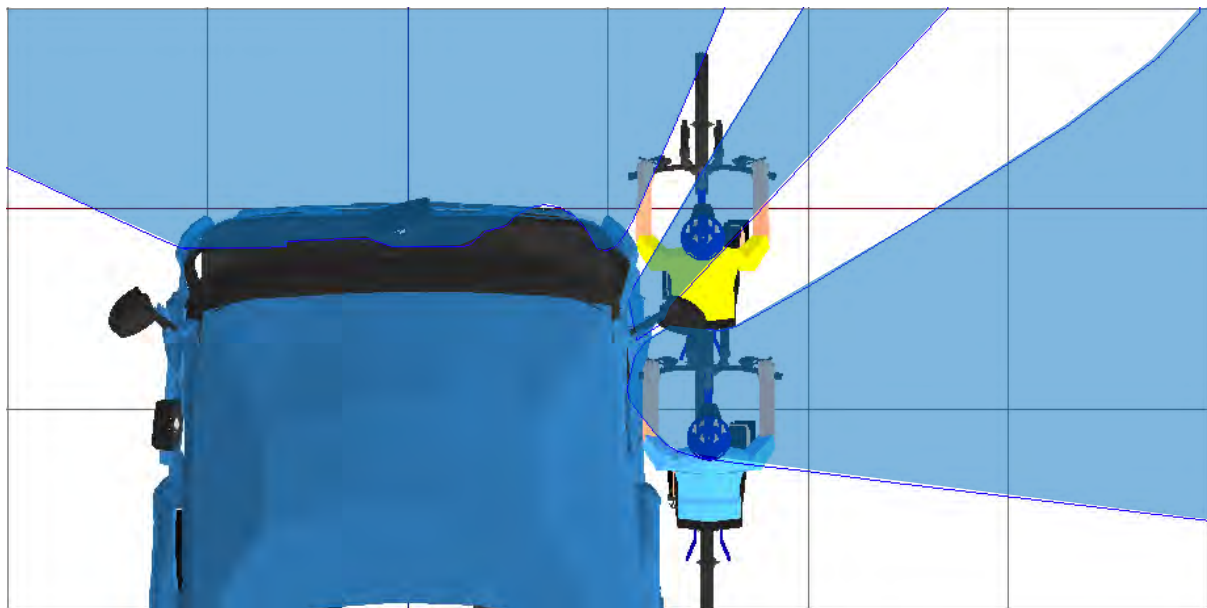


Figure 638. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the windscreen and offside windows at a height that equals the stature of a 50th%ile UK male cyclist

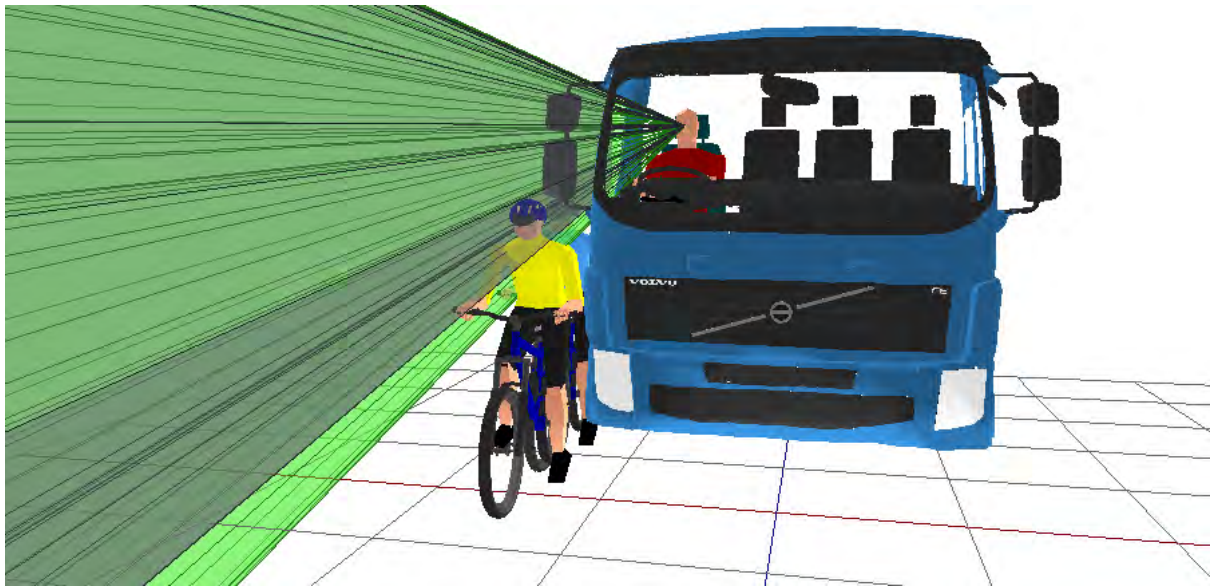


Figure 639. 3D view showing that both cyclists cannot be hidden from direct vision to the offside of the Volvo FE N3 LEC

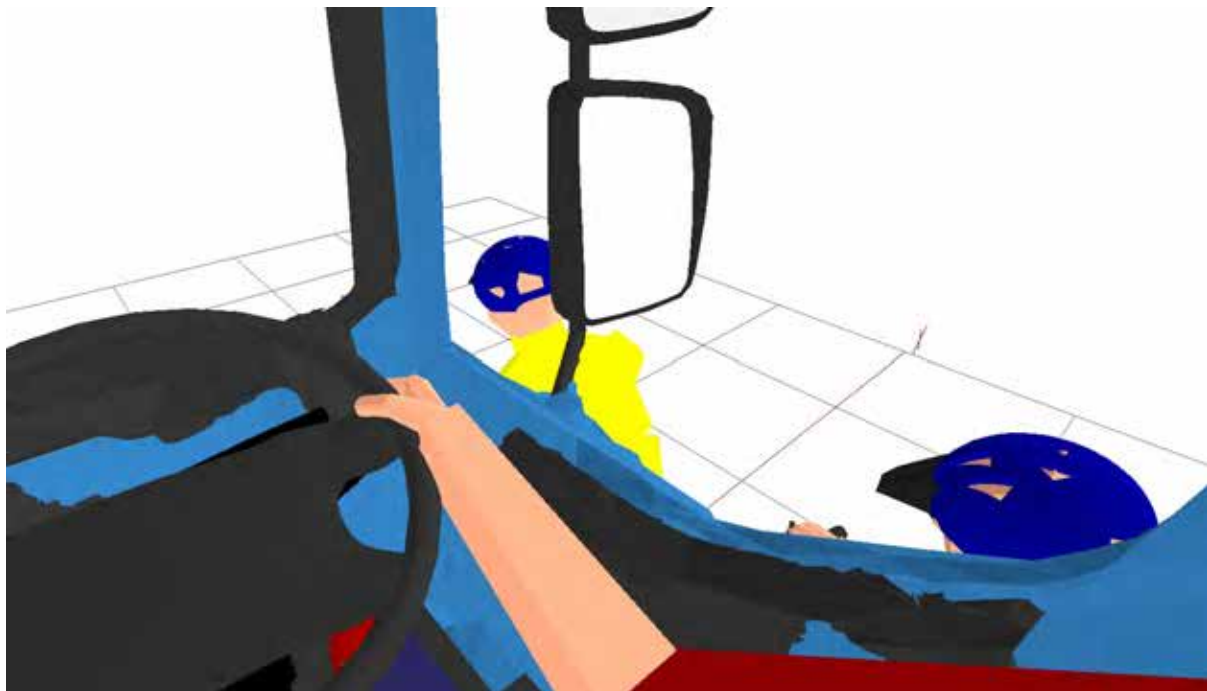


Figure 640. The view from the driver's eyes clearly shows the two cyclists are visible, even when positioned against the side of the vehicle.

For offside visibility of the cyclists there is no blind spot that could obscure a cyclist. Figure 640 shows that even with the cyclists touching the side of the cab they would still be visible to the driver.

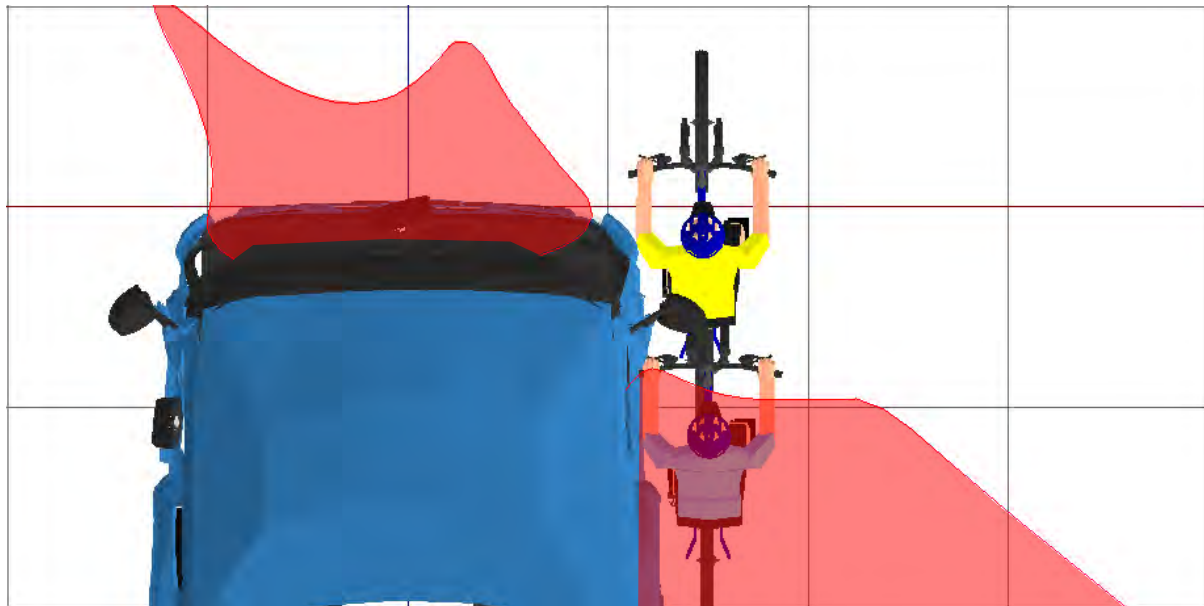


Figure 641. A plan view of the two human models that represent a cyclist moving past on the outside of the vehicle and the projection of the Class IV and Class VI mirrors at a height that equals the stature of a 50th%ile UK male cyclist

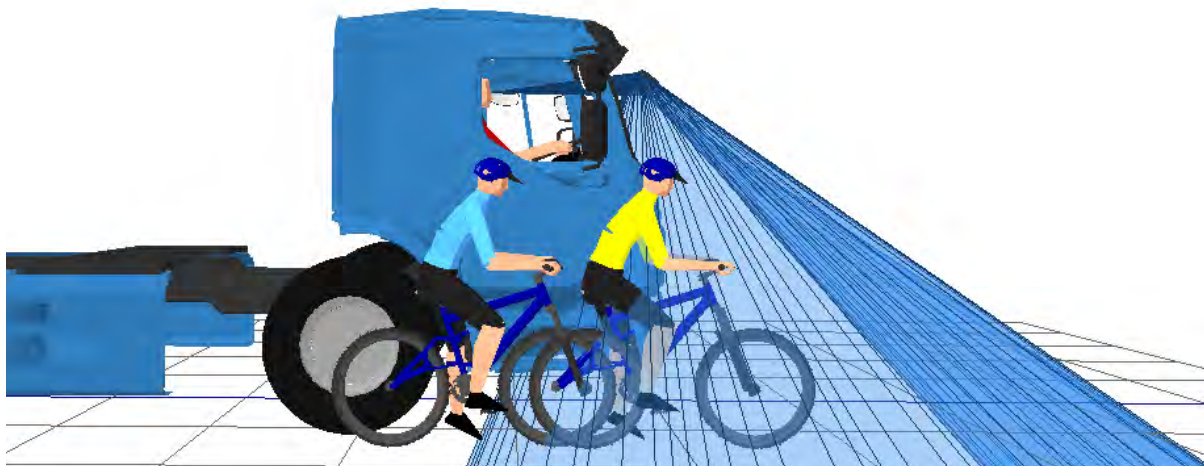


Figure 642. 3D view showing that the front (yellow) cyclist positioned to the offside of the vehicle is visible in the projection of the Class VI

In addition to being visible through direct vision the cyclists are also visible in the mirrors. Figure 642 shows that part of the front (yellow) cyclist would also be visible in the Class VI mirror including their left arm, thighs and lower legs and the majority of the bicycle.

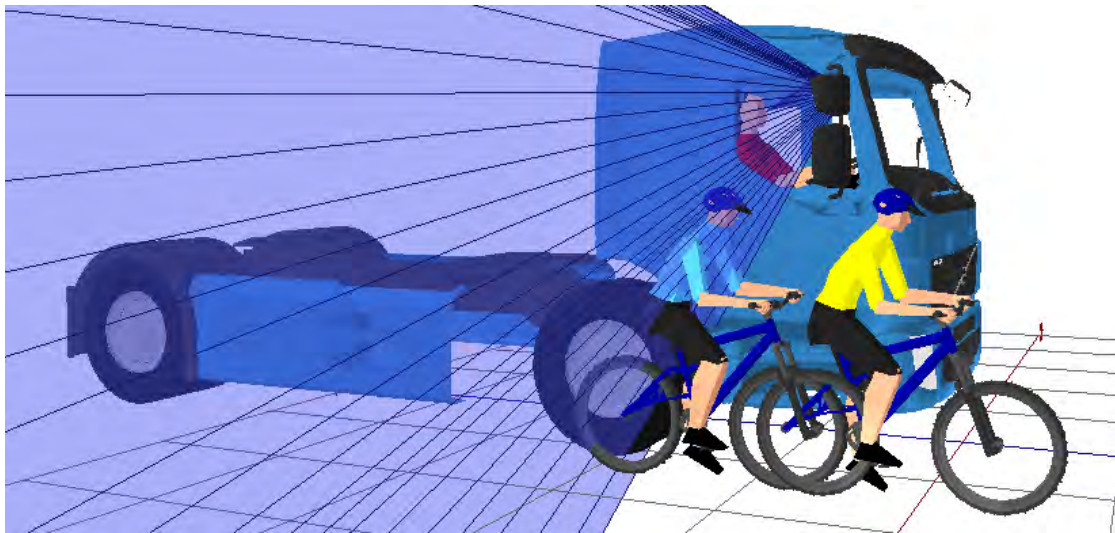


Figure 643. 3D view showing that the rear (blue) cyclist positioned to the offside of the vehicle is visible in the projection of the Class IV mirror

Figure 643 shows that the rear of the two cyclists (blue) is visible in the projection of the offside Class IV mirror. The cyclist would only be partially visible including their head and torso. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the offside of the Volvo FE N3 LEC.

4.1.19.4 NEARSIDE (PASSENGER SIDE) VISIBILITY – CYCLIST

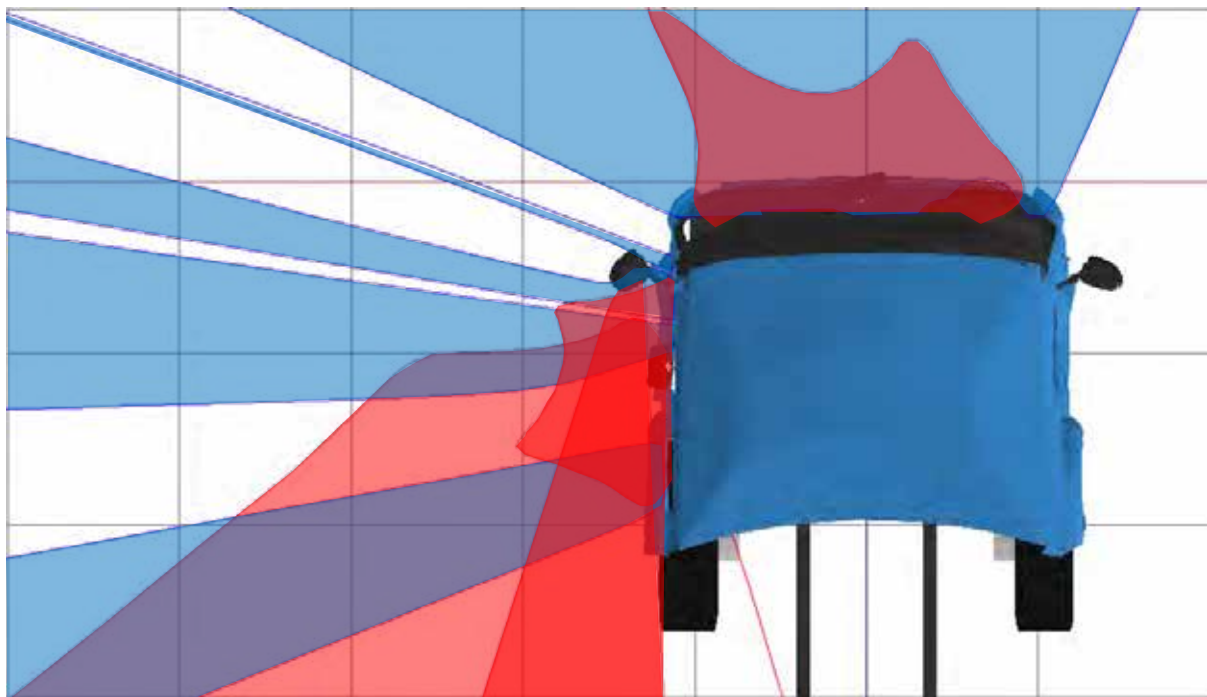


Figure 644. The areas of intersection of the projections of the driver’s field of view through windows and mirrors. The blue areas show the projection of the windscreen and the nearside windows, the red areas show the projection of the Class II, Class IV, Class V and Class VI mirrors, at a height above the ground that equals the height of a 50th%ile UK male cyclist

Figure 645 and Figure 646 show that again there is no space between the nearside of the vehicle and the near edges of the visible areas in which a cyclist could be hidden from direct view.

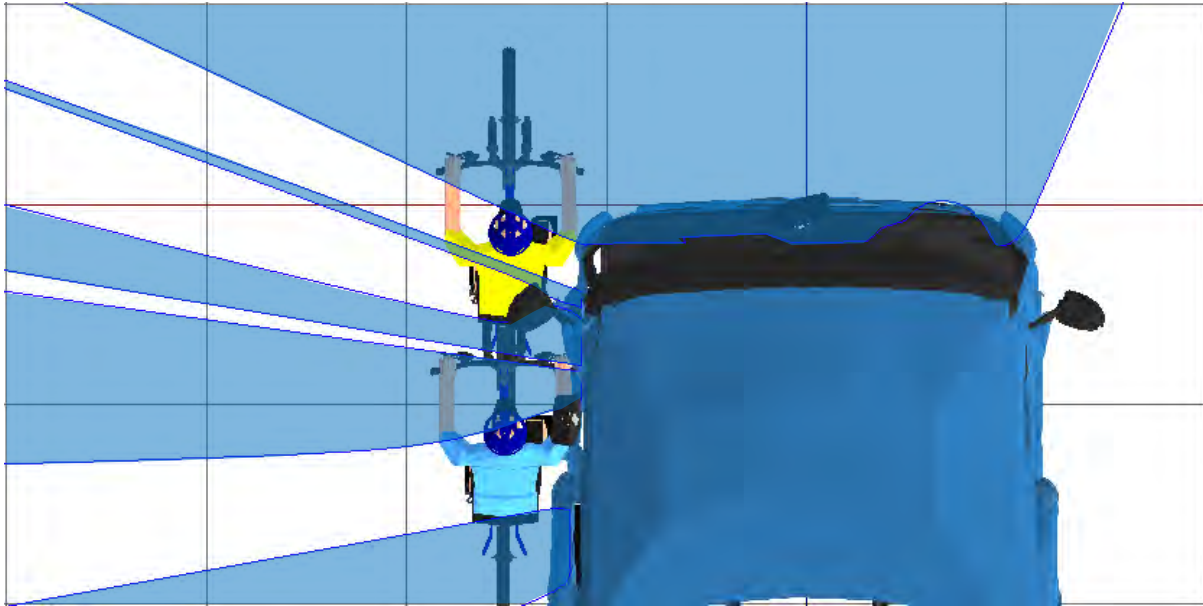


Figure 645. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the windscreen and nearside windows at a height that equals the stature of a 50th%ile UK male cyclist

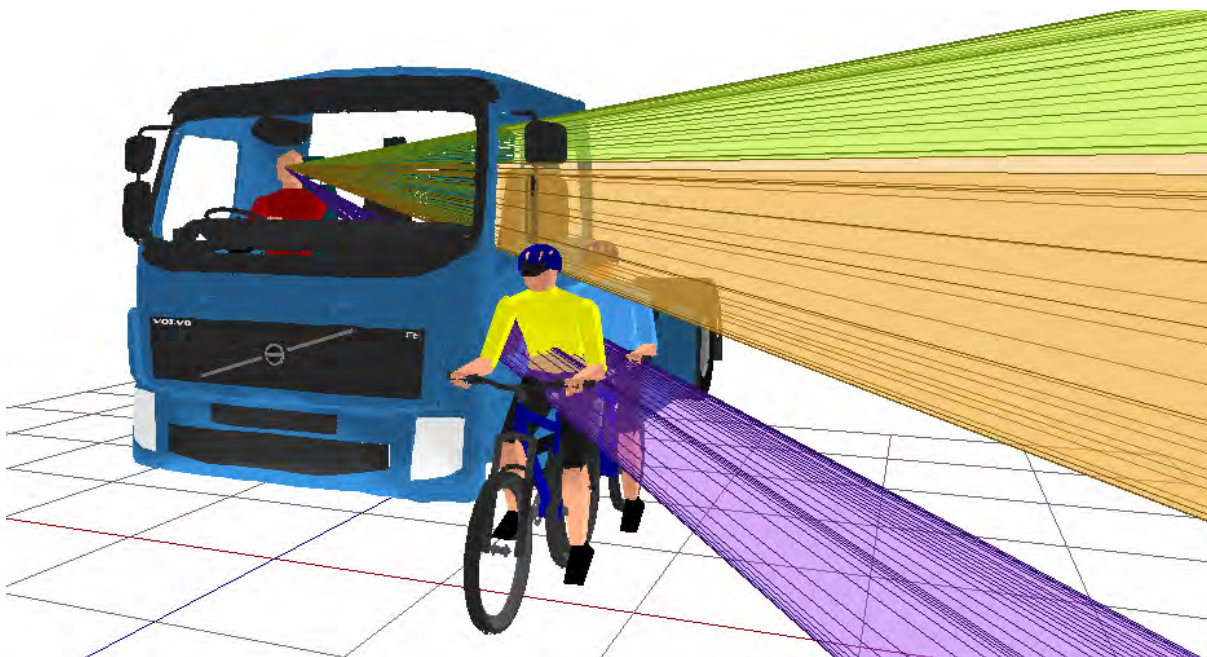


Figure 646. 3D view showing that both cyclists cannot be hidden from direct vision to the nearside of the Volvo FE N3 LEC

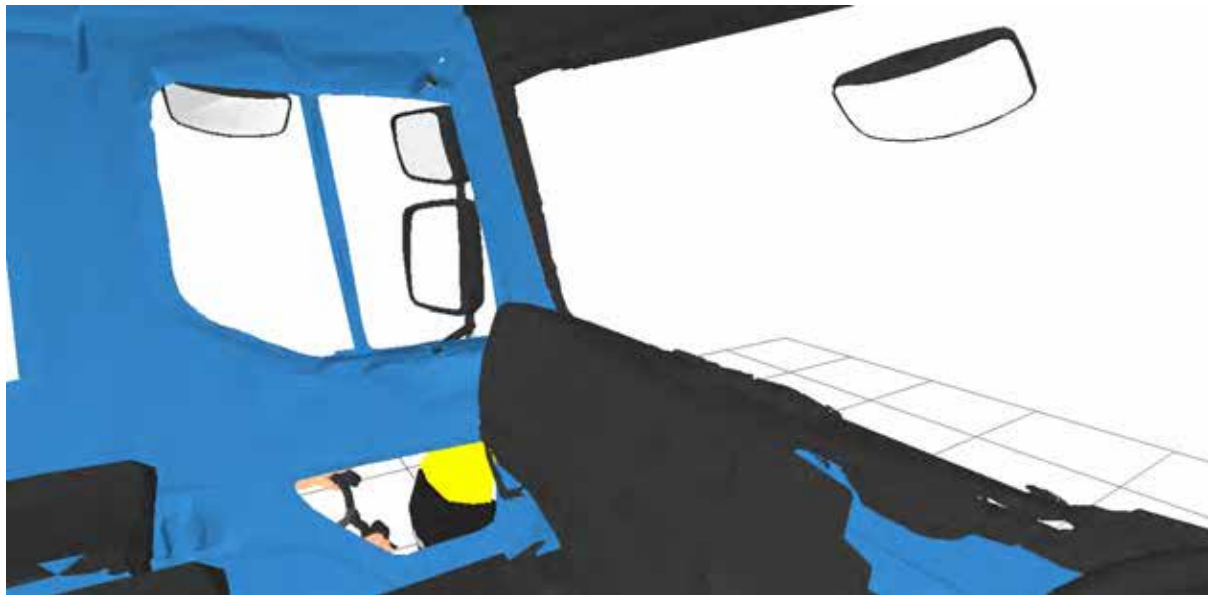


Figure 647. The view from the driver's eyes clearly shows the two cyclists are hidden from view.

For nearside visibility neither of the cyclists both can be hidden from the driver's direct vision. However, both are only visible through the lower passenger door window. The rear (blue) cyclist only has the handlebars of their bicycle visible and the front (yellow) cyclist only has their lower back visible in this location.



Figure 648. A plan view of the two human models that represent a cyclist moving up the inside of the vehicle and the projection of the Class IV, Class V and Class VI mirrors at a height that equals the stature of a 50th percentile UK male cyclist



Figure 649. 3D view showing that both cyclists positioned to the nearside of the vehicle are visible in the projection of the Class V and / or Class VI mirrors

In addition to being visible in direct vision Figure 649 shows that both are visible in the Class V and Class VI mirrors. The front (yellow) cyclist would have their lower arms, lower legs and front of their bicycle visible in the Class VI mirror and would be visible from the waist down in the Class V mirror. The rear (blue) is not visible in the Class VI but would be completely visible in the Class V mirror.



Figure 650. 3D view showing that the rear (blue) cyclist positioned to the nearside of the vehicle is visible in the projection of the Class IV mirror

Figure 650 shows that the rear of the two cyclists (blue) is also visible in the projection of the nearside Class IV mirror. The cyclist would only be partially visible including the head and torso of the rider. The projections show that for a driver using both direct vision and their mirrors, it is not possible to hide the cyclist models that have been tested to the nearside of the Volvo FE N3 LEC.

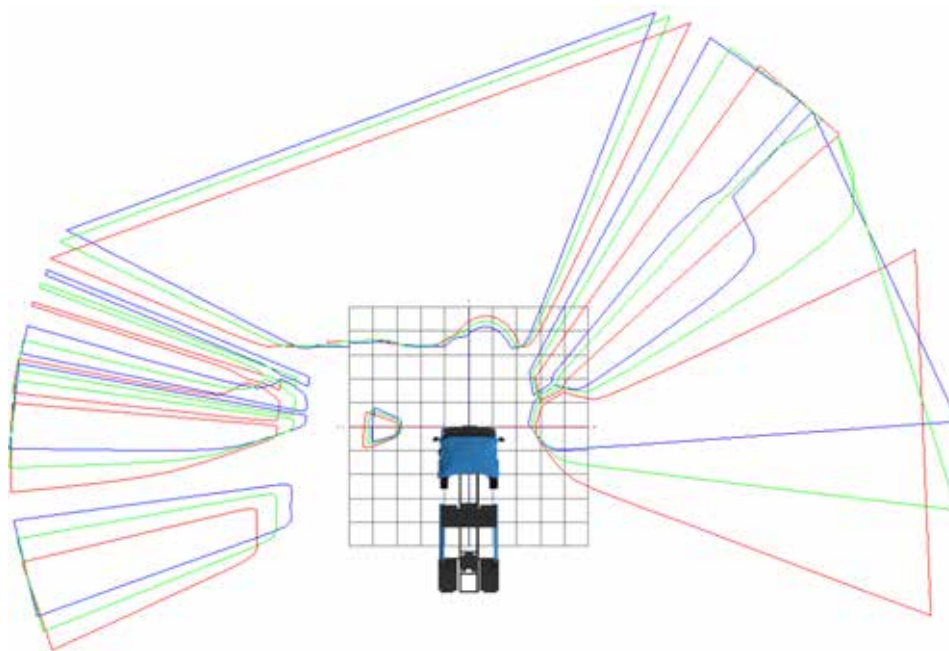
4.1.19.5 COMPARISON BETWEEN DRIVER EYE POINTS 5TH %ILE FEMALE TO 95TH %ILE MALE

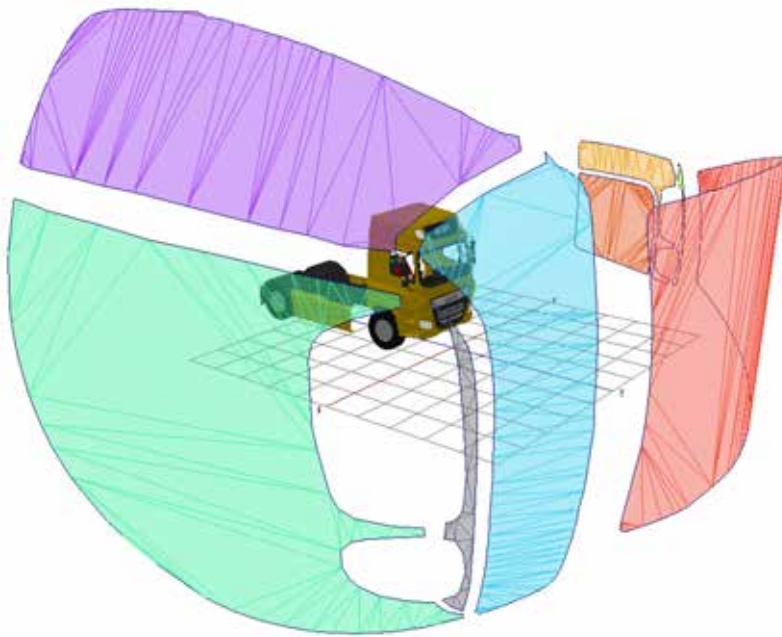
Figure 651. A plan view of the projection of the windscreen and side windows onto the ground plane for the Volvo FE N3 LEC for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

4.2 FIELD OF VIEW – AREA PROJECTIONS

The following section presents the results for the FOV area projection applied to 13 of the 19 vehicles shown in Section 3.1. Only 13 of the vehicles are presented as the FOV area analyses are only based on cab design and not on cab mounting height. Thus the N3 and N3G configurations have the same results for all manufacturers, and for Mercedes the Antos, Arocs and Actros all share the same cab and FOV area results. Results for the 50th ile UK Male driver are presented here. Results for 5th ile UK Female and 95th ile UK Male drivers can be found in Appendix 1. Note that shaded cells in the table highlight FOV area values that have changed for a given window or mirror during the clipping or combining processes from the original, unmodified area.

4.2.1 DIRECT VISION – 50TH %ILE MALE DRIVER

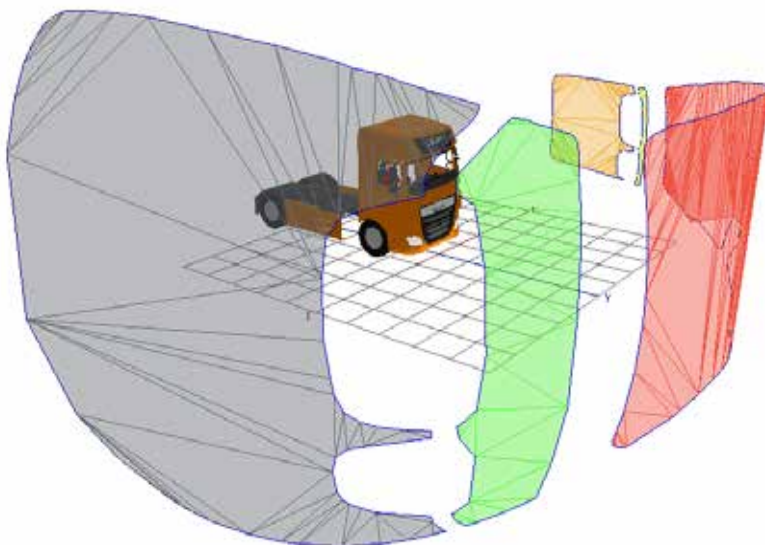
4.2.1.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	93.71
Passenger – p1	0.18
Passenger – p2	0.46
Passenger – p3	4.12
Passenger – p4	8.29
Driver – p1	86.16
Driver – p2	33.57
Driver – p3	20.06
Driver – p4	1.84
Total	248.37

Figure 652. FOV area projection for the DAF CF N3 / N3G

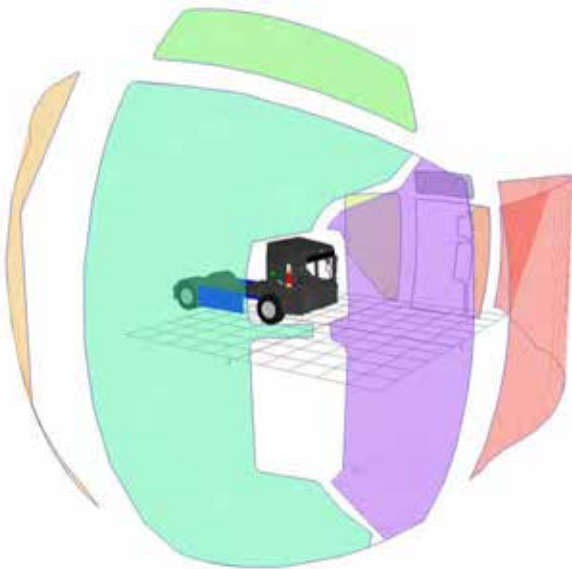
4.2.1.2 DAF XF CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	86.49
Passenger – p1	0.75
Passenger – p2	9.59
Driver – p1	15.22
Driver – p2	96.37
Total	208.41

Figure 653. FOV area projection for the DAF XF N3

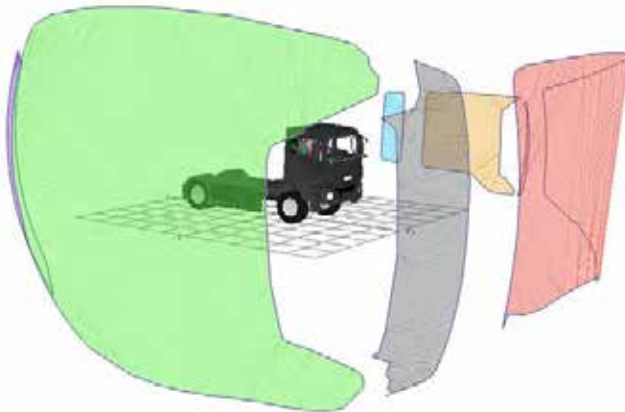
4.2.1.3 DENNIS EAGLE N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	93.53
Passenger – p1	12.36
Passenger – p2	13.0
Passenger – p3	4.86
Passenger – p4	13.07
Driver – p1	79.12
Driver – p2	13.00
Driver – p3	72.09
Driver – p4	28.29
Total	329.32

Figure 654. FOV area projection for the Dennis N3 LEC

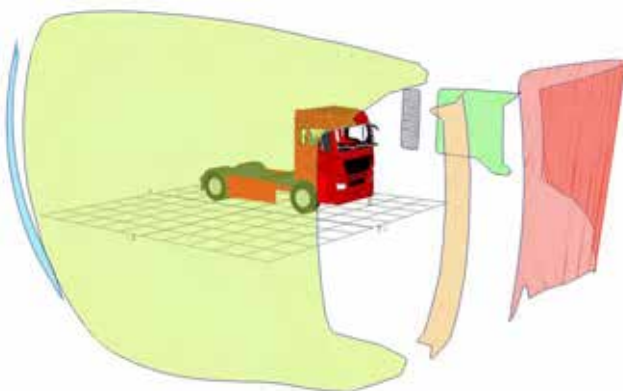
4.2.1.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	92.07
Passenger – p1	0.51
Passenger – p2	12.32
Passenger – p3	2.50
Driver – p1	12.57
Driver – p2	110.57
Driver – p3	14.48
Total	245.02

Figure 655. FOV area projection for the MAN TGS N3 / N3G

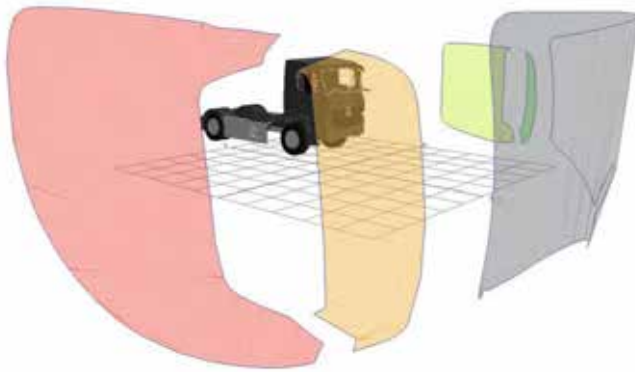
4.2.1.5 MAN TGX CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	84.34
Passenger – p1	10.59
Passenger – p2	2.17
Driver – p1	4.37
Driver – p2	90.38
Driver – p3	15.10
Total	206.95

Figure 656. FOV area projection for the MAN TGX N3 / N3G

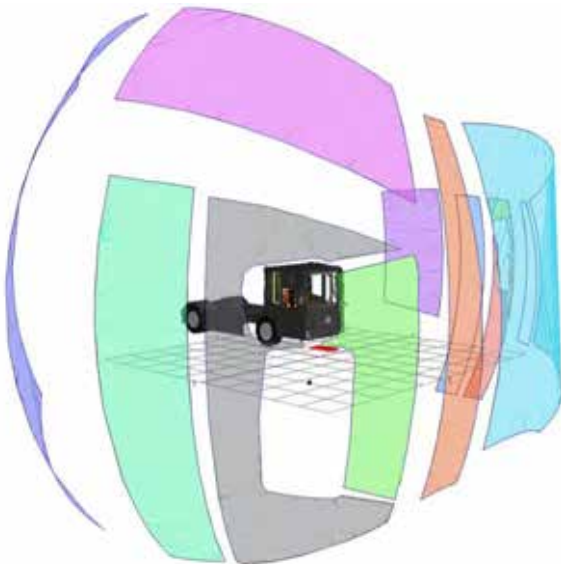
4.2.1.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	83.67
Passenger – p1	1.60
Passenger – p2	12.61
Driver – p1	14.24
Driver – p2	65.92
Total	178.04

Figure 657. FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

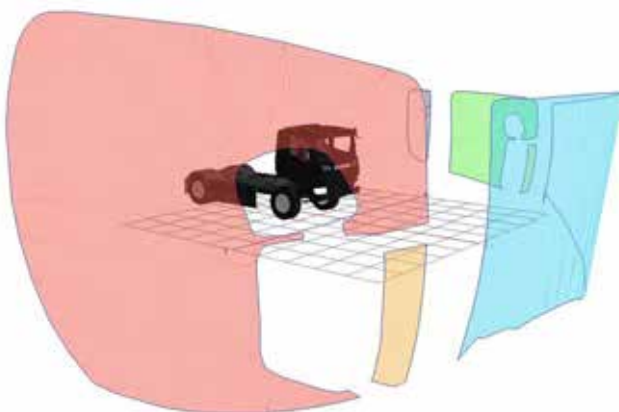
4.2.1.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	94.67
Passenger – p1	3.76
Passenger – p2	1.26
Passenger – p3	0.5
Passenger – p4	5.54
Passenger – p5	11.01
Passenger – p6	15.52
Driver – p1	9.85
Driver – p2	10.52
Driver – p3	21.68
Driver – p4	25.66
Driver – p5	26.1
Driver – p6	116.64
Total	342.71

Figure 658. FOV area projection for the Mercedes Econic N3 LEC

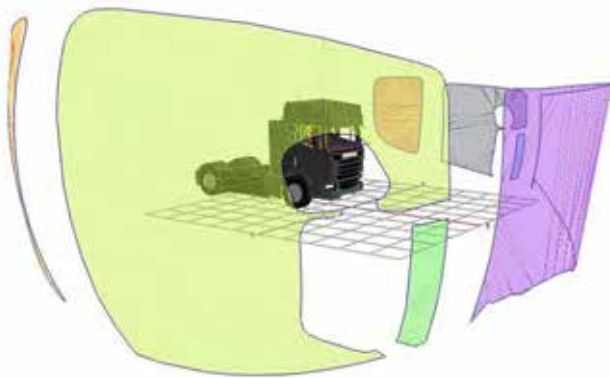
4.2.1.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	77.19
Passenger – p1	0.78
Passenger – p2	11.88
Passenger – p3	3.06
Driver – p1	3.17
Driver – p2	70.62
Total	166.7

Figure 659. FOV area projection for the Scania P N3 / N3G

4.2.1.9 SCANIA R CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	77.19
Passenger – p1	0.78
Passenger – p2	11.88
Passenger – p3	7.14
Driver – p1	3.17
Driver – p2	70.63
Driver – p3	33.50
Total	204.29

Figure 660. FOV area projection for the Scania R N3

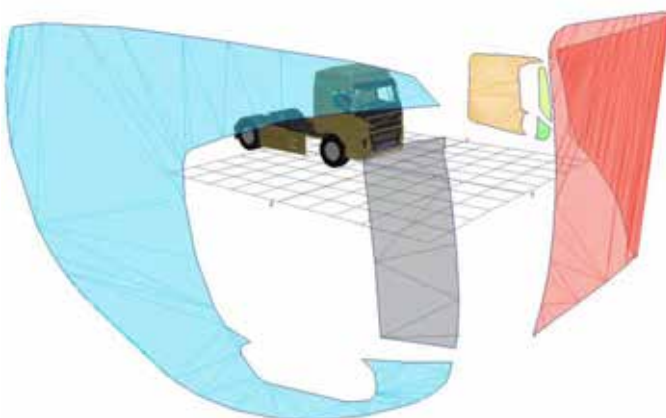
4.2.1.10 SCANIA P N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	77.92
Passenger – p1	0.75
Passenger – p2	11.1
Passenger – p3	5.99
Driver – p1	3.47
Driver – p2	88.60
Driver – p3	36.88
Total	224.71

Figure 661. FOV area projection for the Scania N3 LEC

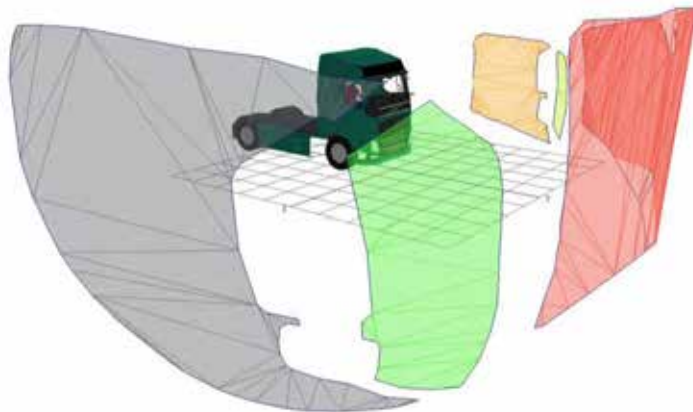
4.2.1.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Window	Area(m ²)
Windscreen	98.72
Passenger – p1	8.54
Passenger – p2	0.97
Passenger – p3	0.45
Driver – p1	100.69
Driver – p2	7.62
Total	216.98

Figure 662. FOV area projection for the Volvo FM N3 / FMX N3G

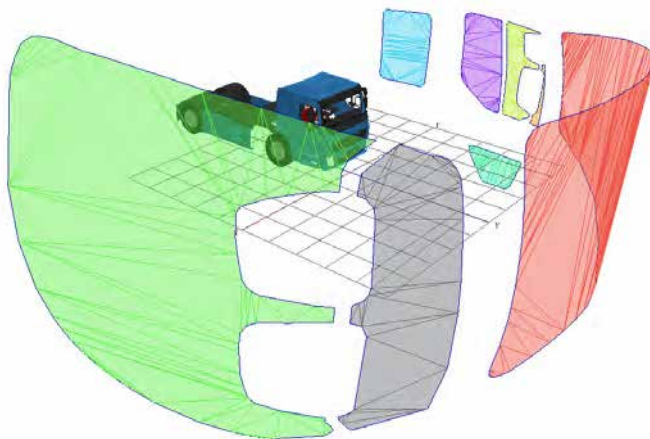
4.2.1.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	93.70
Passenger – p1	11.38
Passenger – p2	1.46
Driver – p1	90.43
Driver – p2	19.83
Total	216.80

Figure 663. FOV area projection for the Volvo FH N3

4.2.1.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

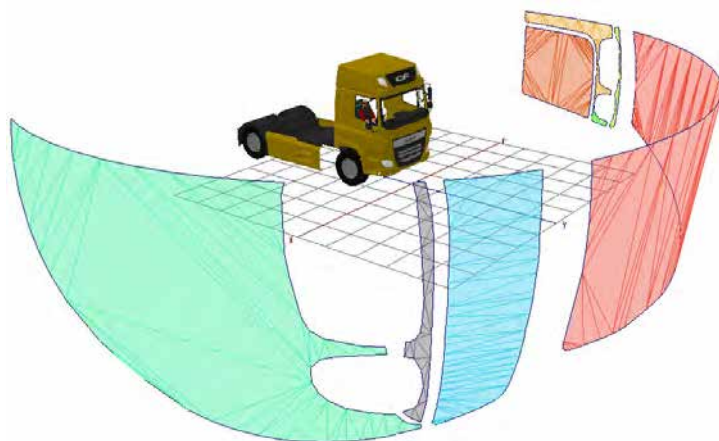


Window	Area(m ²)
Windscreen	90.67
Passenger – p1	5.86
Passenger – p2	3.09
Passenger – p3	0.41
Passenger - Cab	6.00
Passenger - Door	2.41
Driver – p1	79.36
Driver – p2	17.10
Total	204.90

Figure 664. FOV area projection for the Volvo FE N3 LEC

4.2.2 CLIPPED DIRECT VISION +7° – 50TH %ILE MALE DRIVER

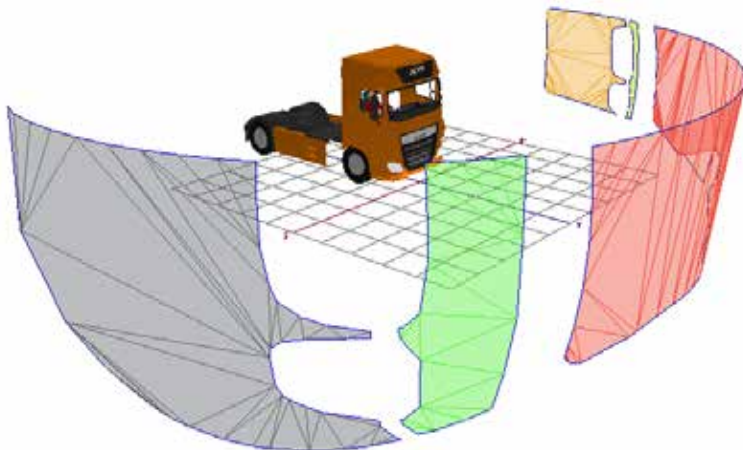
4.2.2.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	68.54
Passenger – p1	0.18
Passenger – p2	0.43
Passenger – p3	2.27
Passenger – p4	8.29
Driver – p1	71.69
Driver – p2	0.00
Driver – p3	12.66
Driver – p4	1.76
Total	165.81

Figure 665. Clipped FOV area projection for the DAF CF N3 / N3G

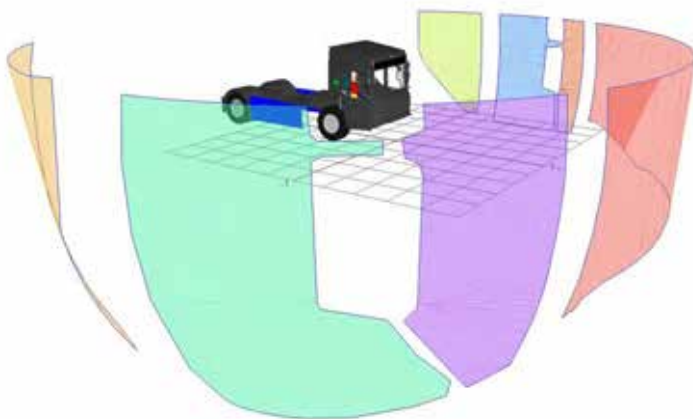
4.2.2.2 DAF XF CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	67.01
Passenger – p1	0.75
Passenger – p2	9.45
Driver – p1	11.46
Driver – p2	63.91
Total	152.59

Figure 666. Clipped FOV area projection for the DAF XF N3

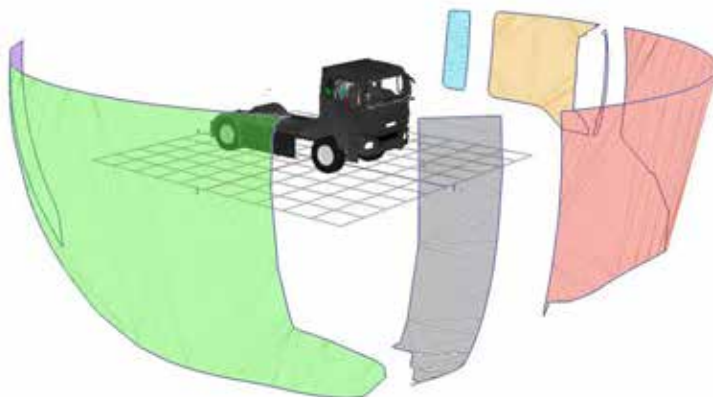
4.2.2.3 DENNIS EAGLE N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	65.64
Passenger – p1	9.75
Passenger – p2	4.27
Passenger – p3	11.07
Passenger – p4	0.00
Driver – p1	46.79
Driver – p2	20.52
Driver – p3	45.91
Driver – p4	0.00
Total	203.95

Figure 667. Clipped FOV area projection for the Dennis N3 LEC

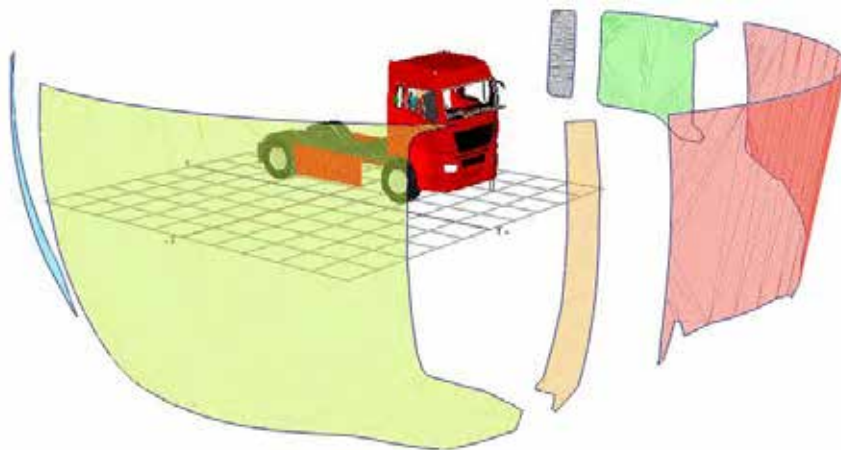
4.2.2.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	68.38
Passenger – p1	0.51
Passenger – p2	12.32
Passenger – p3	2.50
Driver – p1	12.22
Driver – p2	77.20
Driver – p3	9.81
Total	182.94

Figure 668. Clipped FOV area projection for the MAN TGS N3 / N3G

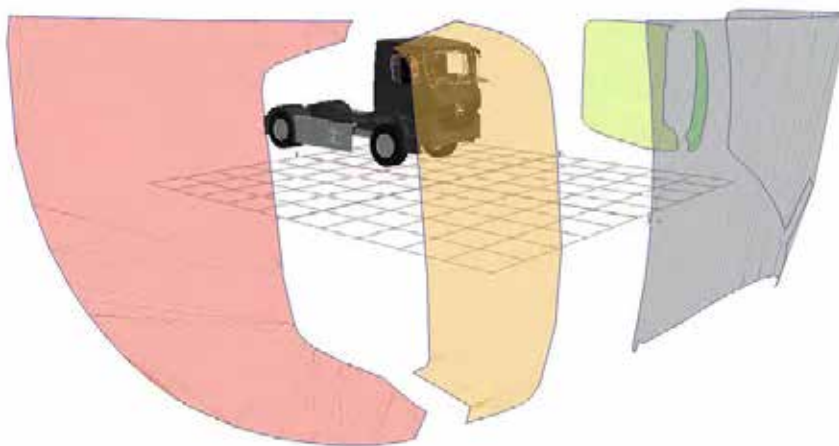
4.2.2.5 MAN TGX CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	68.87
Passenger – p1	10.59
Passenger – p2	2.17
Driver – p1	4.04
Driver – p2	66.14
Driver – p3	11.84
Total	163.65

Figure 669. Clipped FOV area projection for the MAN TGX N3 / N3G

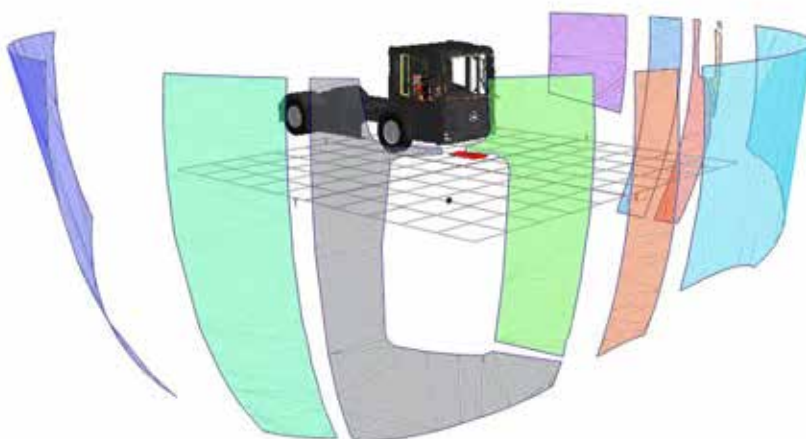
4.2.2.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	75.02
Passenger – p1	1.60
Passenger – p2	12.61
Driver – p1	14.24
Driver – p2	60.22
Total	163.69

Figure 670. Clipped FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

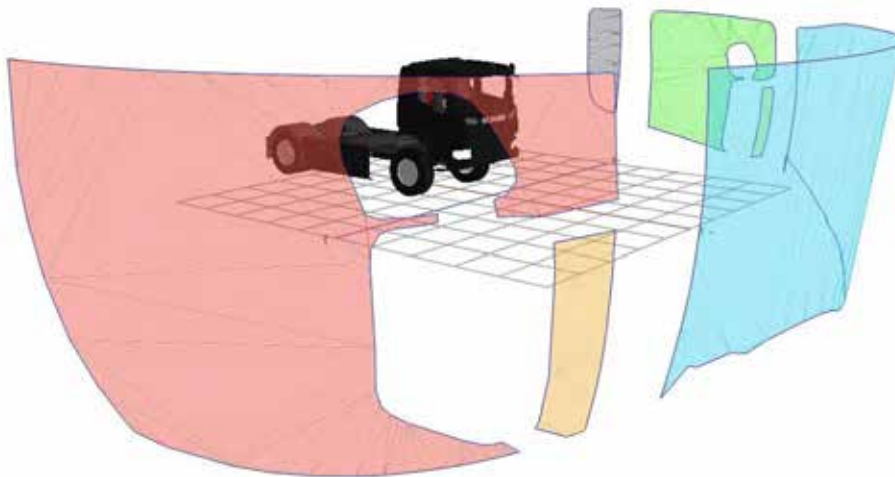
4.2.2.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	52.32
Passenger – p1	2.85
Passenger – p2	0.02
Passenger – p3	0.5
Passenger – p4	5.48
Passenger – p5	8.29
Passenger – p6	8.79
Driver – p1	6.43
Driver – p2	9.34
Driver – p3	16.83
Driver – p4	0.00
Driver – p5	19.91
Driver – p6	59.49
Total	190.25

Figure 671. Clipped FOV area projection for the Mercedes Econic N3 LEC

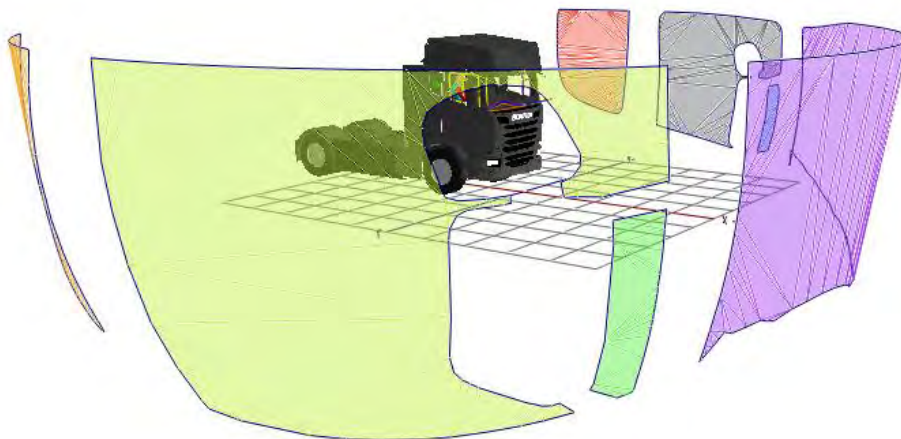
4.2.2.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	70.85
Passenger – p1	0.78
Passenger – p2	11.86
Passenger – p3	3.05
Driver – p1	3.17
Driver – p2	49.36
Total	139.07

Figure 672. Clipped FOV area projection for the Scania P N3 / N3G

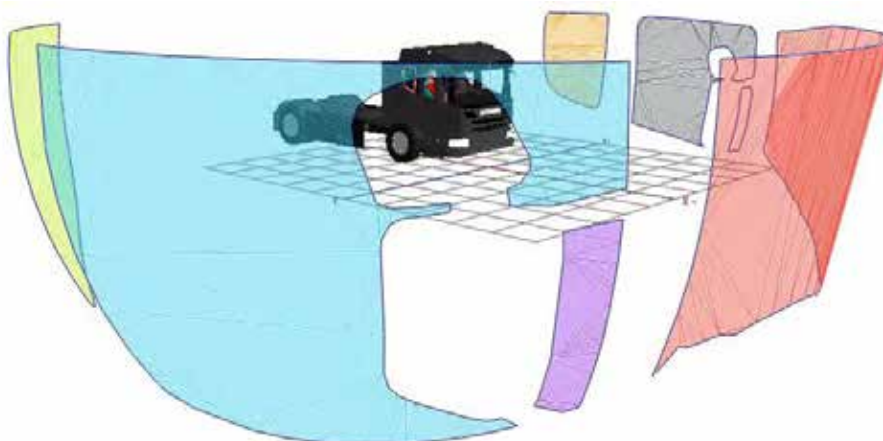
4.2.2.9 SCANIA R CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	70.84
Passenger – p1	0.78
Passenger – p2	11.86
Passenger – p3	6.6
Driver – p1	3.17
Driver – p2	49.36
Driver – p3	23.16
Total	165.77

Figure 673. Clipped FOV area projection for the Scania R N3

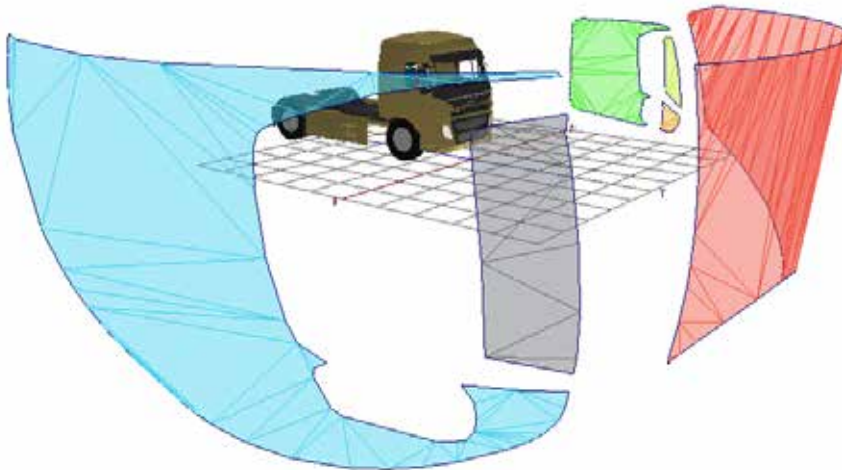
4.2.2.10 SCANIA P N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	71.61
Passenger – p1	0.75
Passenger – p2	11.1
Passenger – p3	5.78
Driver – p1	3.47
Driver – p2	60.96
Driver – p3	24.89
Total	178.56

Figure 674. Clipped FOV area projection for the Scania N3 LEC

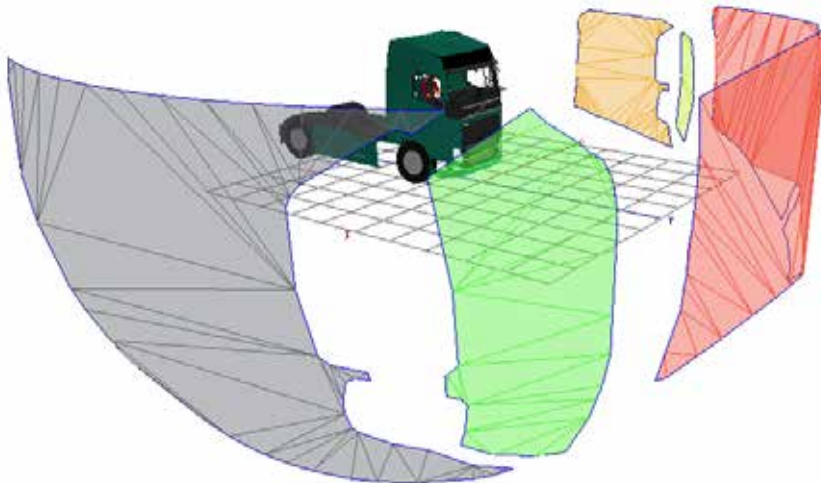
4.2.2.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Window	Area(m ²)
Windscreen	80.54
Passenger – p1	8.54
Passenger – p2	0.97
Passenger – p3	0.45
Driver – p1	85.80
Driver – p2	7.62
Total	183.92

Figure 675. Clipped FOV area projection for the Volvo FM N3 / FMX N3G

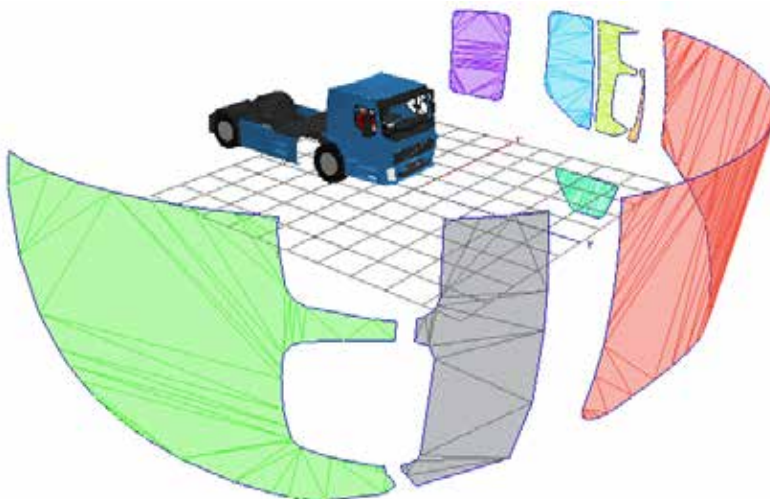
4.2.2.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	79.08
Passenger – p1	11.38
Passenger – p2	1.46
Driver – p1	80.19
Driver – p2	19.83
Total	191.95

Figure 676. Clipped FOV area projection for the Volvo FH N3

4.2.2.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

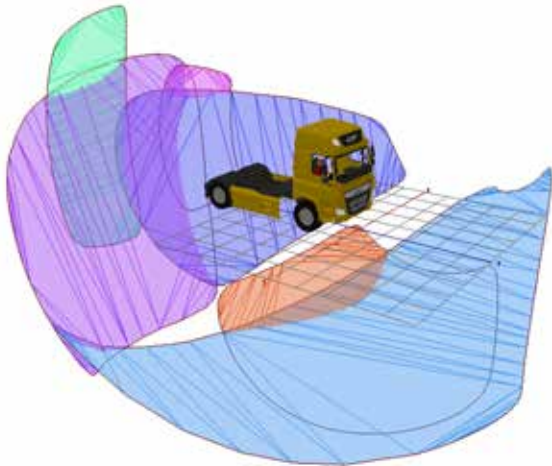


Window	Area(m ²)
Windscreen	72.66
Passenger – p1	5.86
Passenger – p2	3.09
Passenger – p3	0.41
Passenger - Cab	6.00
Passenger - Door	2.41
Driver – p1	56.75
Driver – p2	14.27
Total	161.45

Figure 677. Clipped FOV area projection for the Volvo FE N3 LEC

4.2.3 INDIRECT VISION – 50TH %ILE MALE DRIVER

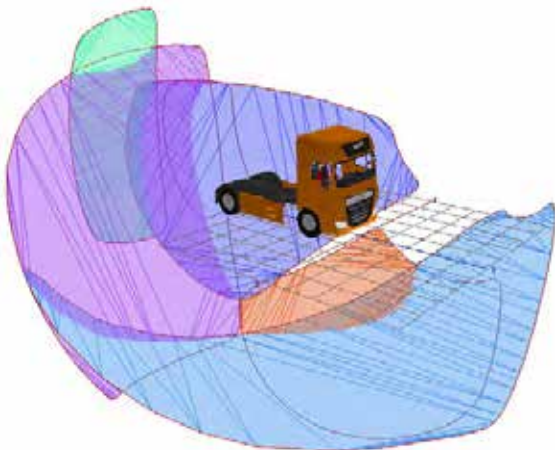
4.2.3.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	20.74
Class IV – Pass	100.57
Class II – Driver	41.68
Class IV – Driver	136.01
Class V	98.14
Class VI	242.55
Total	639.70

Figure 678. Indirect FOV area projection for the DAF CF N3 / N3G

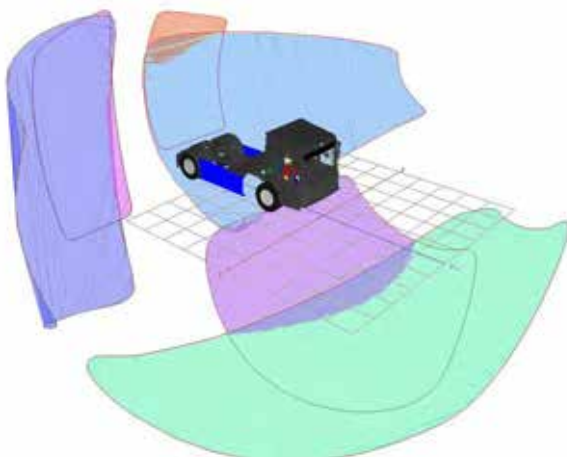
4.2.3.2 DAF XF CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	20.77
Class IV – Pass	113.36
Class II – Driver	43.09
Class IV – Driver	164.27
Class V	96.20
Class VI	246.15
Total	683.85

Figure 679. Indirect FOV area projection for the DAF XF N3

4.2.3.3 DENNIS EAGLE N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	21.94
Class IV – Pass	88.14
Class II – Driver	41.60
Class IV – Driver	131.98
Class V	104.21
Class VI	197.72
Total	585.59

Figure 680. Indirect FOV area projection for the Dennis N3 LEC

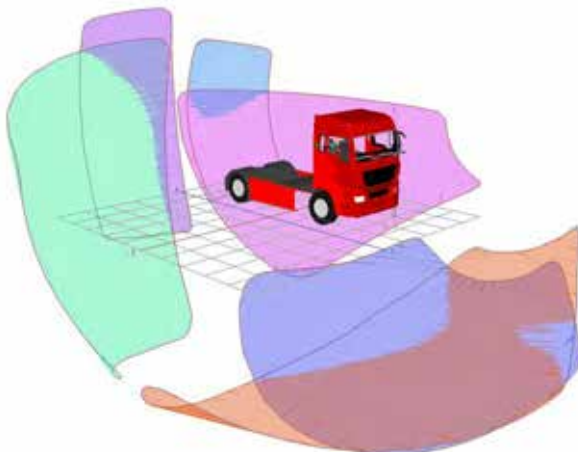
4.2.3.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	23.09
Class IV – Pass	80.58
Class II – Driver	45.06
Class IV – Driver	128.90
Class V	133.32
Class VI	191.06
Total	602.01

Figure 681. Indirect FOV area projection for the MAN TGS N3 / N3G

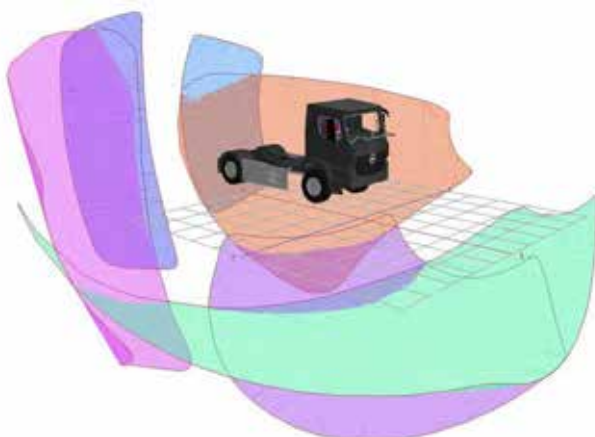
4.2.3.5 MAN TGX CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	23.09
Class IV – Pass	80.58
Class II – Driver	45.06
Class IV – Driver	128.90
Class V	133.32
Class VI	191.06
Total	602.01

Figure 682. Indirect FOV area projection for the MAN TGX N3 / N3G

4.2.3.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	26.91
Class IV – Pass	96.41
Class II – Driver	45.13
Class IV – Driver	137
Class V	139.99
Class VI	264.02
Total	709.46

Figure 683. Indirect FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

4.2.3.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	23.83
Class IV – Pass	88.72
Class II – Driver	47.33
Class IV – Driver	152.66
Class V	133.81
Class VI	258.10
Total	704.45

Figure 684. Indirect FOV area projection for the Mercedes Econic N3 LEC

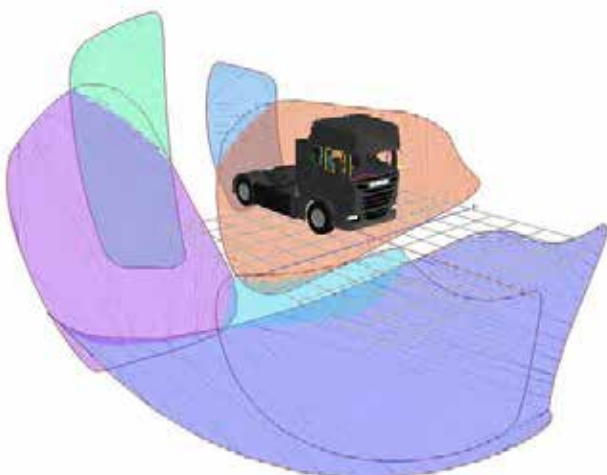
4.2.3.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	23.09
Class IV – Pass	80.58
Class II – Driver	45.06
Class IV – Driver	128.90
Class V	133.32
Class VI	191.06
Total	602.01

Figure 685. Indirect FOV area projection for the Scania P N3 / N3G

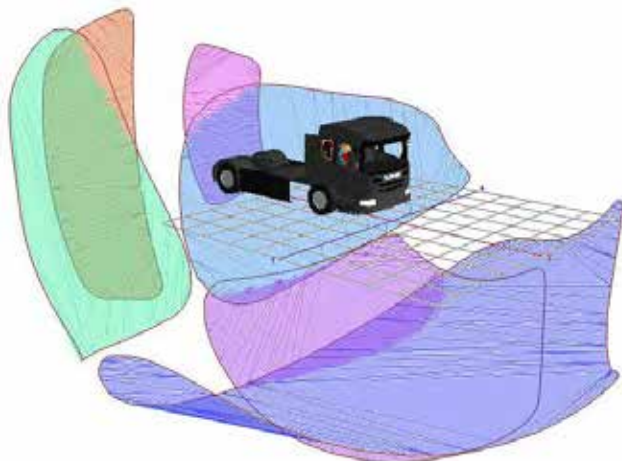
4.2.3.9 SCANIA R CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	19.53
Class IV – Pass	78.18
Class II – Driver	45.64
Class IV – Driver	109.15
Class V	115.55
Class VI	242.76
Total	610.81

Figure 686. Indirect FOV area projection for the Scania R N3

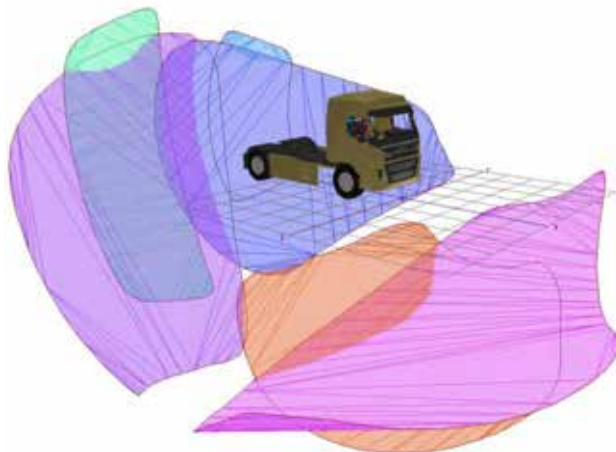
4.2.3.10 SCANIA P N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	18.62
Class IV – Pass	77.94
Class II – Driver	47.62
Class IV – Driver	111.96
Class V	105.89
Class VI	224.93
Total	586.96

Figure 687. Indirect FOV area projection for the Scania N3 LEC

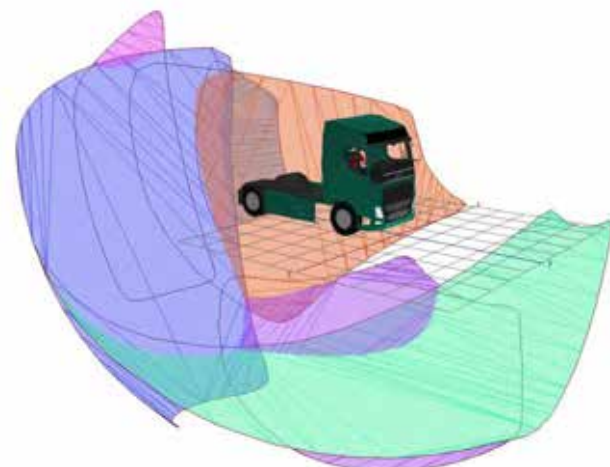
4.2.3.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	22.98
Class IV – Pass	94.73
Class II – Driver	51.08
Class IV – Driver	136.94
Class V	114.94
Class VI	194.42
Total	614.58

Figure 688. Indirect FOV area projection for the Volvo FM N3 / FMX N3G

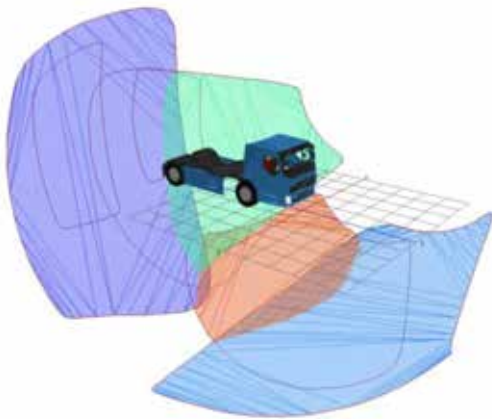
4.2.3.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	22.88
Class IV – Pass	110.75
Class II – Driver	50.35
Class IV – Driver	162.09
Class V	116.21
Class VI	237.02
Total	699.30

Figure 689. Indirect FOV area projection for the Volvo FH N3

4.2.3.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

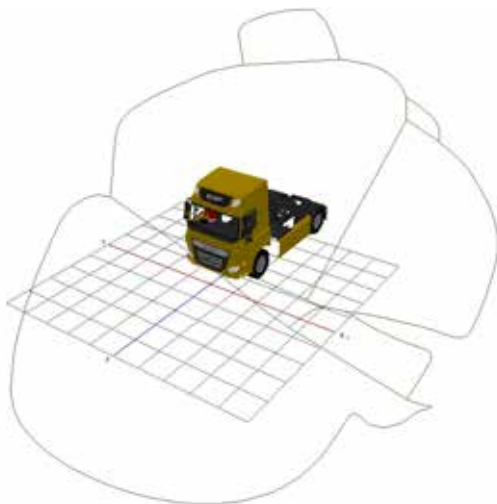


Mirror	Area(m ²)
Class II – Pass	20.21
Class IV – Pass	116.28
Class II – Driver	37.82
Class IV – Driver	186.38
Class V	102.30
Class VI	167.43
Total	630.42

Figure 690. Indirect FOV area projection for the Volvo FE N3 LEC

4.2.4 COMBINED INDIRECT VISION – 50TH %ILE MALE DRIVER

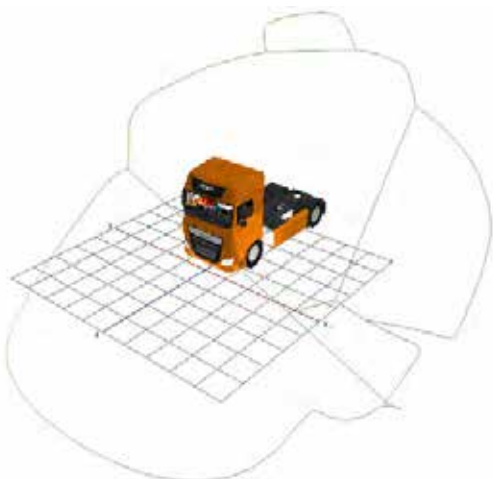
4.2.4.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	1.69
Class IV – Pass	62.95
Class II – Driver	10.06
Class IV – Driver	122.74
Class V	16.74
Class VI	240.60
Total	454.78

Figure 691. Combined indirect FOV area projection for the DAF CF N3 / N3G

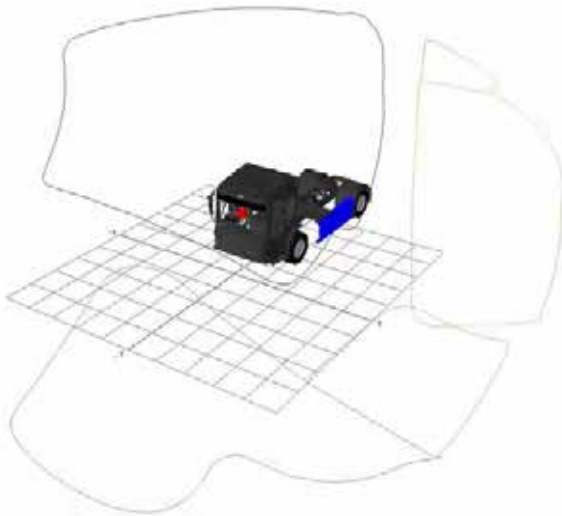
4.2.4.2 DAF XF CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	0.00
Class IV – Pass	61.20
Class II – Driver	7.26
Class IV – Driver	142.47
Class V	17.60
Class VI	234.71
Total	463.23

Figure 692. Combined indirect FOV area projection for the DAF XF N3

4.2.4.3 DENNIS EAGLE N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	4.65
Class IV – Pass	87.14
Class II & IV– Driver	134.61
Class V	43.48
Class VI	195.46
Total	465.34

Figure 693. Combined indirect FOV area projection for the Dennis N3 LEC

4.2.4.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	3.69
Class IV – Pass	77.98
Class II – Driver	6.09
Class IV – Driver	128.74
Class V	27.3
Class VI	191.06
Total	434.86

Figure 694. Combined indirect FOV area projection for the MAN TGS N3 / N3G

4.2.4.5 MAN TGX CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	7.35
Class IV – Pass	77.61
Class II – Driver	30.59
Class IV – Driver	106.84
Class V & VI	206.46
Total	428.85

Figure 695. Combined indirect FOV area projection for the MAN TGX N3 / N3G

4.2.4.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	6.51
Class IV – Pass	83.41
Class II – Driver	30.12
Class IV – Driver	94.54
Class V	27.53
Class VI	239.87
Total	481.98

Figure 696. Combined indirect FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

4.2.4.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	12.91
Class IV – Pass	78.41
Class II – Driver	31.41
Class IV – Driver	129.08
Class V	14.78
Class VI	254.60
Total	512.19

Figure 697. Combined indirect FOV area projection for the Mercedes Econic N3 LEC

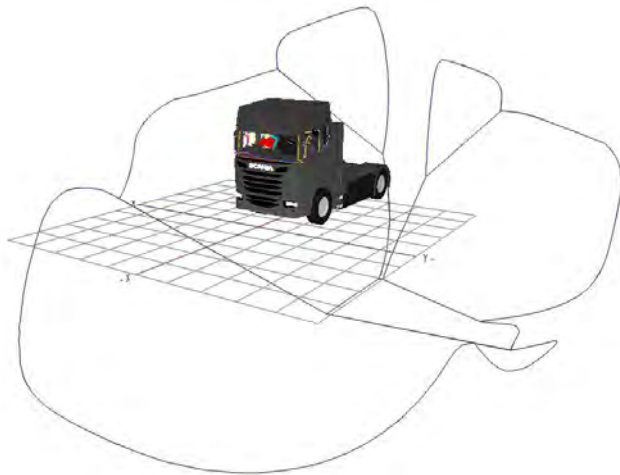
4.2.4.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	7.01
Class IV – Pass	75.02
Class II – Driver	16.16
Class IV – Driver	102.49
Class V	21.07
Class VI	232.45
Total	454.2

Figure 698. Combined indirect FOV area projection for the Scania P N3 / N3G

4.2.4.9 SCANIA R CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	10.18
Class IV – Pass	72.72
Class II – Driver	19.5
Class IV – Driver	95.46
Class V	15.59
Class VI	237.93
Total	451.38

Figure 699. Combined indirect FOV area projection for the Scania R N3

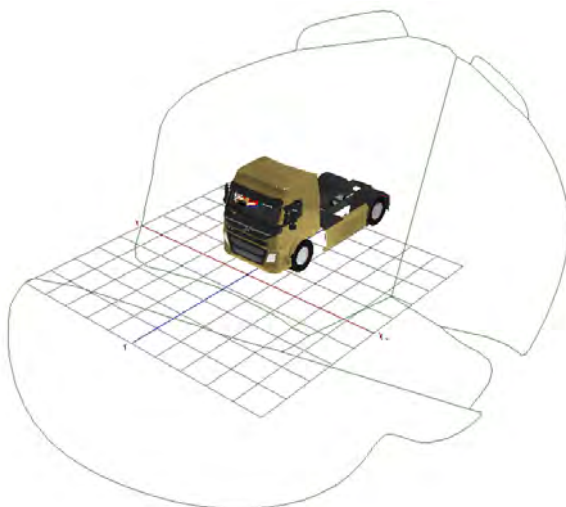
4.2.4.10 SCANIA P N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	7.66
Class IV – Pass	73.06
Class II – Driver	8.92
Class IV – Driver	109.42
Class V	35.30
Class VI	221.90
Total	456.26

Figure 700. Combined indirect FOV area projection for the Scania N3 LEC

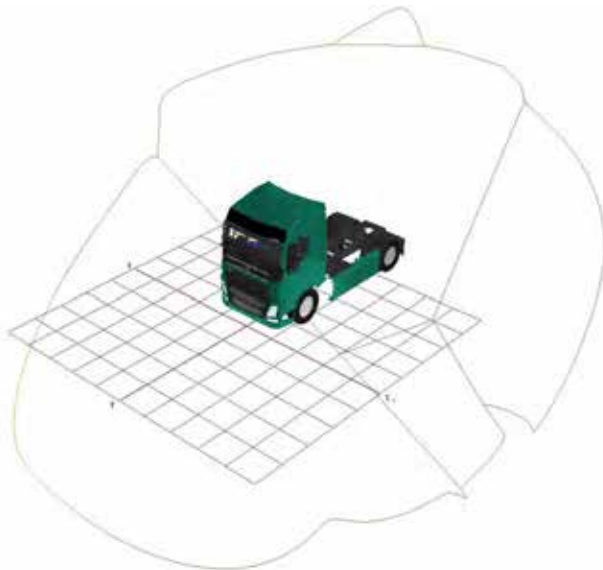
4.2.4.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	1.74
Class IV – Pass	72.28
Class II – Driver	4.61
Class IV – Driver	128.05
Class V	29.96
Class VI	189.20
Total	425.85

Figure 701. Combined indirect FOV area projection for the Volvo FM N3 / FMX N3G

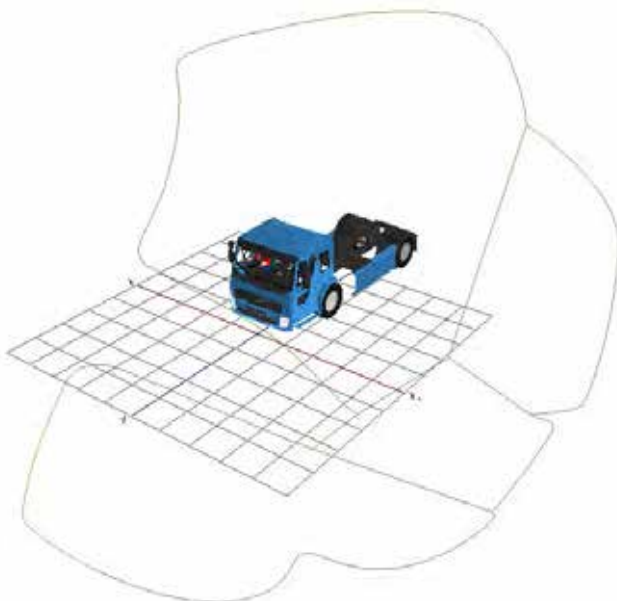
4.2.4.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	0.02
Class IV – Pass	68.12
Class II – Driver	2.93
Class IV – Driver	121.56
Class V	24.15
Class VI	231.22
Total	448.00

Figure 702. Combined indirect FOV area projection for the Volvo FH N3

4.2.4.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

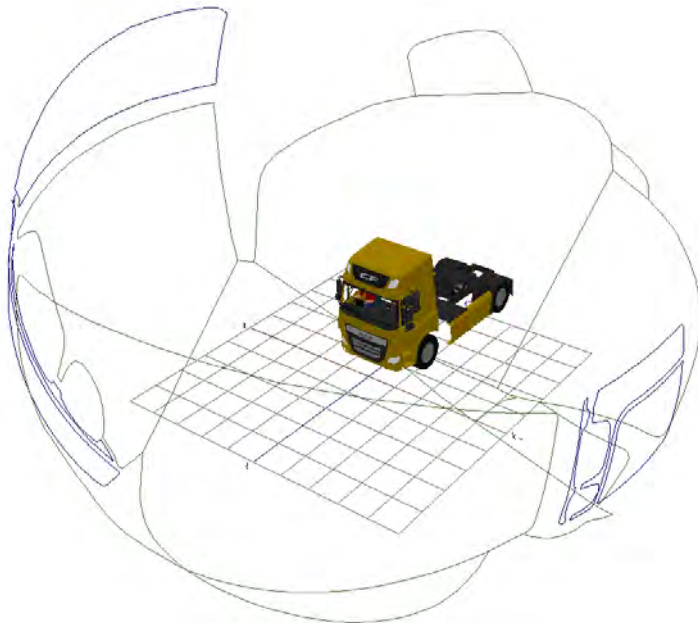


Mirror	Area(m ²)
Class II – Pass	0.00
Class IV – Pass	59.08
Class II – Driver	0.00
Class IV – Driver	179.42
Class V	41.93
Class VI	163.34
Total	443.76

Figure 703. Combined indirect FOV area projection for the Volvo FE N3 LEC

4.2.5 COMBINED DIRECT AND INDIRECT VISION – 50TH %ILE MALE DRIVER

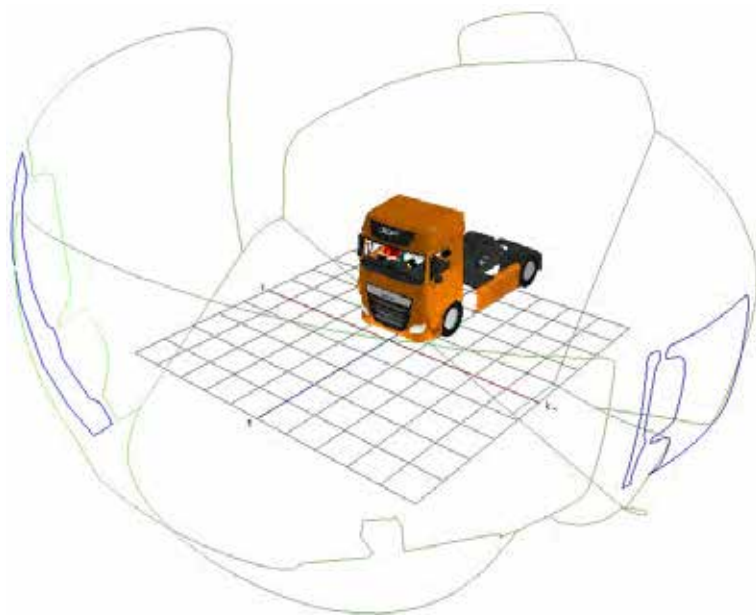
4.2.5.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	93.71
Passenger – p1	0.18
Passenger – p2	0.46
Passenger – p3	4.12
Passenger – p4	8.29
Driver – p1	73.13
Driver – p2	33.57
Driver – p3	20.06
Driver – p4	1.84
Class II – Pass	1.69
Class IV – Pass	62.95
Class II – Driver	10.06
Class IV – Driver	122.74
Class V	16.74
Class VI	237.39
Total	686.93

Figure 704. Combined direct and indirect FOV area projection for the DAF CF N3 / N3G

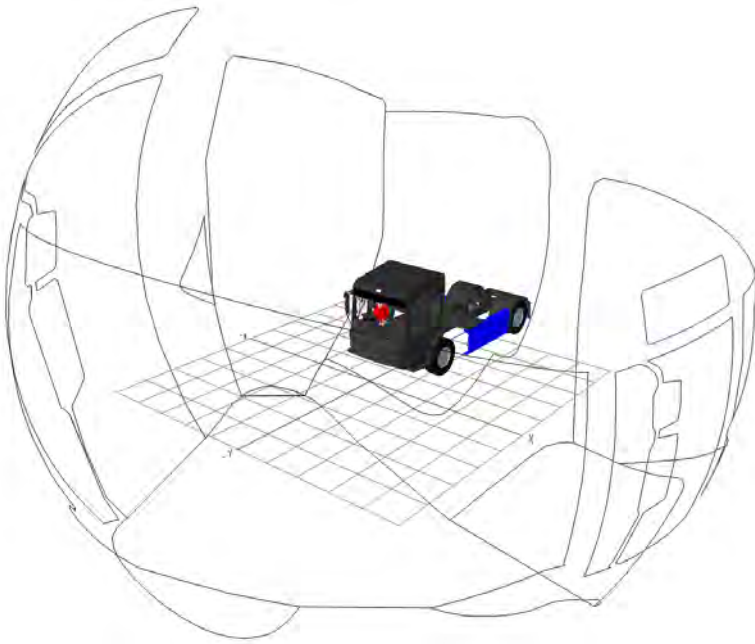
4.2.5.2 DAF XF CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	86.49
Passenger – p1	0.75
Passenger – p2	9.59
Driver – p1	15.22
Driver – p2	86.13
Class II – Pass	0.00
Class IV – Pass	61.20
Class II – Driver	7.26
Class IV – Driver	142.47
Class V	17.60
Class VI	235.86
Total	661.93

Figure 705. Combined direct and indirect FOV area projection for the DAF XF N3

4.2.5.3 DENNIS EAGLE N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	93.41
Passenger – p1	3.3
Passenger – p2	4.86
Passenger – p3	13.07
Passenger – p4	1.46
Passenger – p5	3.61
Driver – p1	79.12
Driver – p2	13.00
Driver – p3	68.45
Driver – p4	28.29
Class II – Pass	4.65
Class IV – Pass	86.52
Class II & IV– Driver	78.06
Class V	43.44
Class VI	193.94
Total	715.18

Figure 706. Combined direct and indirect FOV area projection for the Dennis N3 LEC

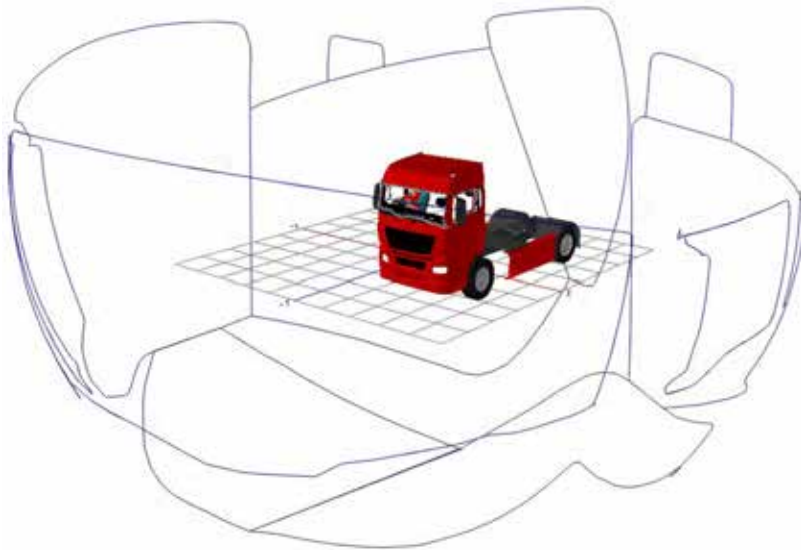
4.2.5.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	92.07
Passenger – p1	0.51
Passenger – p2	12.32
Passenger – p3	1.86
Driver – p1	1.93
Driver – p2	106.44
Driver – p3	14.49
Class II – Pass	3.69
Class IV – Pass	77.88
Class II – Driver	6.09
Class IV– Driver	119.01
Class V	27.3
Class VI	181.68
Total	645.27

Figure 707. Combined direct and indirect FOV area projection for the MAN TGS N3 / N3G

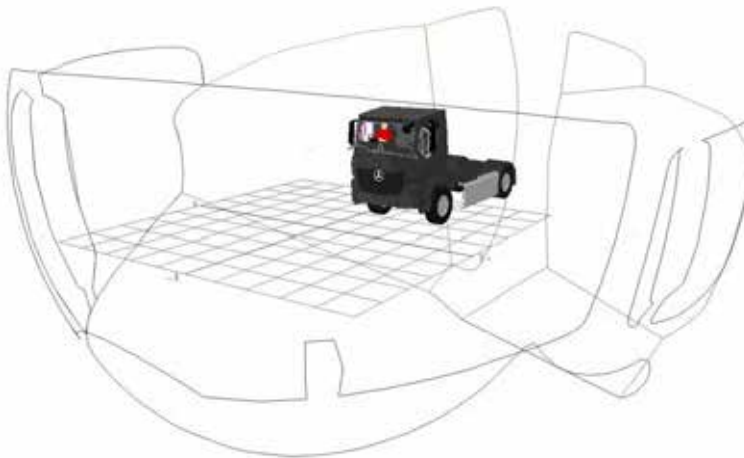
4.2.5.5 MAN TGX CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	84.34
Passenger – p1	10.59
Passenger – p2	2.05
Driver – p1	4.37
Driver – p2	86.2
Driver – p3	2.2
Class II – Pass	7.35
Class IV – Pass	77.61
Class II – Driver	30.59
Class IV – Driver	103.13
Class V & VI	204.57
Total	613.00

Figure 708. Combined direct and indirect FOV area projection for the MAN TGX N3 / N3G

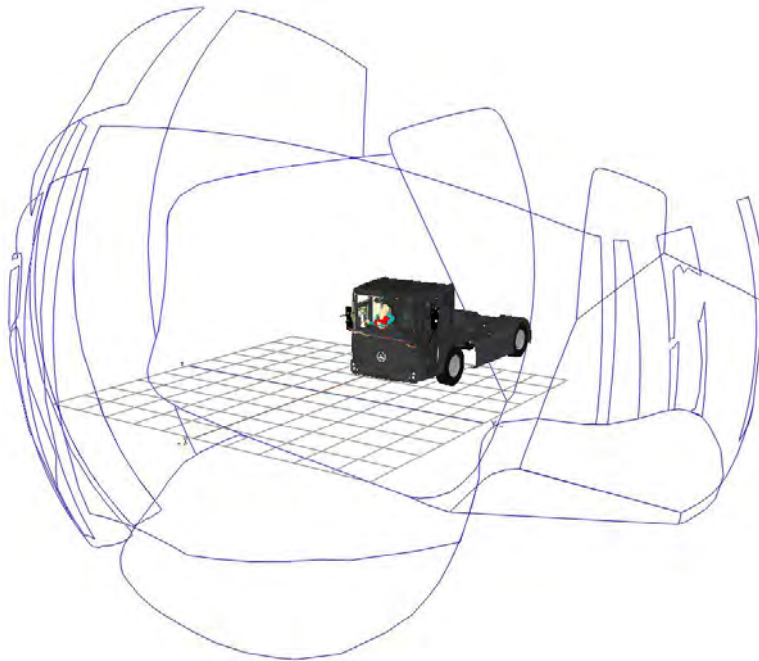
4.2.5.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Mirror	Area(m ²)
Windscreen	83.67
Passenger – p1	1.6
Passenger – p2	12.61
Driver – p1	13.42
Driver – p2	38.24
Class II – Pass	6.51
Class IV – Pass	83.41
Class II – Driver	30.12
Class IV – Driver	94.54
Class V	27.53
Class VI	239.87
Total	631.52

Figure 709. Combined direct and indirect FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

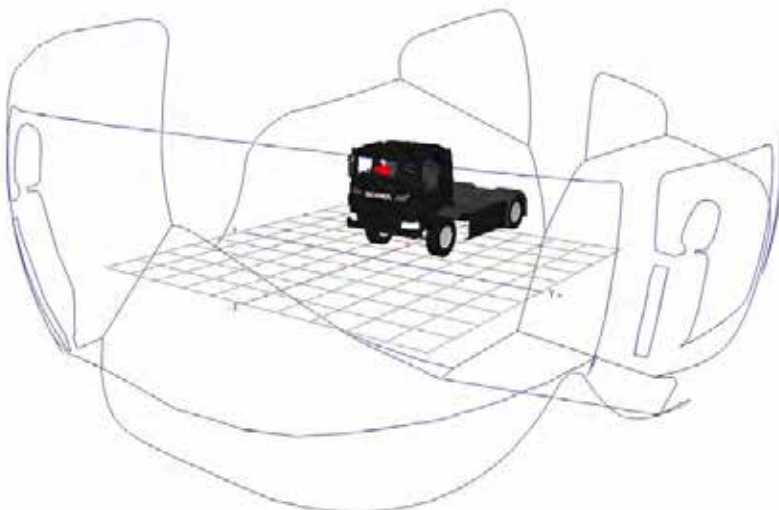
4.2.5.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	89.3
Passenger – p1	2.1
Passenger – p2	1.26
Passenger – p3	0.3
Passenger – p4	0.51
Passenger – p5	6.71
Passenger – p6	14.55
Driver – p1	9.85
Driver – p2	10.52
Driver – p3	21.68
Driver – p4	25.66
Driver – p5	26.1
Driver – p6	45.01
Class II – Pass	12.98
Class IV – Pass	77.78
Class II – Driver	31.41
Class IV – Driver	129.08
Class V	14.78
Class VI	254.59
Total	774.17

Figure 710. Combined direct and indirect FOV area projection for the Mercedes Econic N3 LEC

4.2.5.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	77.19
Passenger – p1	0.78
Passenger – p2	11.88
Passenger – p3	3.06
Driver – p1	3.17
Driver – p2	64.07
Class II – Pass	7.01
Class IV – Pass	75.02
Class II – Driver	16.16
Class IV – Driver	102.49
Class V	21.07
Class VI	229.33
Total	611.23

Figure 711. Combined direct and indirect FOV area projection for the Scania P N3 / N3G

4.2.5.9 SCANIA R CATEGORY N3 DISTRIBUTION

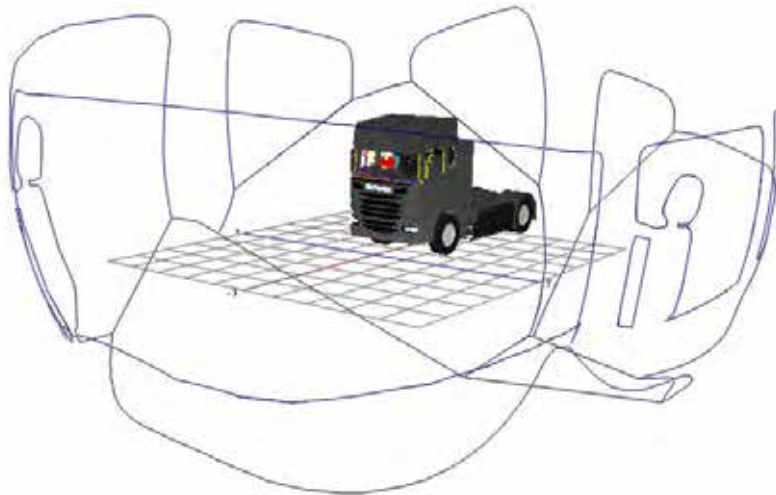


Figure 712. Combined direct and indirect FOV area projection for the Scania R N3

Window	Area(m2)
Windscreen	77.18
Passenger – p1	0.78
Passenger – p2	11.88
Passenger – p3	19.56
Driver – p1	3.17
Driver – p2	63.84
Driver – p3	6.96
Class II – Pass	10.18
Class IV – Pass	72.62
Class II – Driver	19.5
Class IV– Driver	91.89
Class V	15.59
Class VI	236.17
Total	629.32

4.2.5.10 SCANIA P N3 LOW ENTRY CAB

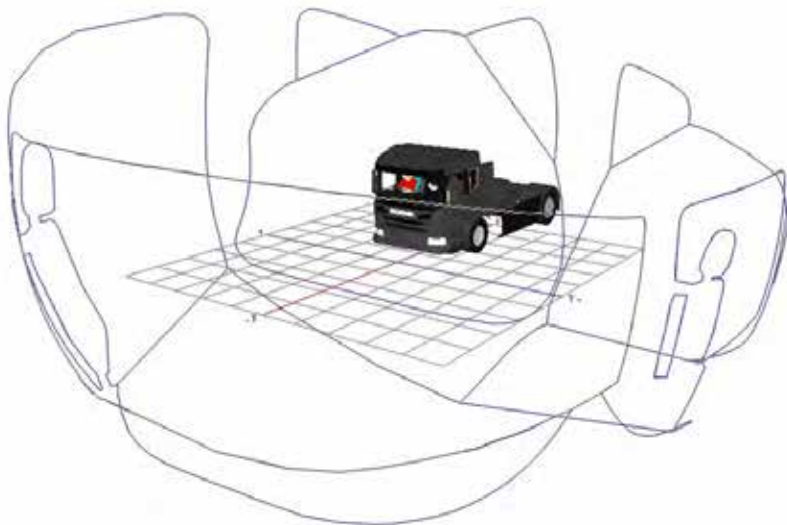
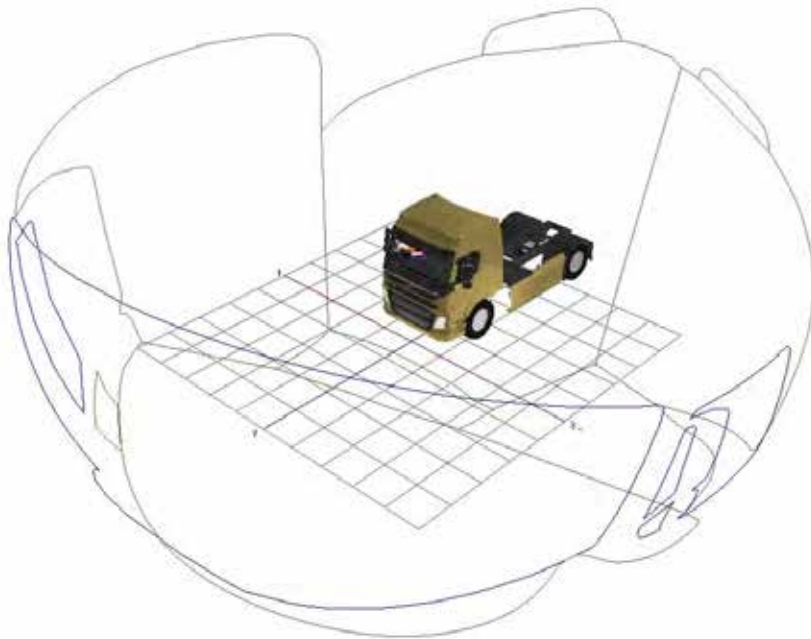


Figure 713. Combined direct and indirect FOV area projection for the Scania N3 LEC

Window	Area(m2)
Windscreen	77.92
Passenger – p1	0.75
Passenger – p2	11.1
Passenger – p3	5.89
Driver – p1	3.74
Driver – p2	81.86
Driver – p3	5.44
Class II – Pass	7.66
Class IV – Pass	73.01
Class II – Driver	8.92
Class IV– Driver	109.7
Class V	35.3
Class VI	211.45
Total	632.74

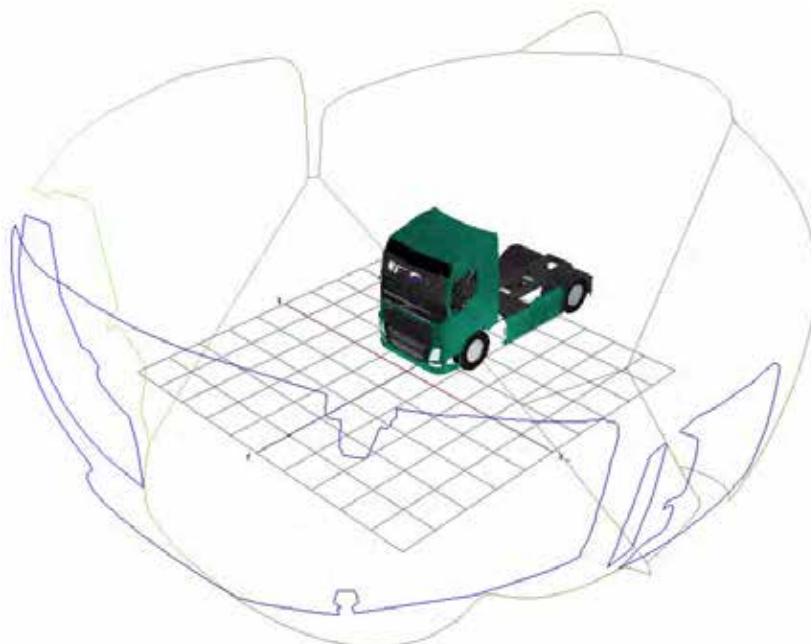
4.2.5.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Window	Area(m ²)
Windscreen	98.72
Passenger – p1	8.54
Passenger – p2	0.97
Passenger – p3	0.45
Driver – p1	86.80
Driver – p1a	1.87
Driver – p2	7.62
Class II – Pass	1.74
Class IV – Pass	72.28
Class II – Driver	4.61
Class IV – Driver	122.66
Class V	29.96
Class VI	187.68
Total	623.90

Figure 714. Combined direct and indirect FOV area projection for the Volvo FM N3 / FMX N3G

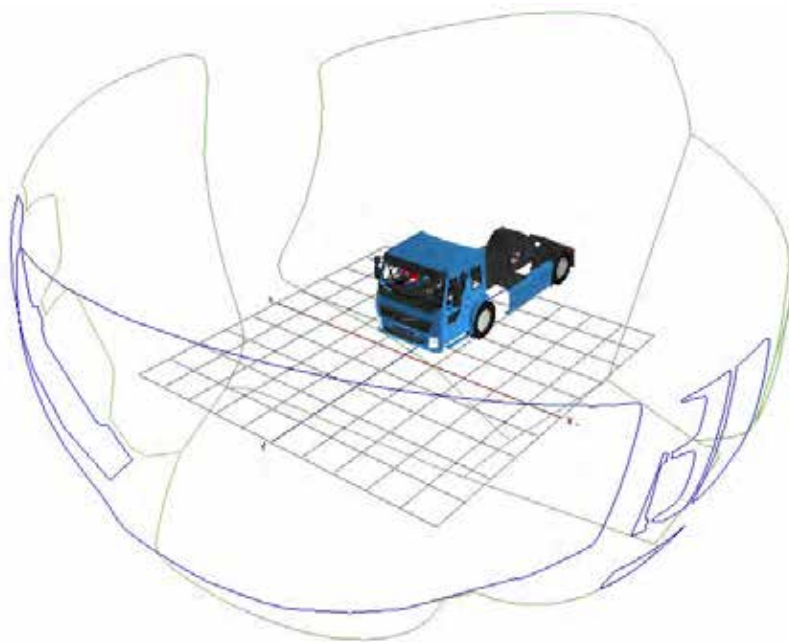
4.2.5.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	93.70
Passenger – p1	11.38
Passenger – p2	1.46
Driver – p1	60.64
Driver – p2	19.83
Class II – Pass	0.02
Class IV – Pass	68.12
Class II – Driver	2.93
Class IV – Driver	121.56
Class V	24.15
Class VI	231.82
Total	635.61

Figure 715. Combined direct and indirect FOV area projection for the Volvo FH N3

4.2.5.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	90.67
Passenger – p1	5.86
Passenger – p2	3.09
Passenger – p3	0.41
Passenger - Cab	5.61
Passenger - Door	2.41
Driver – p1	78.83
Driver – p2	17.10
Class II – Pass	0.00
Class IV – Pass	59.14
Class II – Driver	0.00
Class IV – Driver	179.42
Class V	41.93
Class VI	162.62
Total	647.09

Figure 716. Combined direct and indirect FOV area projection for the Volvo FE N3 LEC

5 SUMMARY OF THE RESULTS

The following section summarises the results of the VRU Visibility and the FOV Area analyses.

5.1 VRU VISIBILITY

Table 3 shows the complete data for the VRU visibility analyses.

Manufacturer	Model	Driver	VRU Obscuration Distances (mm)						
			Pedestrians			Offside Cyclists		Nearside Cyclists	
			Left	Centre	Right	Front	Rear	Front	Rear
DAF	CF N3	50th Male	154	144	163	Visible	Visible	230	848
	CF N3G	50th Male	463	429	453	Visible	Visible	744	1472
	XF	50th Male	962	432	622	Visible	53	1452	1827
Dennis	LEC	50th Male	Visible	Visible	Visible	Visible	Visible	Visible	Visible
MAN	TGS N3	50th Male	546	613	1122	0 ¹⁰	160	760	1951
	TGS N3G	50th Male	786	789	1296	0	240	1102	2218
	TGX	50th Male	843	647	1140	0	297	1220	2592
Mercedes	Antos N3	50th Male	40	0	95	Visible	Visible	359	300
	Arocs N3G	50th Male	751	623	1034	120	0	1115	1356
	Actros	50th Male	749	624	1084	120	0	1114	1316
	Econic LEC	50th Male	Visible	Visible	Visible	Visible	Visible	Visible	Visible
Scania	P N3	50th Male	Visible	Visible	Visible	Visible	Visible	Visible	Visible
	P N3G	50th Male	219	224	751	Visible	0	769	1315
	R	50th Male	295	391	781	Visible	277	1260	1766
	LEC	50th Male	Visible	Visible	Visible	Visible	Visible	Visible	Visible
Volvo	FM N3	50th Male	Visible	Visible	191	Visible	Visible	354	186
	FMX N3G	50th Male	124	71	447	Visible	Visible	462	526
	FH	50th Male	652	621	1404	Visible	Visible	725	1255
	FE LEC	50th Male	Visible	Visible	Visible	Visible	Visible	Visible	Visible

Table 3. Table of VRU visibility distances for the assessed vehicles

The following Figures (717-720) further illustrate these results for each of the vehicles assessed grouped by vehicle category. The Illustrations show the vehicle in plan view with the VRUs positioned at their maximum distance from the vehicle at which they are fully obscured. VRUs coloured in red are obscured in the positions shown, those coloured green are visible in the locations shown and cannot be obscured from direct vision in the assessed locations.

¹⁰ Note that obscuration distances of 0mm indicate that the VRU can be obscured but only when positioned directly against the side of the vehicle

5.1.1 CONSTRUCTION VARIANTS (CATEGORY N3G)

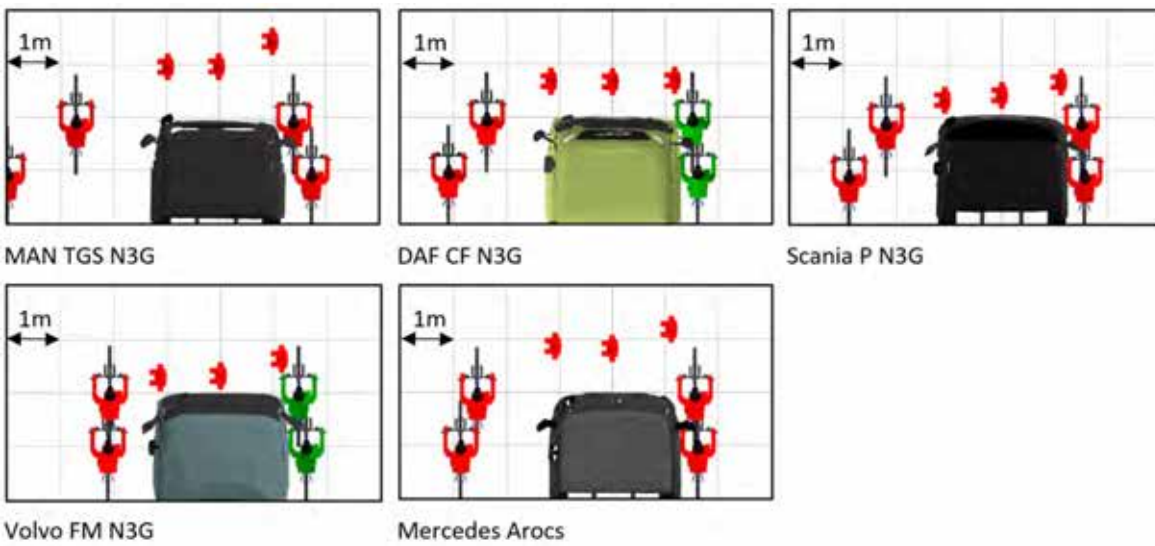


Figure 717. Illustrations of the cyclist and pedestrian models at the maximum distance at which they can be fully obscured from the driver of the Construction vehicles

5.1.2 DISTRIBUTION VARIANTS (CATEGORY N3)

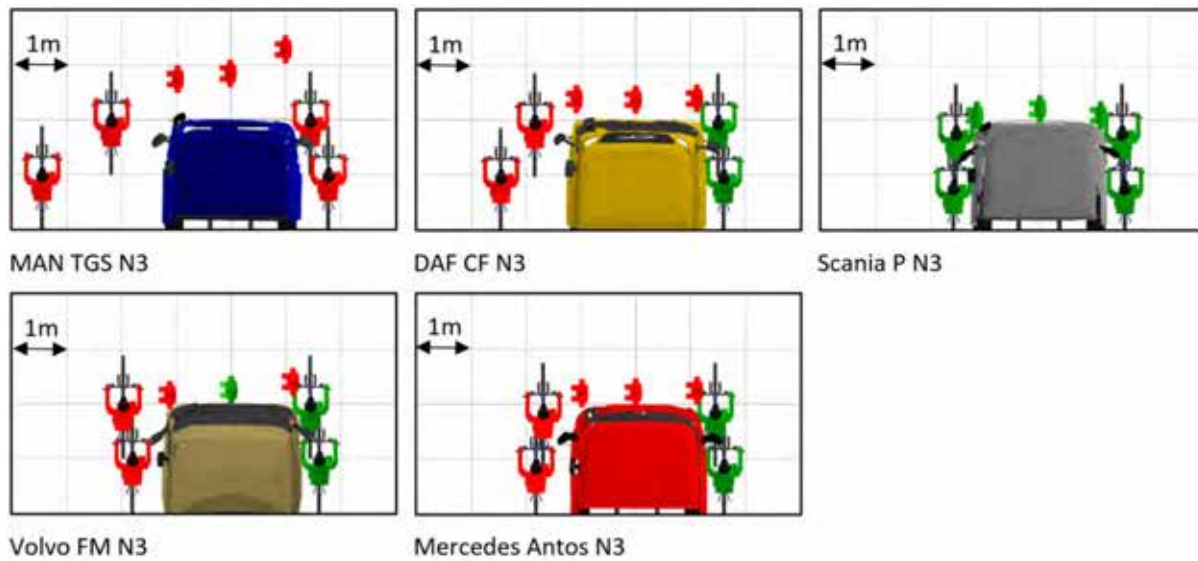


Figure 718. Illustrations of the cyclist and pedestrian models at the maximum distance at which they can be fully obscured from the driver of the distribution vehicles

5.1.3 LARGE DISTRIBUTION (CATEGORY N3)

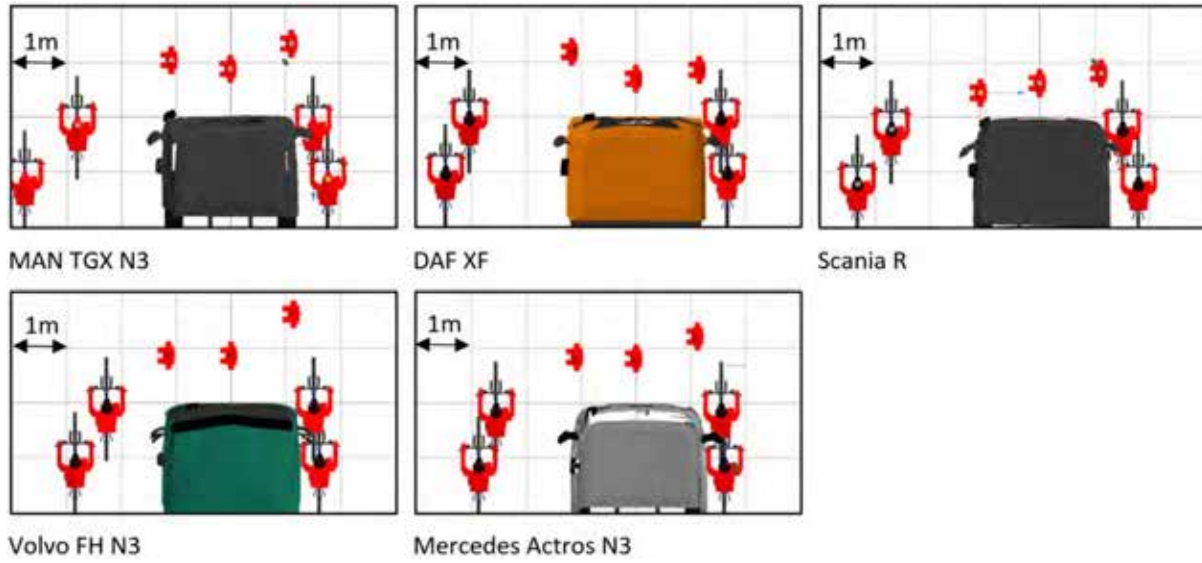


Figure 719. Illustrations of the cyclist and pedestrian models at the maximum distance at which they can be fully obscured from the driver of the large distribution vehicles

5.1.4 LOW ENTRY CABS (CATEGORY N3)

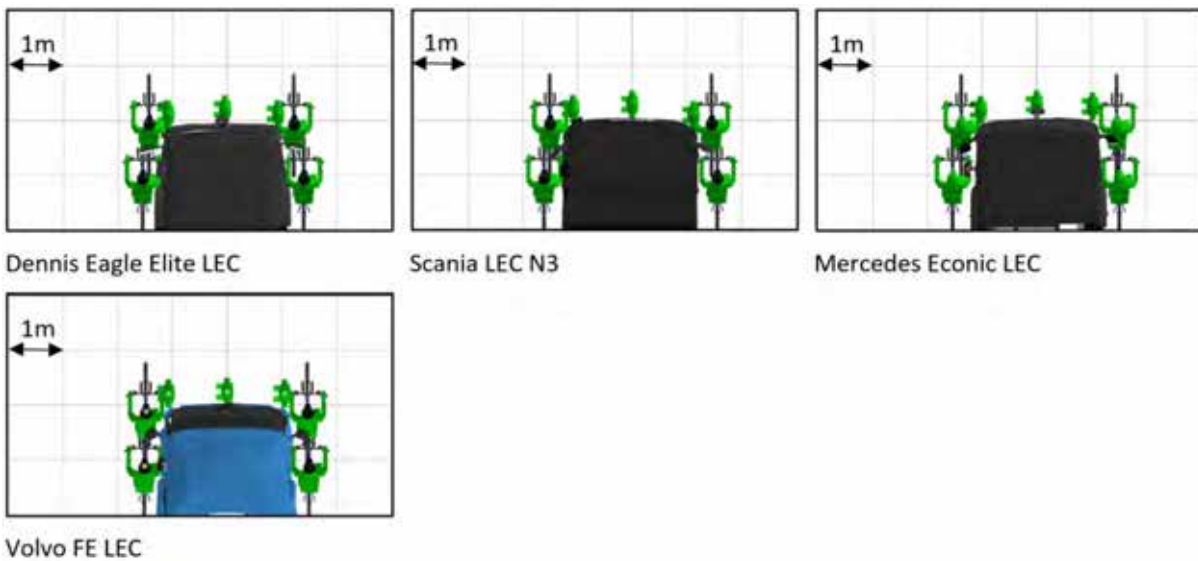


Figure 720. Illustrations of the cyclist and pedestrian models at the maximum distance at which they can be fully obscured from the driver of the large low entry cab vehicles

5.1.5 VRU OBSCURATION RANGES

The graphs shown in Figure 721 and Figure 722 show how far away a cyclist can get from the passenger side of the assessed vehicles without being visible to the driver using direct vision through the windows.

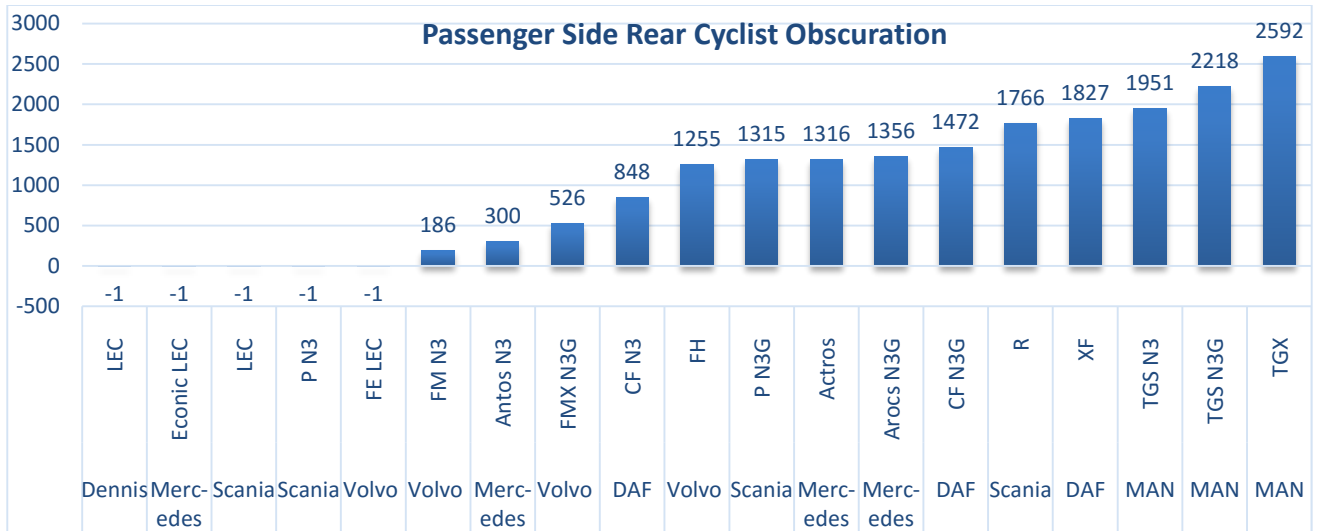
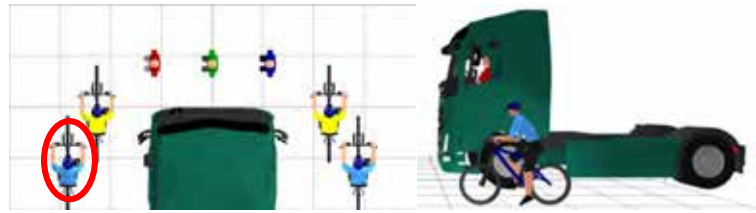


Figure 721. Graph showing the distance in metres from the side of the cab to the passenger side rear cyclist

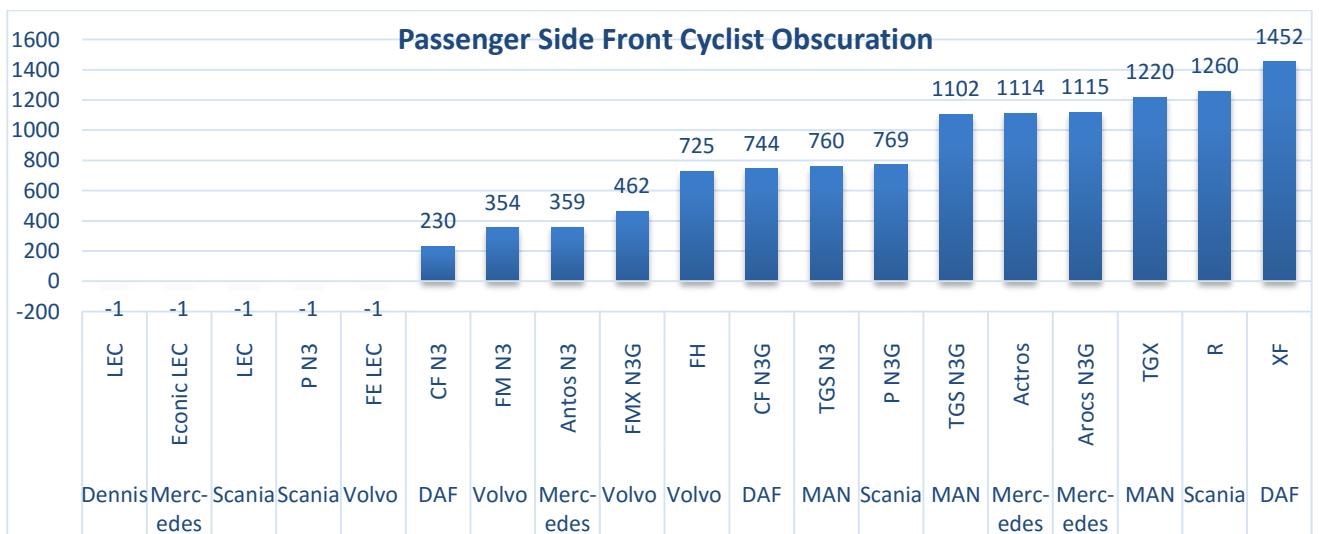
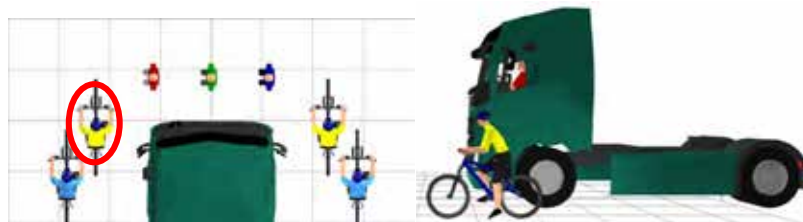


Figure 722. Graph showing the distance in metres from the side of the cab to the passenger side front cyclist

The graphs shown in Figure 723, Figure 724 and Figure 725 show how far away a pedestrian can get from the front of the assessed vehicles without being visible to the driver using direct vision through the windows.

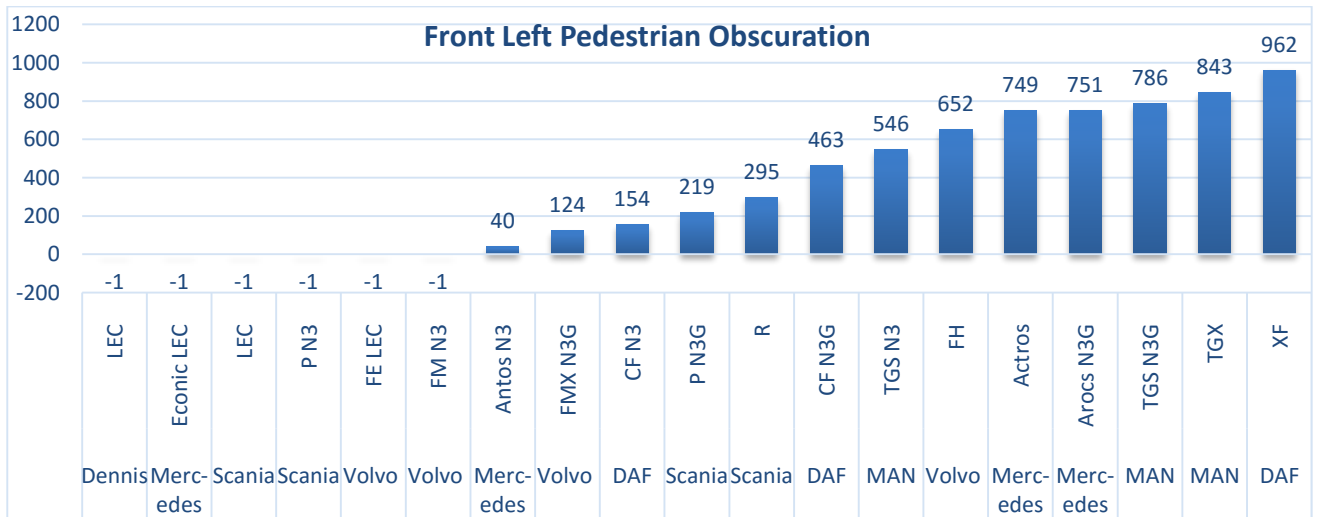
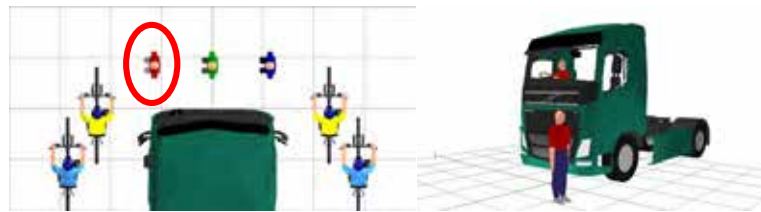


Figure 723. Graph showing the distance in metres from the front of the cab to the left pedestrian

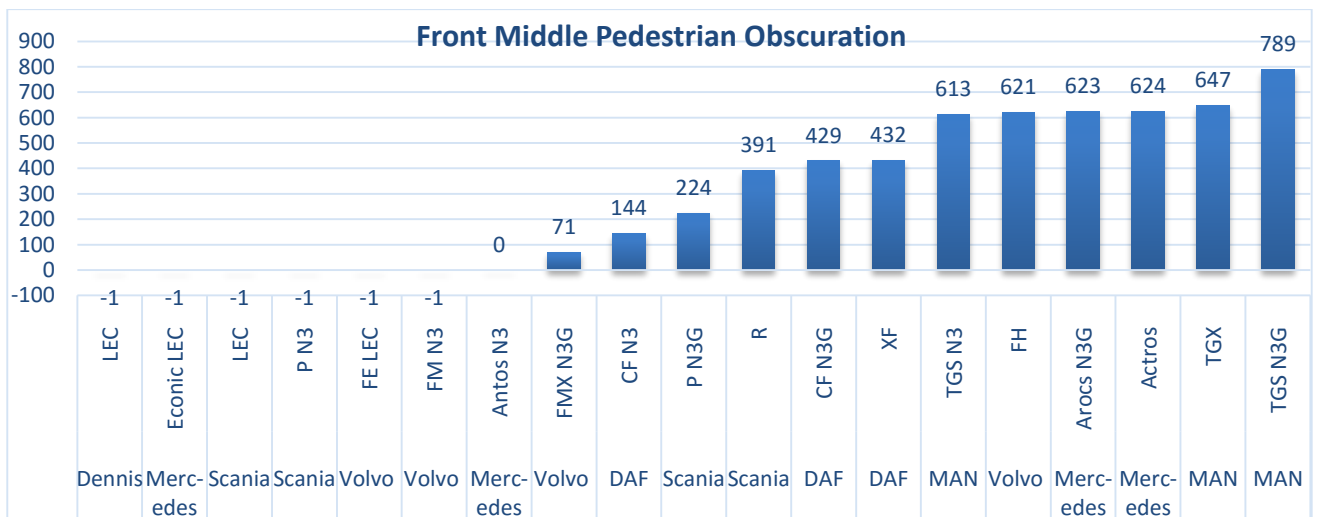
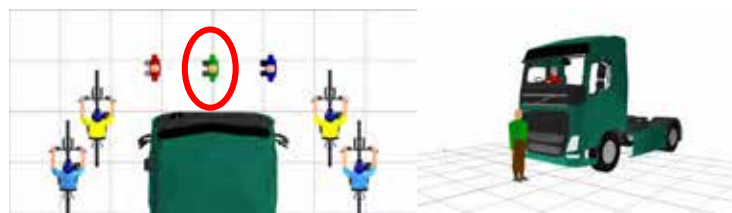


Figure 724. Graph showing the distance in metres from the front of the cab to the middle pedestrian

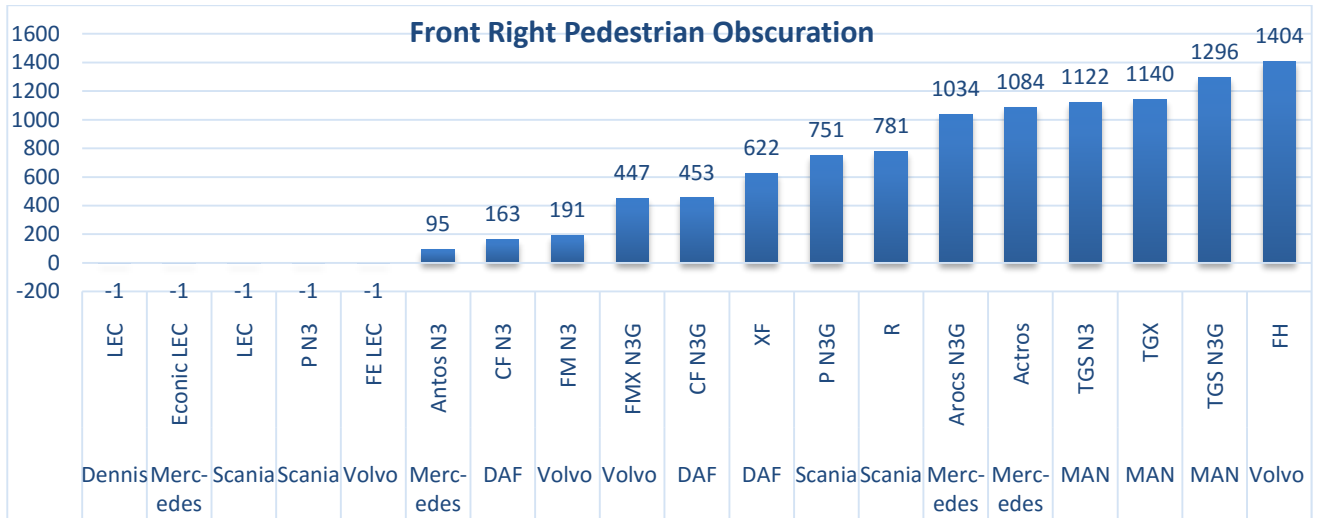
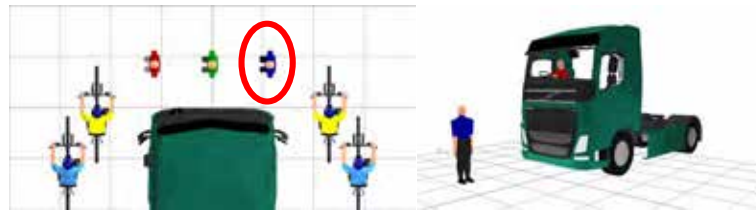


Figure 725. Graph showing the distance in metres from the front of the cab to the right pedestrian

5.2 FOV AREA ANALYSIS

Table 4 shows the complete data for the FOV Area projection analyses for the assessed vehicles.

Manufacturer	Model	Driver	Spherical Projection Areas (m ²)				
			Direct	Direct Clipped	Indirect	Indirect Combined	All Combined
DAF	CF N3 / N3G	5th Female	282.12	169.48	639.26	457.42	718.15
		50th Male	248.37	165.81	639.7	454.78	686.93
		95th Male	214.68	157.99	638.76	450	651.76
	XF	5th Female	238.02	155.69	689.74	463.39	691.18
		50th Male	208.41	152.59	683.85	463.23	661.93
		95th Male	180.79	145.9	674.45	456.87	630.99
Dennis	LEC	5th Female	323.24	194.49	590.81	465.86	722.34
		50th Male	329.32	203.95	585.59	465.34	715.18
		95th Male	313.13	214.03	598.32	468.07	710.05
MAN	TGS N3 / N3G	5th Female	273.18	177.71	585.88	426.66	627.46
		50th Male	245.02	182.94	602.01	434.86	645.54
		95th Male	240.57	192.31	594.97	429.61	627.89
	TGX	5th Female	239.66	163.46	581.43	428.61	646.31
		50th Male	206.95	163.65	602.01	428.85	612.99
		95th Male	195.86	167.07	581.75	426.26	598.26
Mercedes	Antos N3 / Arocs N3G / Actros N3	5th Female	236.19	187.91	703.72	466.01	644.57
		50th Male	178.04	163.69	709.46	481.98	631.52
		95th Male	171.83	171.83	702.06	475.52	617.67
	Econic LEC	5th Female	357.27	157.23	700.31	520.71	787.46
		50th Male	342.71	190.25	704.45	512.19	774.17
		95th Male	323.46	186.74	697.08	518.14	765.48
Scania	P N3 / N3G	5th Female	222.83	156.41	617.92	461.6	666.01
		50th Male	166.7	139.07	602.01	454.2	611.23
		95th Male	146.99	133.49	610.74	443.16	583.97
	R	5th Female	259.42	176.9	613.26	459.84	670.77
		50th Male	204.29	165.77	610.81	451.38	629.32
		95th Male	188.96	166.45	613.74	439.07	608.84
	LEC	5th Female	269.45	180.99	615.11	475.71	678.93
		50th Male	224.71	178.56	586.96	456.26	632.74
		95th Male	193.65	168.88	580.65	453	615
Volvo	FM N3 / FMX N3G	5th Female	255.38	186.55	622.88	428.46	660.17
		50th Male	216.98	183.92	614.58	425.85	623.9
		95th Male	186.15	179.24	610.4	422.84	591.02
	FH	5th Female	249.17	195.78	697.04	451.84	664.58
		50th Male	216.8	191.95	699.3	448	635.61
		95th Male	189.28	182.56	701.38	442.42	608.12
	FE LEC	5th Female	246.23	174.14	648.33	449.06	691.72
		50th Male	204.9	161.45	630.42	443.76	647.09
		95th Male	172.68	150.51	629.53	437.75	609.72

Table 4. Table of spherical projections for the assessed vehicles

For each key metric the assessed vehicles can be compared for FOV Area. Figure 726 shows a comparison of the FOV Area for direct vision with the 50th %ile male driver.

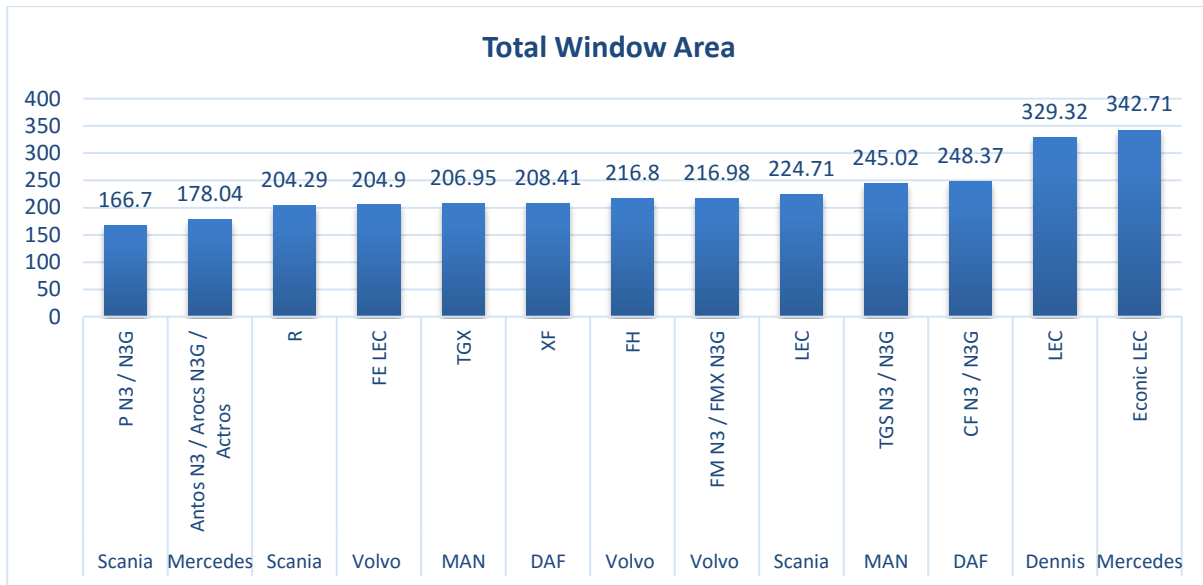


Figure 726. FOV Area comparison for direct vision and the 50th %ile male driver

Figure 726 shows a comparison of the FOV Area for direct vision with the 50th %ile male driver. In contrast to Figure 727 the spherical projections are clipped to +7 degrees above horizontal.

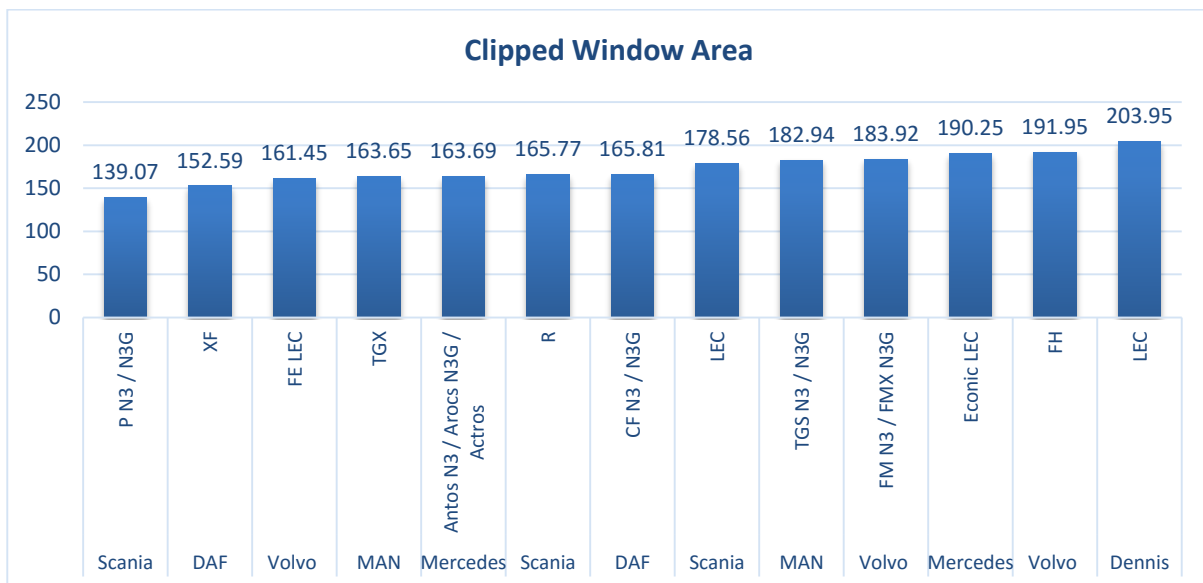


Figure 727. Clipped (+7°) FOV Area comparison for direct vision and the 50th %ile male driver

Figure 728 shows a comparison of the combined FOV Area for indirect vision with the 50th %ile male driver. These data remove any overlap between the projections of the mirrors and thus provide a true total indirect vision projection area.

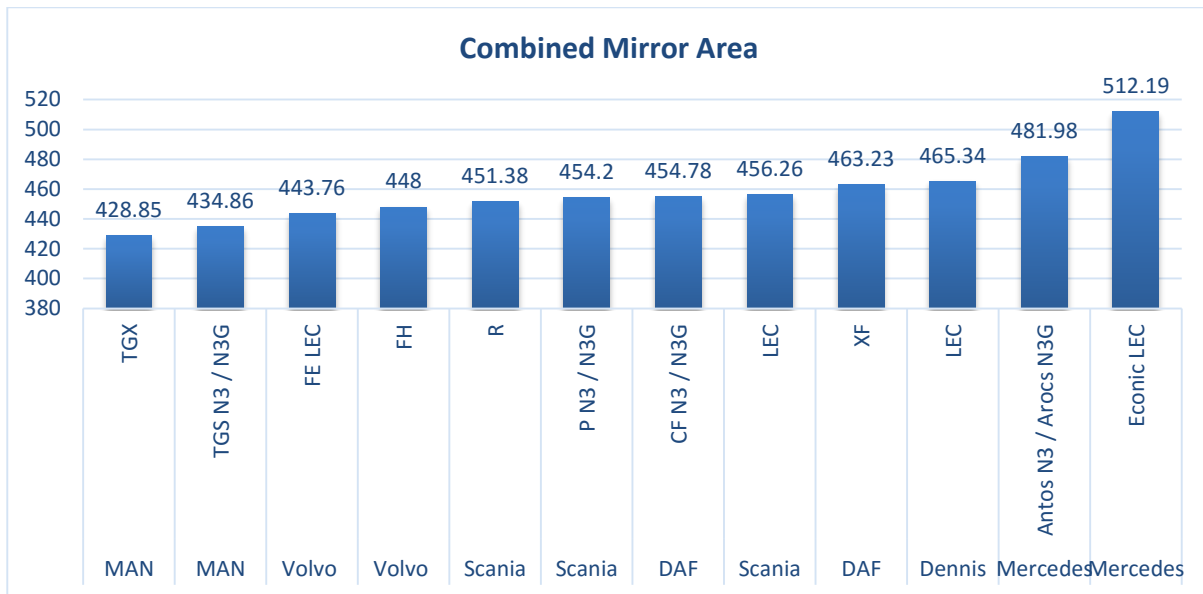


Figure 728. FOV Area comparison for combined indirect vision and the 50th %ile male driver

Figure 729 shows a comparison of the overall total combined FOV Area for direct and indirect vision with the 50th %ile male driver. These data represent the true total FOV area afforded the driver of each vehicle through windows and mirrors.

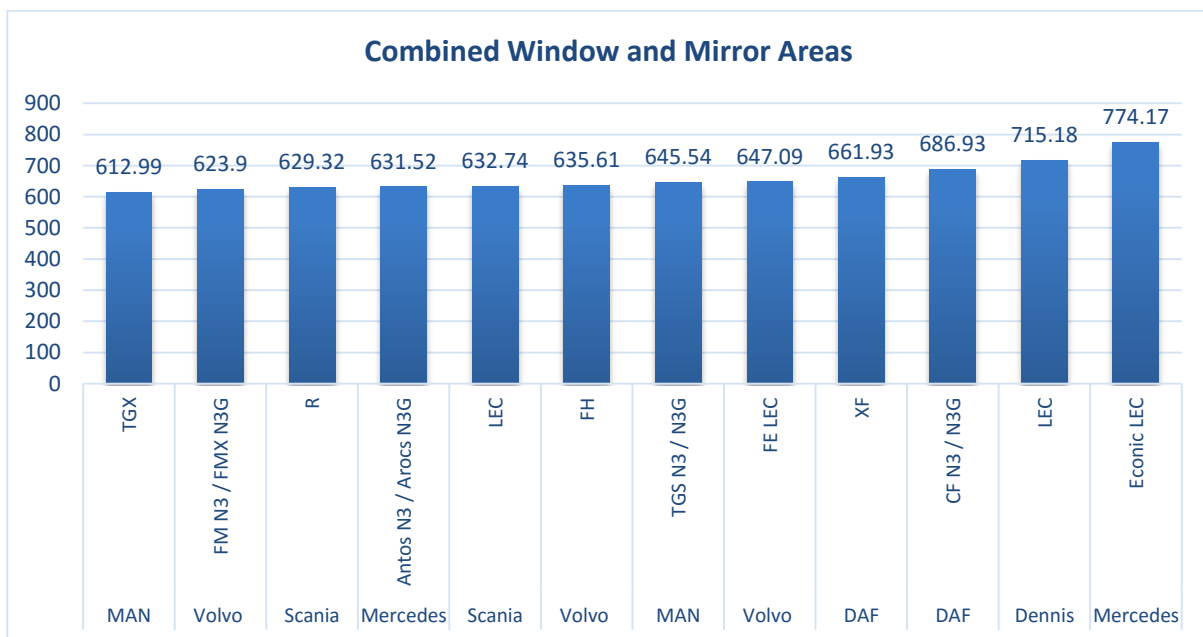


Figure 729. FOV Area comparison for combined direct vision for the 50th %ile male driver

6 DISCUSSION OF THE RESULTS

6.1 VRU VISIBILITY

6.1.1 DISCUSSION OF THE DIRECT VISION RESULTS – PASSENGER SIDE CYCLIST VISIBILITY

The LEC cab designs all perform very well in this assessment such that cyclists cannot be hidden from the view of the driver in the assessed locations. This is illustrated in Figure 720 where the cyclists can be touching the cab and would still be visible to the driver. The standard cabs show a large variation in performance, from more or less touching the cab, to nearly 3m away (see Figure 717, and). It is interesting to note that the order of vehicles in Figure 721 and Figure 722 is not the same even though the assessments are similar. For example, the MAN TGX performs significantly better for visibility of the front cyclist than for the rear. The reason for this can be seen in the design of the window on the MAN TGX as shown in Figure 732 and Figure 739 where the lower edge of the window drops towards the front providing greater visibility of the driving environment in that area. In addition it is also easy to see the impact of height of the vehicle, where the N3G construction variants that are typically higher than the N3 distribution variants but with the same cab, show consistently higher values and thus larger blind spots. This issue is discussed further in Section 6.3.3.

6.1.2 DISCUSSION OF THE DIRECT VISION RESULTS – FRONT PEDESTRIAN VISIBILITY

As with the Passenger side cyclist visibility, the LEC cab designs all perform very well at this assessment such that pedestrians cannot be hidden from the view of the driver in the assessed locations (see Figure 720). The variation in performance of the standard cabs is less than that seen for the passenger side cyclists but still varies from zero to nearly 1.5m away. As with the cyclist assessment the relative order of the vehicles varies between tests. For this assessment it is interesting to note that visibility to the front right of the cab is typically worse due to obscuration from the steering wheel. For the purpose of the testing performed, it has been assumed that any portion of the pedestrian that may be visible through the steering wheel, is actually obscured. As with the cyclist obscuration tests the height of the vehicle is a critical factor, with N3G construction variants (Figure 717) showing consistently higher values than the N3 distribution variants (See Section 6.3.3).

6.1.3 DISCUSSION OF THE VRU ANALYSIS FOR INDIRECT VISION (USE OF MIRRORS)

On first inspection the indirect vision results indicate that all but three vehicles allow all of the VRU objects that were tested in the project to be seen through the mirrors. Closer inspection of the results indicates that often only a small portion of the VRU object can be seen in a mirror, and often at the edge of the mirror. The curved nature of the mirrors that are currently used on HGVs is defined to allow a larger FOV of the areas around the vehicle. For example, the Class V which allows the driver to view the side of the passenger door and the area adjacent to it, has a radius of curvature of approximately 300mm. This produces distorted images of the objects being viewed. An illustration of the type of view that a driver receives from the mirror can be seen in Figure 730 which shows a silver car adjacent to the vehicle cab.



Figure 730. The view that a driver has of a Class V 'Look Down' mirror showing a silver car adjacent to the cab

Figure 731 shows a number of examples where a small portion of the passenger side cyclist is intersecting with the volume of space that is visible to the driver through the Class V or Class IV mirrors. The left hand and middle images show the bottom half of the bicycle wheels being visible in the Class V 'Look Down' mirror and a small portion of the cyclist's back and helmet being seen in the Class IV mirror which is a wide angle mirror looking rearwards. The right hand image shows that the rear passenger side cyclist is only visible through the Class IV mirror with a small portion of the upper body of the cyclist being visible. In all three cases shown in Figure 731 the location of cyclist indicates that the portion of the cyclists visible would be located at the edge of the mirror, in a similar manner to the car shown in Figure 730.

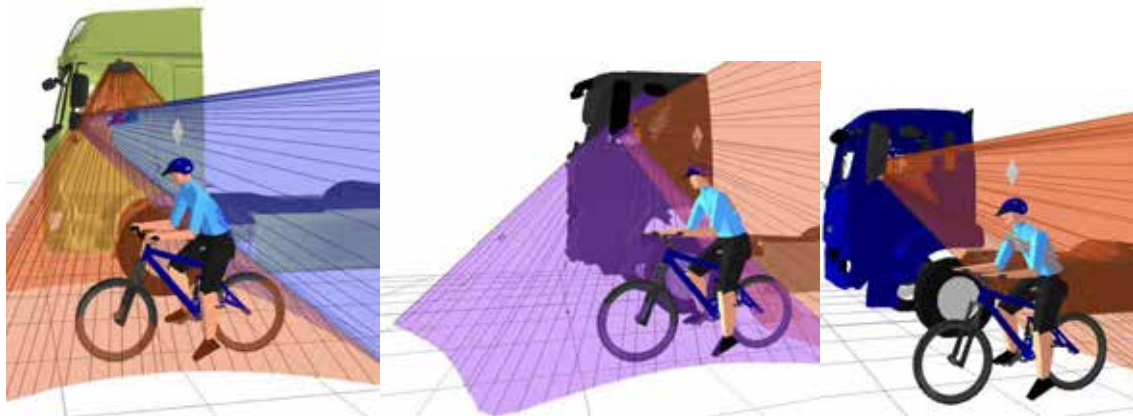


Figure 731. Examples of small portions of the VRU object intersecting with the volume of space visible through a mirror

In all cases shown in Figure 731 the cyclist is not visible to the driver through the windows. This highlights the difficulty that a driver has in determining if there is a VRU in close proximity to the vehicle. The driver must be able to use six mirrors to gain awareness and there is a time associated with the viewing of each mirror and moving the gaze to the mirror. If there is only a small portion of the VRU visible to the driver, in the distorted edge of the mirror view, then the ability of the driver to recognise the VRU is questionable. In high work load situations when multiple cyclists and pedestrians are moving round the vehicle in city centre locations, the task for the driver is difficult. This may be one of the reasons why accidents between HGVs and VRUs are still occurring even though vehicles fitted with the required mirrors should be able to see VRUs in the assessed locations around the cab through indirect vision, even if they are obscured to direct vision. It

is possible that these results indicate that a reliance on indirect vision via mirrors is an unreliable means of detecting the presence of VRUs in close proximity to the vehicle. If this is the case this reinforces the message that direct vision should be prioritised. As an example of this, all of the cyclists shown in Figure 732 are not visible to the driver via direct vision through the windows, with the eye point being determined by a standard sitting position (i.e. without leaning to improve the field of view).

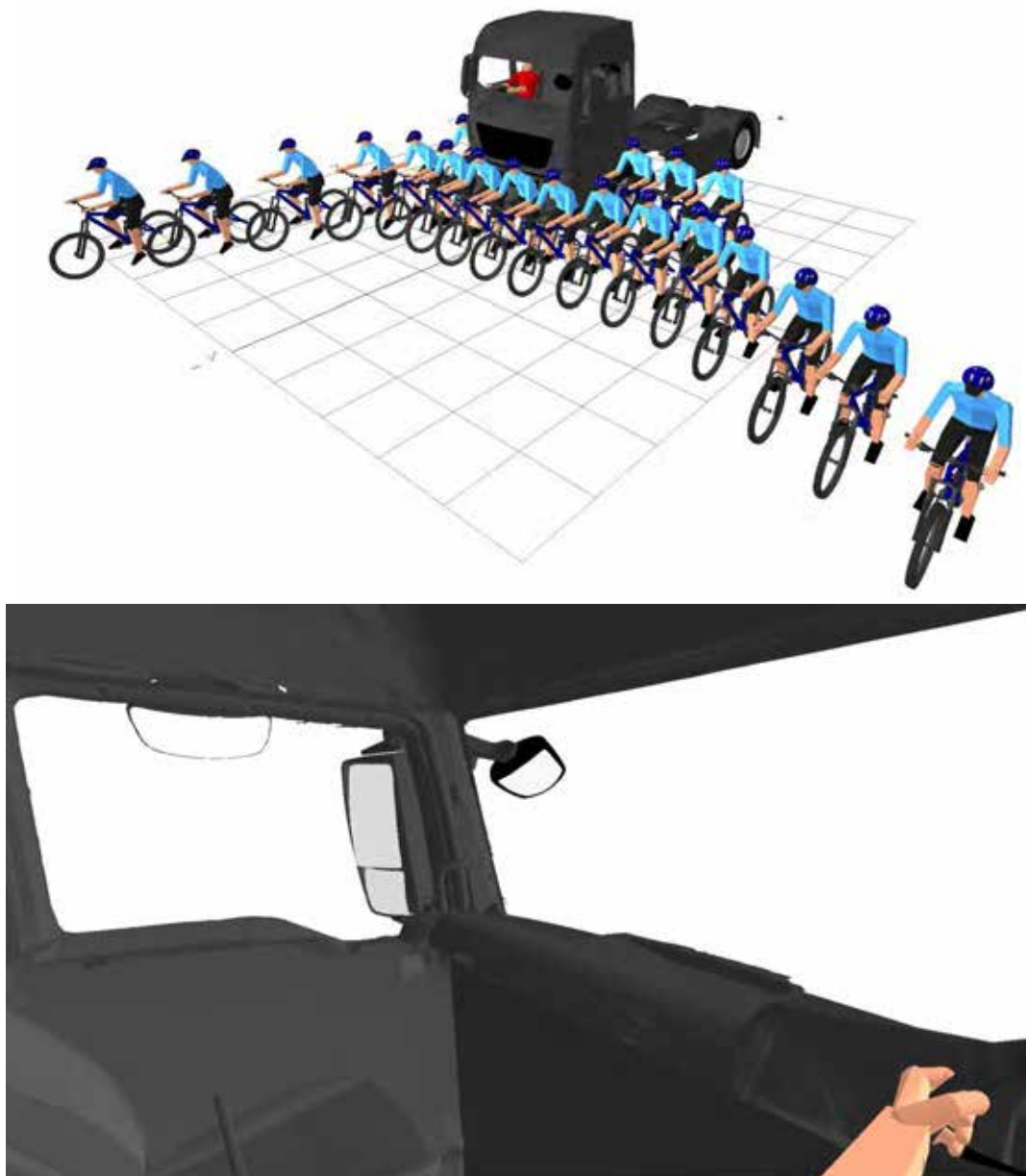


Figure 732. The top image shows the number and location of cyclists that can be placed around an example vehicle cab without being seen through direct vision, and the bottom image shows the driver's view through the windows

6.2 COMBINED FOV AREA AND VRU ANALYSES

The dedicated LECs (Dennis and Mercedes Econic) tend to show the largest FOV area values. The LECs based on standard cabs such as the Scania and the Volvo show variable performance across the assessments shown in Figure 726, Figure 727, Figure 728 and Figure 729. There are a number of interesting observations that can be made from the area assessments, especially when considered together with the VRU evaluations.

The FOV area analysis offers a means to differentiate between vehicles that may perform equally well in the VRU analyses. For example pedestrians and cyclists in the assessed locations cannot be hidden from the driver's direct vision in any of the LEC vehicles (Figure 720). However the FOV area analysis shows significant differences in the FOV available (Figure 726).

To fully understand the impact of vehicle design and configuration on the FOV available to the driver a combination of the FOV area needs to be understood together with the specific VRU analysis results. In many ways the results appear relatively predictable. Vehicles such as the Mercedes Econic and Dennis have large FOV areas and VRU tests show that the cyclists and pedestrians cannot be hidden from direct view in the locations assessed. Vehicles such as the DAF XF have some of the smallest clipped FOV areas and in the VRU test show that the distance cyclists and pedestrians can be from the vehicle and still be hidden from the driver are some of the largest of the vehicles assessed. Thus these results suggest that larger window areas lead to improved VRU visibility.

However, the DAF XF is towards the middle of the range for total FOV area suggesting that large window areas are not the complete answer, the FOV needs to be provided in critical areas. This is supported by examples such as the DAF CF that is in the middle of the range for clipped FOV area but has some of the smallest distances away from the cab at which the VRUs can be obscured in its N3 configuration. This shows that whilst the FOV is not the largest it is provided in these critical areas and thus offers reduced blind spots to direct vision. Equally, the Volvo FM has the smallest passenger door window FOV area and yet exhibits consistently small distances away from the cab at which the VRUs can be obscured to the passenger side indicating effective use of the view provided. This is discussed further in Section 6.3.1.

Further reinforcing the impact of vehicle height, the Mercedes Antos, Arocs, Actros range all share the same windscreen that provides one of the largest windscreen FOV areas. However the lowest variant, the Antos, exhibits some of the smallest distances away from the cab at which the VRUs can be obscured, and the higher variants, the Antos and Actros, exhibit some of the largest distances away from the cab at which the VRUs can be obscured.

6.3 VARIABILITY IN VEHICLE DIMENSIONS AND DESIGN

As discussed in Section 3.1, the vehicle sample was derived from the best-selling manufacturers in the UK, whose models were selected from the most sold configurations of the Distribution (N3), Construction (N3G) and Haulage (N3) vehicles, combined with a sample of low entry cab models. This resulted in a sample with variability in the driver eye height within the cab due to the differences in tyre, suspension type and engine size, which affect the height of the driver's cab above the ground. Figure 733 shows a graph which illustrates the cab floor height and average sized driver eye height above the ground for all models tested. This illustrates the variability in the height of the sample vehicles with the Mercedes Econic having the lowest driver eye height, and the Mercedes Arocs (N3G) having the highest.

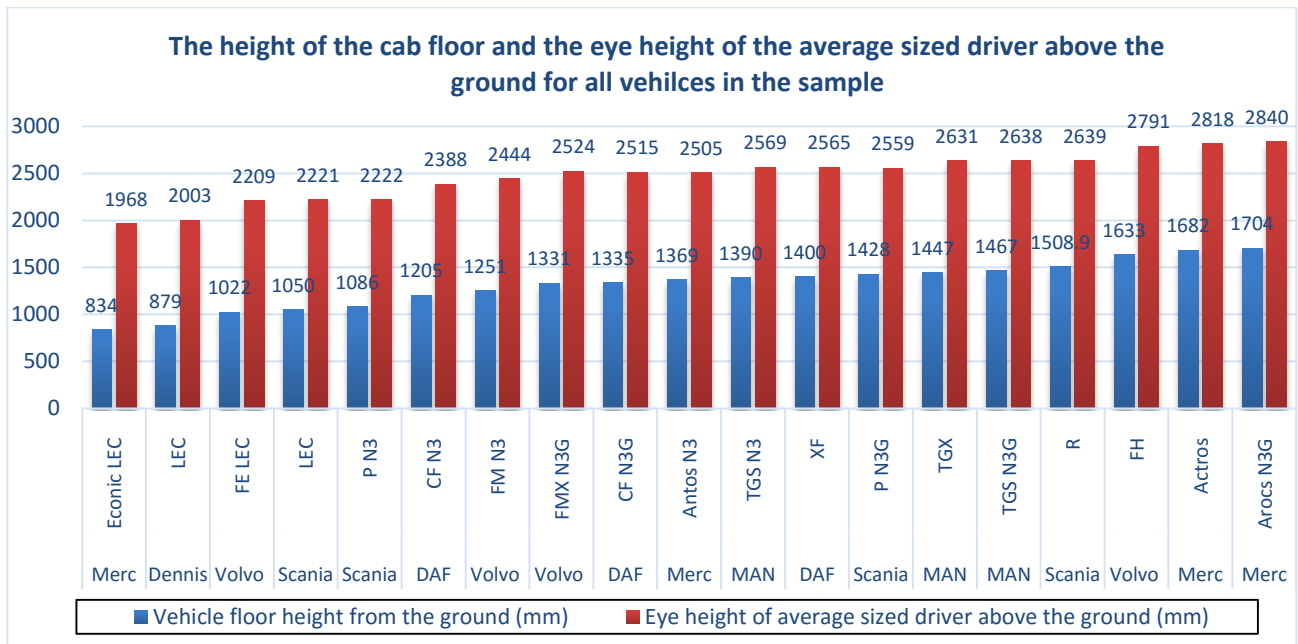


Figure 733. Comparing the floor height and driver’s eye height across the 19 vehicles in the sample

The width of the vehicle cabs also varied across the sample with reported values from the manufacturers which fell into two distinct categories of approximately 2300mm wide and 2500mm wide.

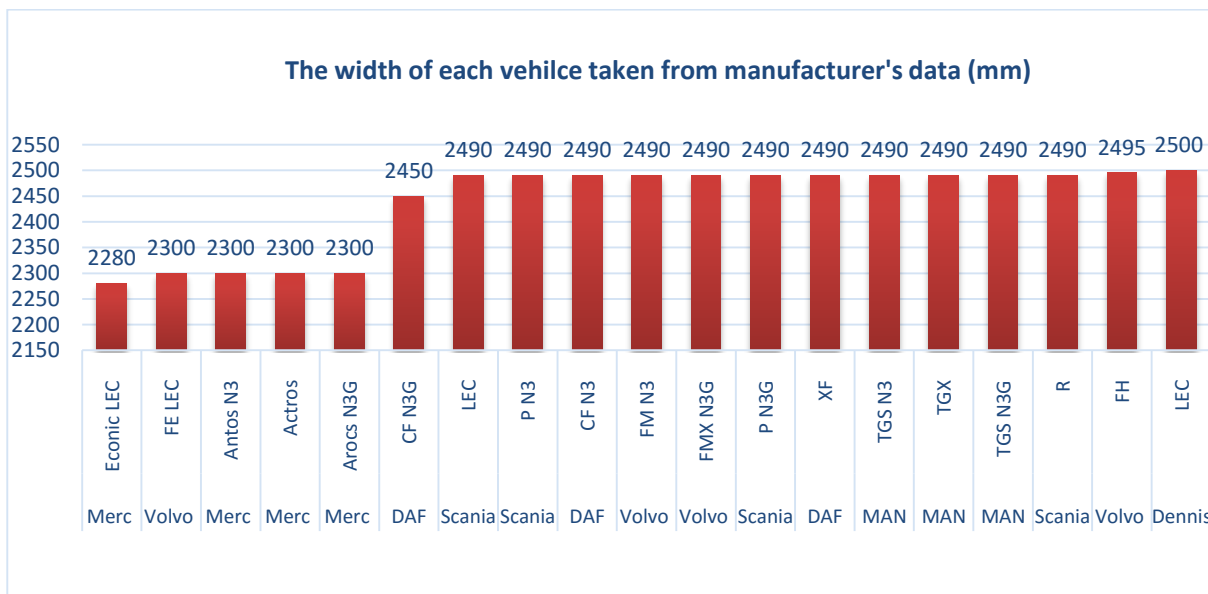


Figure 734. Comparing the cab width for all vehicles

6.3.1 COMPARING THE EFFECT OF EYE HEIGHT AND VEHICLE DESIGN VARIABLES UPON THE DISTANCE AWAY THAT THE NEAR SIDE CYCLIST CAN BE HIDDEN FROM THE DRIVER

Following the production of the results using the digital human modelling tool, a further analysis was performed to explore the design features of the different cab designs which have an effect on the distances at which vulnerable road users can be obscured from the driver’s vision.

This involved performing comparisons and statistical tests between the data associated with the following design features;

- The height of the driver’s eye point above the ground for each vehicle
- The distance at which the passenger side rear most cyclist can be hidden from the driver using direct vision
- The distance at which the middle pedestrian in front of the cab can be hidden from the direct using direct vision
- The widths of the cabs

The first comparison made was the driver’s eye height (50thile UK male driver) above the ground and the distance away from the vehicle that the rear near side cyclist could be obscured. Figure 735 shows these two variables plotted in a graph for the standard vehicle designs, the low entry cabs were excluded as their designs are generally different to the standard cab designs.

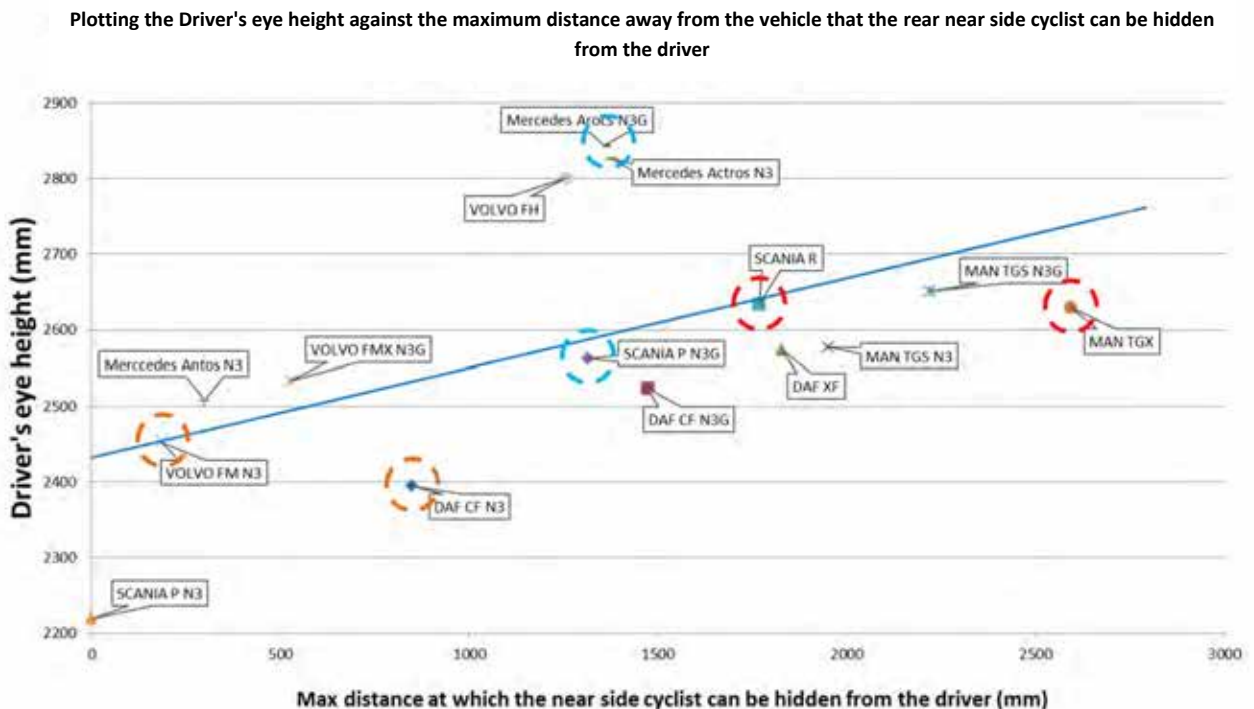


Figure 735. Plotting the maximum distance at which the near side rear cyclist can be obscured from the driver, against the driver eye height above the ground

The graph shows that generally there is a trend of increasing driver eye height with increasing distance away from the cab at which the near side rear cyclist can be obscured. In order to explore this further and to see if there is any statistical significance in this trend, a Spearman’s Rho (single tailed) correlation test was performed. This demonstrated a strong correlation coefficient of 0.6 ($r_s = .6, p < 0.009$) where values between 0.5 and 1 are considered to be strong. This means that there is a link between the eye height of the driver above the floor and the maximum distance that a cyclist can be hidden to the near side of the cab. There were however some anomalies in this trend when comparing the results between vehicles in the same category. The identified cases were;

- Case 1. The eye height of the driver for the Mercedes Arocs is considerably higher than the Scania P N3G, and yet the cyclist is hidden from view at approximately the same distance away from both vehicles as highlighted by the blue dotted circles in Figure 735
- Case 2. DAF CF has a lower driver eye height above the ground than the Volvo FM, but the cyclist is fully hidden further away from the vehicle when compared to the Volvo FM, as highlighted by the orange dotted circles in Figure 735
- Case 3. MAN TGX has a lower driver eye height above the ground than the Scania R, but the cyclist is fully hidden further away from the vehicle when compared to the Scania R as highlighted by the red dotted circles in Figure 735

These anomalies were considered to be important because a comparison of design features associated with the three anomalies has the potential to highlight design features which are associated with improving direct vision. The following dimensions were therefore compared between the vehicles in the three anomalous cases;

1. The driver's eye height above the ground (50thile UK male driver)
2. The distance at which the rearmost near side cyclist can be hidden
3. The distance vertically between the eye height of the driver and the bottom of the passenger window sill at a point in line with the head of the cyclist
4. The width of the vehicle cab

Figure 736 shows these dimensions. The following sections provide content which shows the differences between the vehicle designs in the three cases that have been highlighted, which account for the anomalies identified in Figure 735 (Graph and correlation).

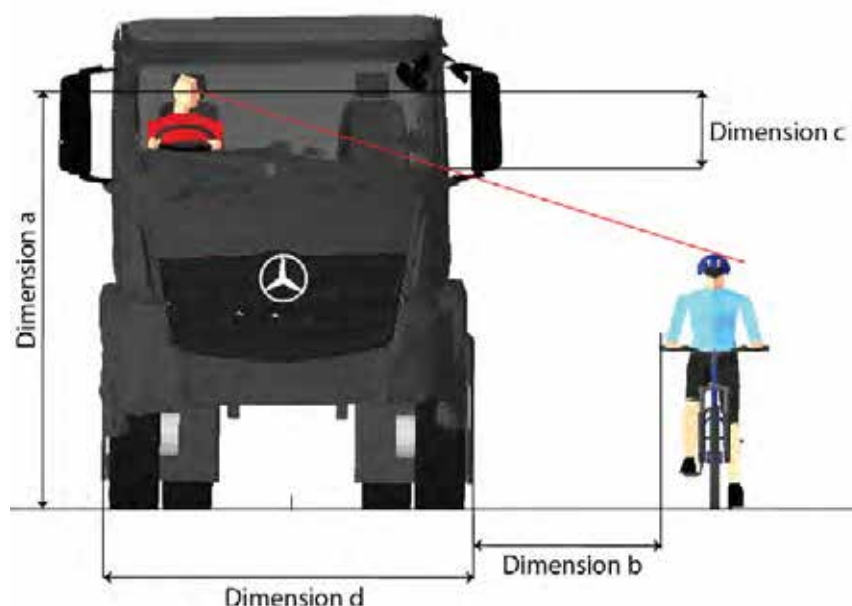


Figure 736. The dimensions that are used to compare and unpack the results for the distance at which the rear passenger side cyclist can be obscured from the driver's view

6.3.1.1 CASE 1. COMPARING THE MERCEDES AROCS N3G TO THE SCANIA P N3G

In the case of the comparison between the Mercedes Arocs N3G and the Scania P N3G, the eye height of the driver for the Mercedes Arocs N3G is considerably higher (281mm) than the Scania P N3G, and yet the cyclist

is hidden from view at approximately the same distance away from both vehicles. A comparison of the vehicle design variables shows that this can be attributed to the width of the cab, where the Mercedes Arocs N3G is narrower than the Scania P N3G combined with the design of the window. The Mercedes Arocs has a lower window bottom edge in relation to the eye position in the cab. In effect, when looking through the eyes of the driver, the bottom edge of the window would appear lower in the Mercedes Arocs N3G than in the Scania P N3G, allowing the driver to see more. This is shown in Figure 737.

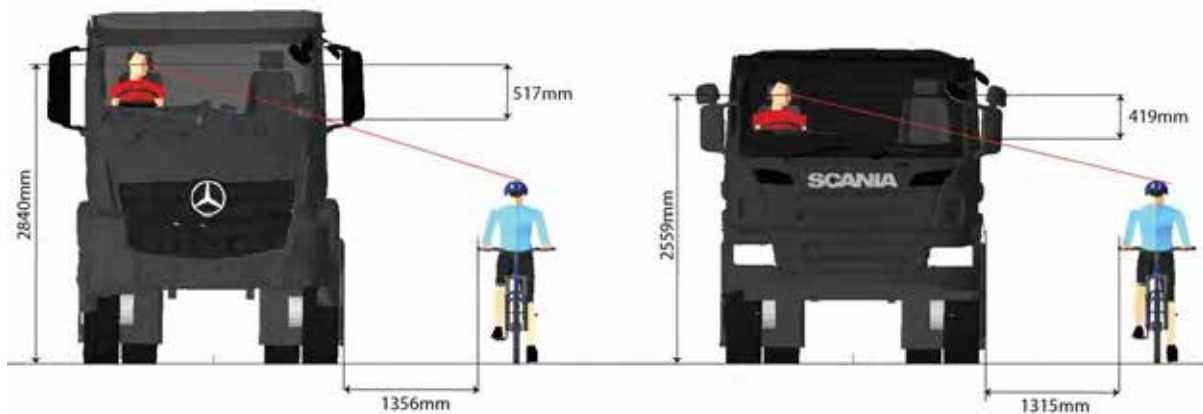


Figure 737. Illustrations of the comparison between the Mercedes Arocs N3G and the Scania P N3G where the driver eye height is considerably higher for the Mercedes but the cyclists are hidden at similar distances

6.3.1.2 CASE 2. COMPARING THE DAF CF N3 TO THE VOLVO FM N3

In the case of the comparison between the DAF CF N3 and Volvo FM N3, the DAF CF has a lower driver eye height above the ground than the Volvo FM, but the cyclist is fully hidden further away from the vehicle when compared to the Volvo FM. A comparison of the design variables shows that this can be attributed to the window design, where the Volvo FM has a lower window bottom edge in relation to the eye position of the driver in the cab. In effect, when looking through the eyes of the driver, the bottom edge of the window would appear lower in the Volvo FM than in the DAF CF, allowing the driver to see more. The width of the Volvo FM and DAF CF cabs are both reported as being 2490mm by the manufacturers. Therefore the cab width does not affect the performance in this case.

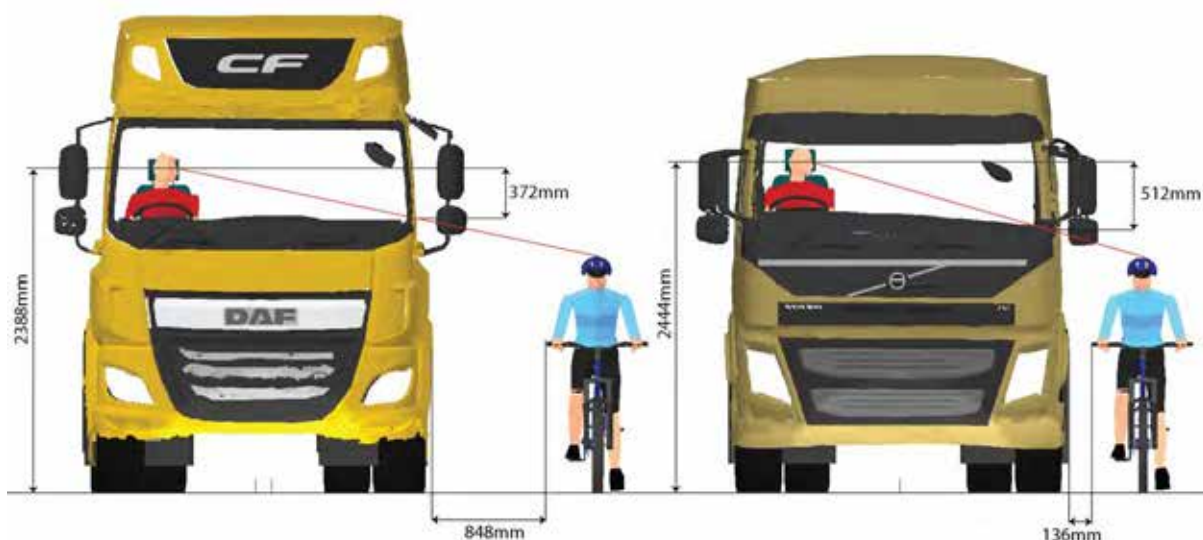


Figure 738. Illustrations of the comparison between the DAF CF N3 and the Volvo FM N3 where the driver eye height of the DAF is lower than that of the Volvo, but the cyclist is hidden further away for the DAF

6.3.1.3 CASE 3. COMPARING THE SCANIA R N3 TO THE MAN TGX N3

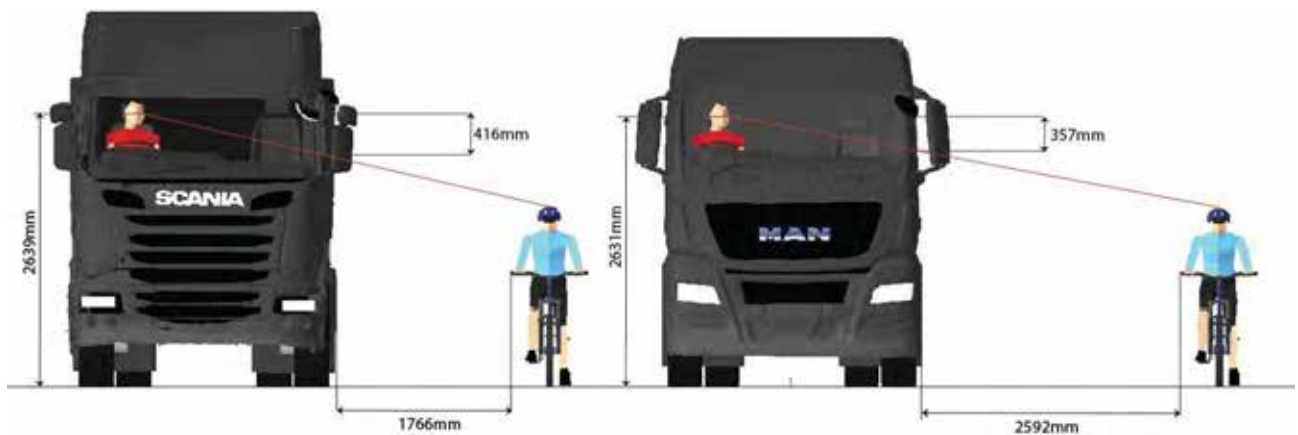


Figure 739. Illustrations of the comparison between the Scania R N3 and the MAN TGX N3 where the eye heights of the drivers are similar, but the cyclist can be hidden further away from the vehicle cab

In the case of the comparison between the Scania R N3 and the MAN TGX N3 the MAN TGX has a lower driver eye height above the ground than the Scania R, but the cyclist is fully hidden further away from the vehicle when compared to the Scania R. A comparison of the design variables shows that this can be attributed to the window design, where the Scania R has a lower window bottom edge in relation to the eye position in the cab. In effect, when the looking through the eyes of the driver, the bottom edge of the window would appear lower in the Scania R due differences in the profile of the window bottom edge as shown in Figure 740 which shows the driver’s eye view of the passenger window for both vehicles.

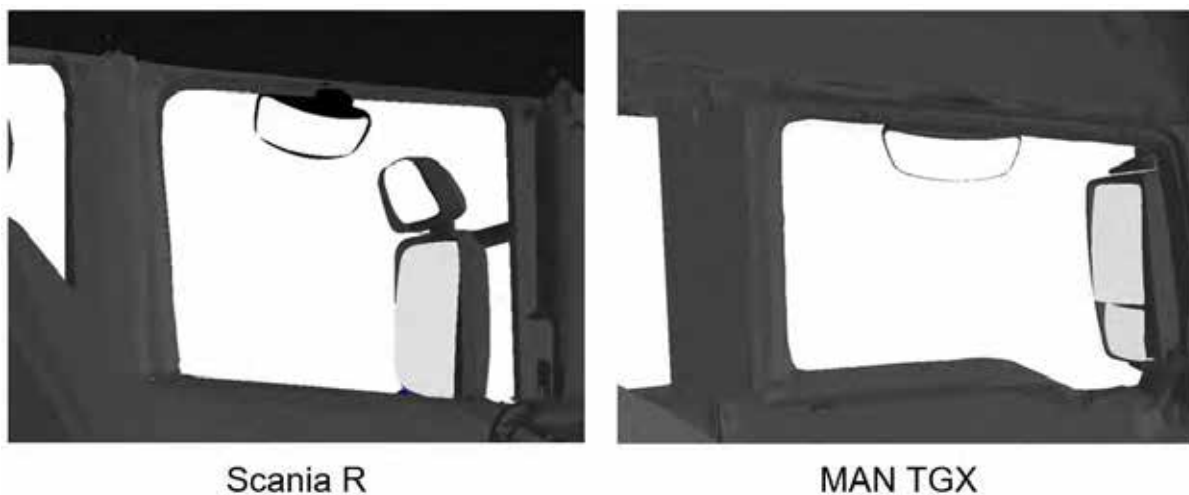


Figure 740. The drivers eye view of the passenger window for the Scania R and the MAN TGX

6.3.1.4 SUMMARY FOR THE COMPARISON BETWEEN DRIVER EYE HEIGHT AND THE OBSCURATION DISTANCE OF THE NEAR SIDE CYCLIST

The correlation between eye height of the driver and the distance at which the rear near side cyclist can be obscured from the driver has shown that, in general, an increase in driver height produces an increased distance away from the cab at which the cyclist can be obscured. The low entry cabs showed a much improved ability for the driver to directly see vulnerable road users when compared to ‘standard’ vehicle

designs, as Table 3 illustrates. The further analysis of the situation for the ‘standard’ cab designs has shown that the variability in the design of window apertures can produce results which ‘buck the trend’ that is established by the graph in Figure 735, and the statistical testing of correlation. This is shown in Cases 2 and 3 where the vehicles with the larger vertical distance between the eye point and the lower edge of the window glass outperformed the other vehicles which were being compared. Case 1 illustrated that width of the vehicle can also be a factor, with the narrow cab of the Mercedes Arocs combined with a lower window edge with respect to the eye position, allowing the Mercedes Arocs to outperform the Scania P N3G.

On the basis of these analysis the following recommendations can be made with regard to cab design

Recommendation 1: The ability of a driver to directly see vulnerable road users to the nearside of the vehicle can be maximised by designing window apertures with a bottom edge that is as low as possible with respect to the eye position of the driver.

Recommendation 2: The ability of a driver to directly see vulnerable road users to the near side of the vehicle can be maximised by designing a cab to have the minimum possible width between the side windows

6.3.2 COMPARING THE EFFECT OF EYE HEIGHT AND VEHICLE DESIGN VARIABLES UPON THE DISTANCE AWAY THAT THE FRONT MIDDLE PEDESTRIAN CAN BE HIDDEN FROM THE DRIVER

The second comparison made was the driver’s eye height (50thile UK male driver) above the ground and the distance away from the vehicle that the central pedestrian object to the front of the cab could be obscured from the driver. Figure 741 shows these two variables plotted in a graph for the standard vehicle designs, the low entry cabs were excluded as their designs are generally different to the standard cab designs.

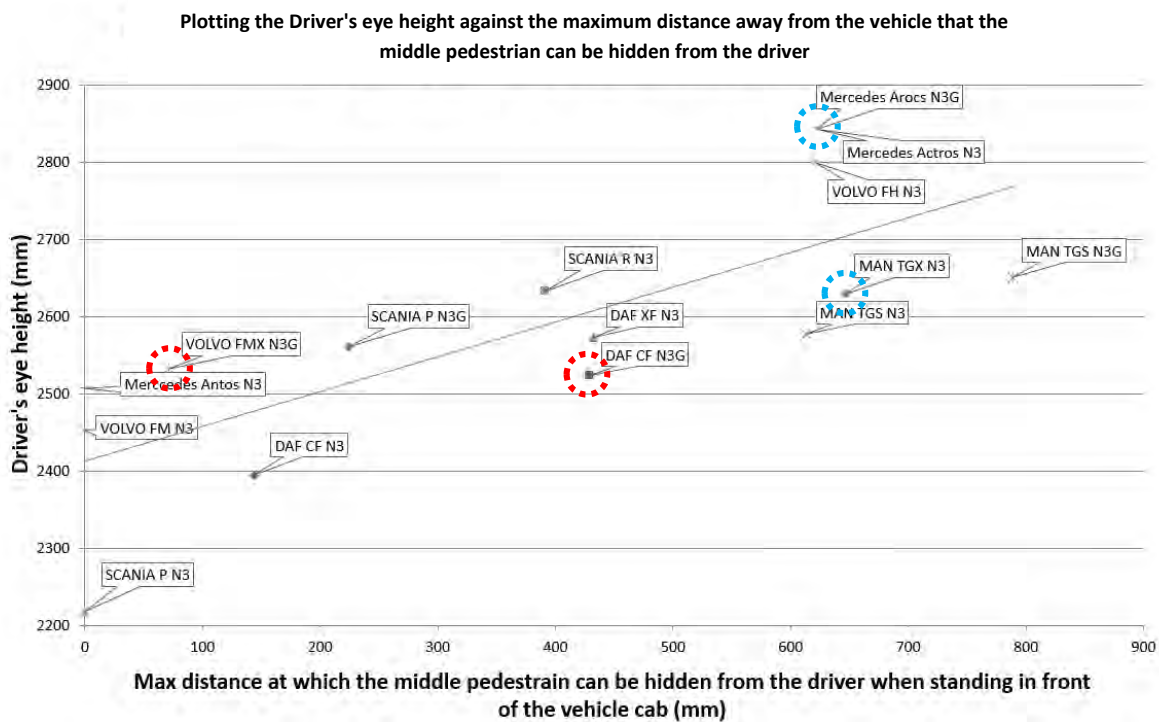


Figure 741. Plotting the max. distance at which the near side rear cyclist can be obscured from the driver, against the driver eye height above the ground

The graph shows that generally there is a trend of increasing driver eye height with increasing distance away from the cab front at which the central pedestrian can be obscured from the driver. In order to explore this further and to see if there is any statistical significance in this trend, a Spearman's Rho (single tailed) correlation test was performed. This demonstrated a very strong correlation coefficient of 0.846 ($r_s = .846$, $p < 0.00004$) where values between 0.5 and 1 are considered to be strong. This means that there is a link between the eye height of the driver above the floor and the maximum distance that a pedestrian can be hidden from the driver's view. There were however some anomalies in this trend when comparing the results between vehicles in the same category. The identified cases were;

Case 4. The eye height of the driver for the Mercedes Actros N3 is considerably higher than the MAN TGX N3, and yet the pedestrian is hidden from view at approximately the same distance away from both vehicles as highlighted by the blue dotted circles in Figure 741.

Case 5. The DAF CF N3G and the Volvo FMX N3G have a similar eye height above the ground, and yet the pedestrian is fully hidden further away from the vehicle for the DAF CF N3G, as highlighted by the red dotted circles in Figure 741.

The following dimensions were therefore compared between the vehicles in the two anomalous cases associated with view of pedestrians in front of the vehicle cab:

- The driver's eye height above the ground (50thile UK male driver)
- The distance at which the central pedestrian can be hidden
- The distance vertically between the eye height of the driver and the bottom of the windscreen sill at a point in line with the head of the cyclist

Figure 742 shows these dimensions. The following sections provide content which shows the differences between the vehicle designs in the two cases that have been highlighted, which account for the anomalies identified in Figure 741 (Graph and correlation).

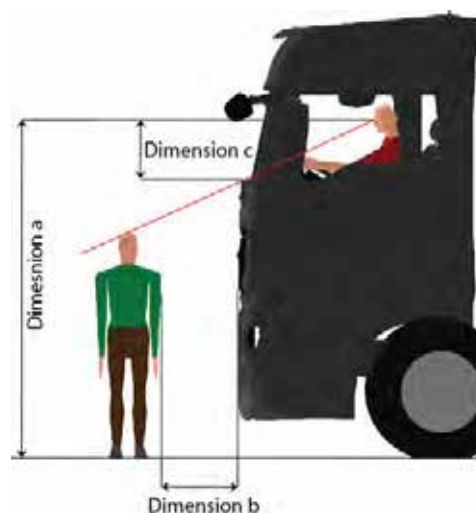


Figure 742. The dimensions that are used to compare and unpack the results for the distance at which the middle pedestrian can be obscured from the driver's view

6.3.2.1 CASE 4. COMPARING THE DAF CF N3G TO THE VOLVO FMX N3G

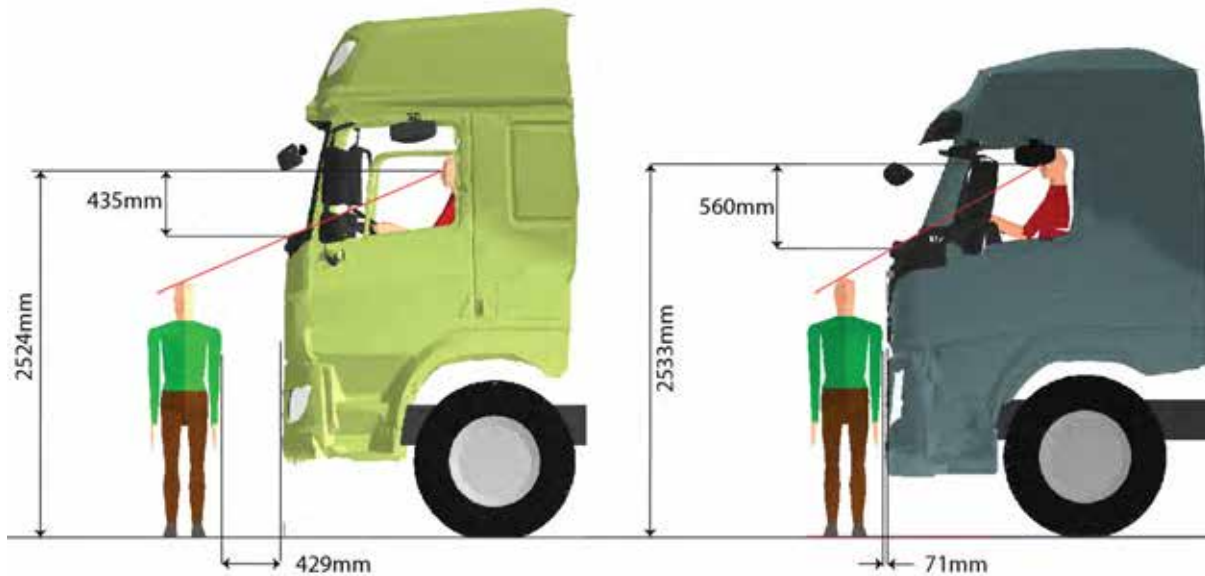


Figure 743. Illustrations of the comparison between the DAF CF N3G and the Volvo FMX N3G where the eye heights of the drivers are similar, but the pedestrian can be hidden further away from the vehicle cab for the DAF

In the case of the comparison between the DAF CF N3G and Volvo FMX N3G, the DAF CF N3G has a similar driver eye height above the ground (9mm lower) than the Volvo FM, but the pedestrian is fully hidden further away from the vehicle when compared to the Volvo FMX N3G . A comparison of the design variables shows that this can be attributed to the window design, where the Volvo FMX N3G has a lower windscreen bottom edge in relation to the eye position of the driver in the cab. In effect, when the looking through the eyes of the driver, the bottom edge of the windscreen would appear lower in the Volvo FMX N3G than in the DAF CF N3G, allowing the driver to see more.

6.3.2.2 CASE 5. COMPARING THE MERCEDES ACTROS N3 TO THE MAN TGX N3

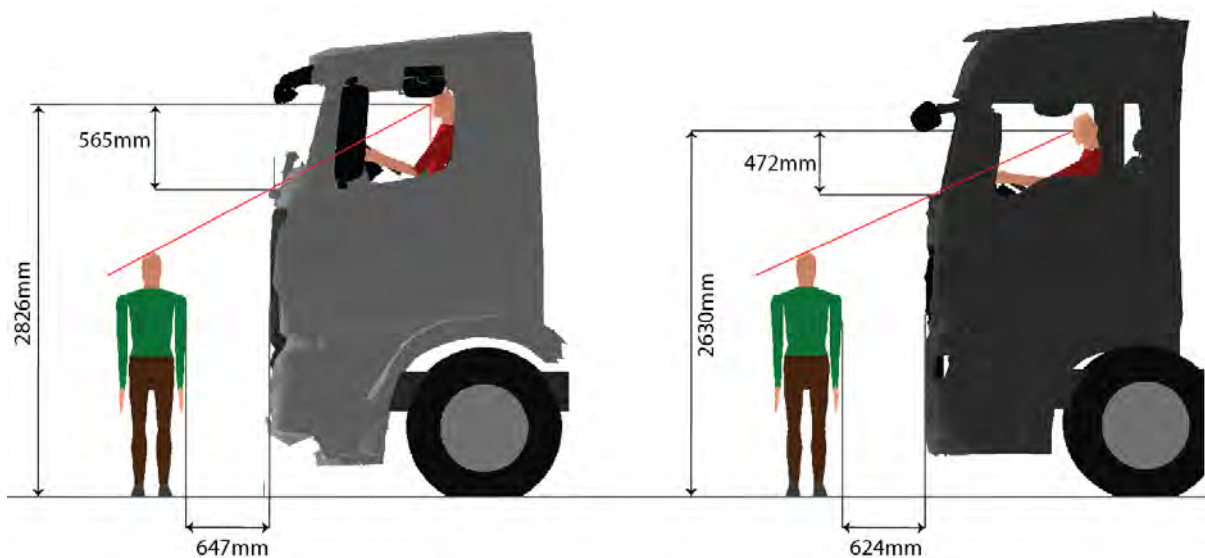


Figure 744. Illustrations of the comparison between the Mercedes Actros N3 and the Volvo FMX N3G where the eye heights of the drivers are similar, but the pedestrian can be hidden further away from the vehicle cab for the DAF

In the case of the comparison between the Mercedes Actros N3 and MAN TGX N3, the Mercedes Actros N3 has a higher driver's eye height than the MAN TGX N3 (196mm higher) but there is only 23mm difference between the two vehicles in terms of the distance away that the pedestrian can be hidden. A comparison of the design variables shows that this can be attributed to the windscreen design, where the Mercedes Actros N3 has a lower windscreen bottom edge in relation to the eye position of the driver in the cab (93mm lower). In effect, when the looking through the eyes of the driver, the bottom edge of the windscreen would appear lower in the Mercedes Actros N3 than in the MAN TGX N3, allowing the driver to see more.

6.3.2.3 SUMMARY FOR THE COMPARISON BETWEEN DRIVER EYE HEIGHT AND THE OBSCURATION DISTANCE OF THE CENTRAL PEDESTRIAN

The correlation between eye height of the driver and the distance at which the central pedestrian can be obscured from the driver has shown that, in general, an increase in driver height produces an increased distance away from the cab at which the pedestrian can be obscured. The variation in this measure is less and the strength of the correlation is stronger than in the analysis of the lateral visibility of the cyclist. The low entry cabs showed a much improved ability for the driver to directly see vulnerable road users when compared to 'standard' vehicle designs, as Table 3 illustrates, the further analysis of the situation for the 'standard' cab designs has shown that the design of the windscreen lower edge, and the design of the dash board which was used to modify the projection of windscreen visibility, can affect the performance of a vehicle in the test being described.

On the basis of these analysis the following recommendation can be made with regard to cab design:

Recommendation 1: The ability of a driver to directly see vulnerable road users to the front of the vehicle can be maximised by designing windscreen apertures with a bottom edge that is as low as possible with respect to the eye position of the driver.

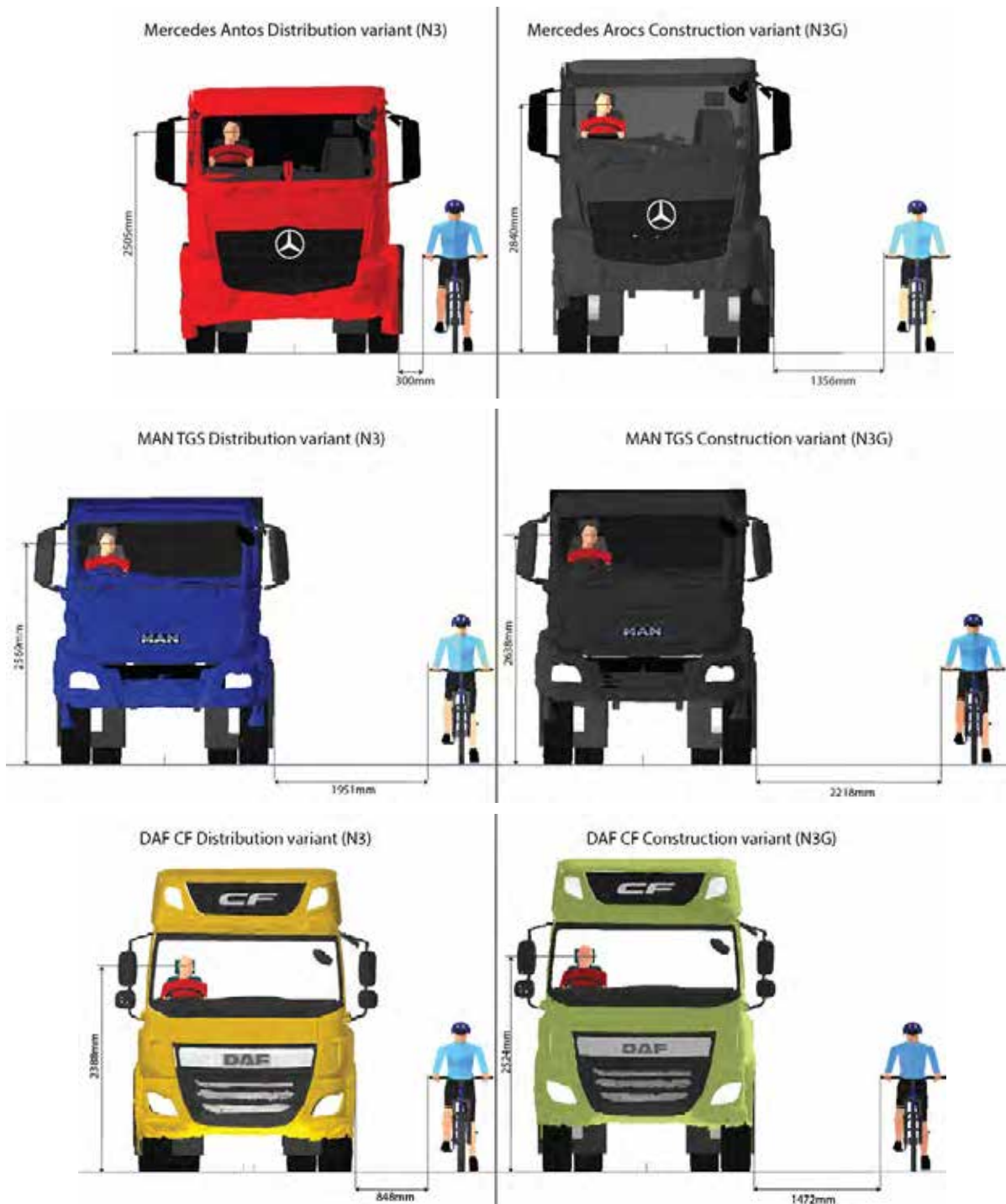
Consultation with vehicle manufacturers during the project has highlighted that the size of glazed areas is a factor which must be balanced with the strength of the cab which is tested during the type approval process.

6.3.3 THE DIFFERENCE BETWEEN N3 DISTRIBUTION AND N3G CONSTRUCTION VEHICLE VARIANTS

A key aspect of vehicle specification which affects the overall height of the cab above the ground is the intended purpose for the vehicle. The research has shown that vehicles which are specified for the activity of distribution of goods (N3 configuration) have lower cabs than the same vehicle which has been specified for construction use (N3G configuration). This is highlighted by the following key messages.

1. The N3G cabs assessed in the project are on average 32% higher than the same cab design in the N3 configuration
2. For the N3G cabs the distance away that a pedestrian in front of the vehicle can be hidden from the driver's view is on average nearly three times greater than the N3 configurations
3. For the N3G cabs the distance away that a cyclist at the passenger side of the vehicle can be hidden is on average more than two times greater than the N3 configurations

Figure 745 shows examples of the height difference between the ‘most sold’ configurations of distribution and construction vehicles produced by Mercedes and Scania. The effect of the height difference is demonstrated by the distance away that a cyclist to the passenger side of the cab can be hidden from the driver’s direct vision.



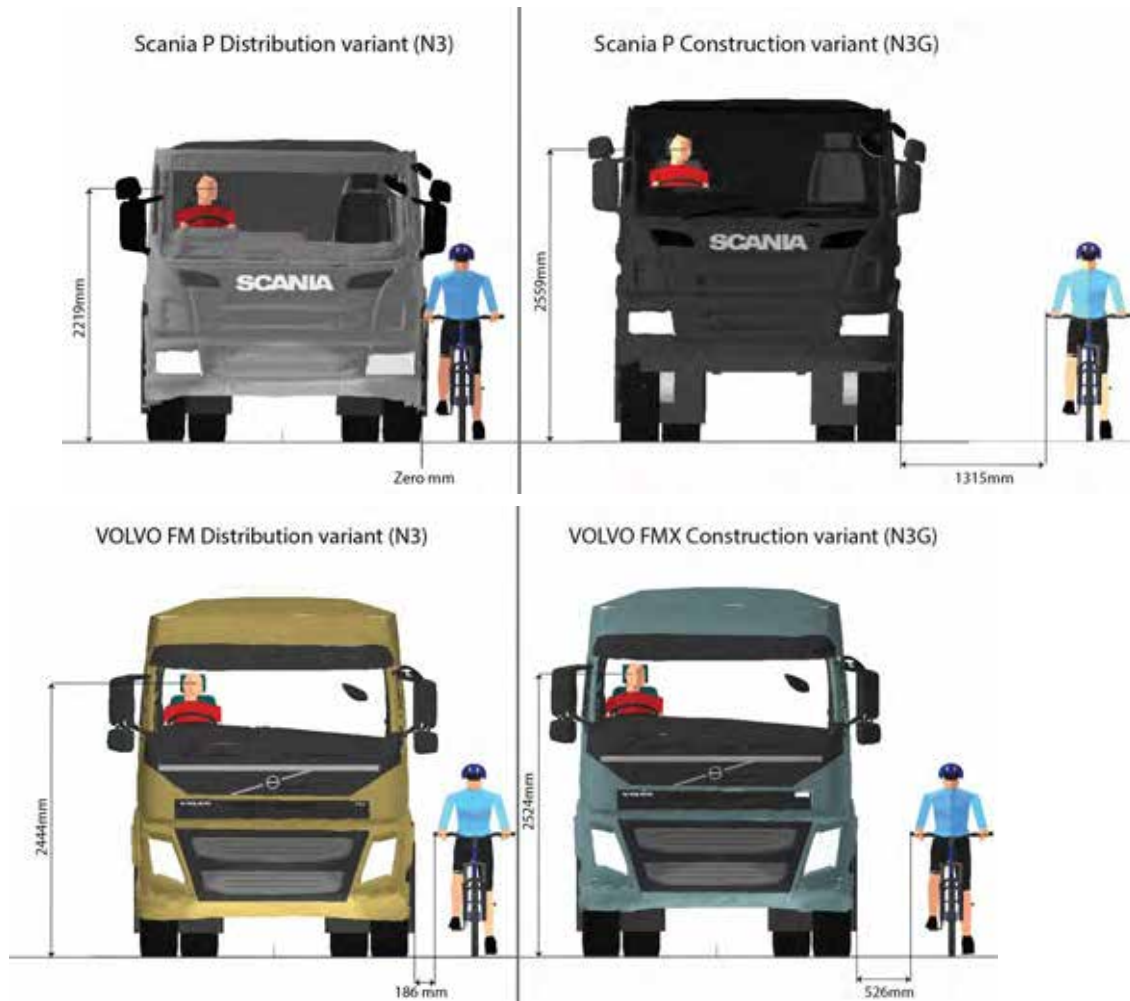


Figure 745. Illustrating the height difference between distribution and construction variants of the same cab design, and the distance away that a cyclist to the passenger side of the vehicle can be hidden from the driver’s direct vision

6.3.4 THE EFFECTS OF DRIVER SIZE (EYE POINT) ON FOV

The VRU Analyses detailed in Section 4.1 were all performed with a 50th %ile UK male driver. As discussed in Section 3.4 this was done as part of a standardised evaluation and for pragmatic reasons where evaluating all vehicles in all conditions for multiple eye points was beyond the scope of this work. However, it is recognised that eye point plays a significant role in the FOV afforded the driver. FOV is directly influenced by the location of the eye point relative to a window or mirror surface. What determines an eye point is based upon two broad factors: the design of the interior package of the vehicle (seat, pedals, steering wheel etc.) and the size of the driver. Together these will result in a driver adopting a posture that will place the eye point in a particular location. It is also true that driver preference will also play a part in the posture adopted with some drivers preferring a relatively upright driving position, and other preferring a relatively reclined driving position. This was demonstrated in previous work performed by the LDS team where 20 driver postures were captured, see Figure 746 for examples of these postures.



Figure 746. The variability in driving posture exhibited by a sample of drivers

The posturing of the human models used in the analysis was standardised to minimise these variables however it is still possible to explore the effects of different driver sizes in a standardised manner. The examples below use a single vehicle (Mercedes Antos) as an example of eye point variability and its influence on FOV.

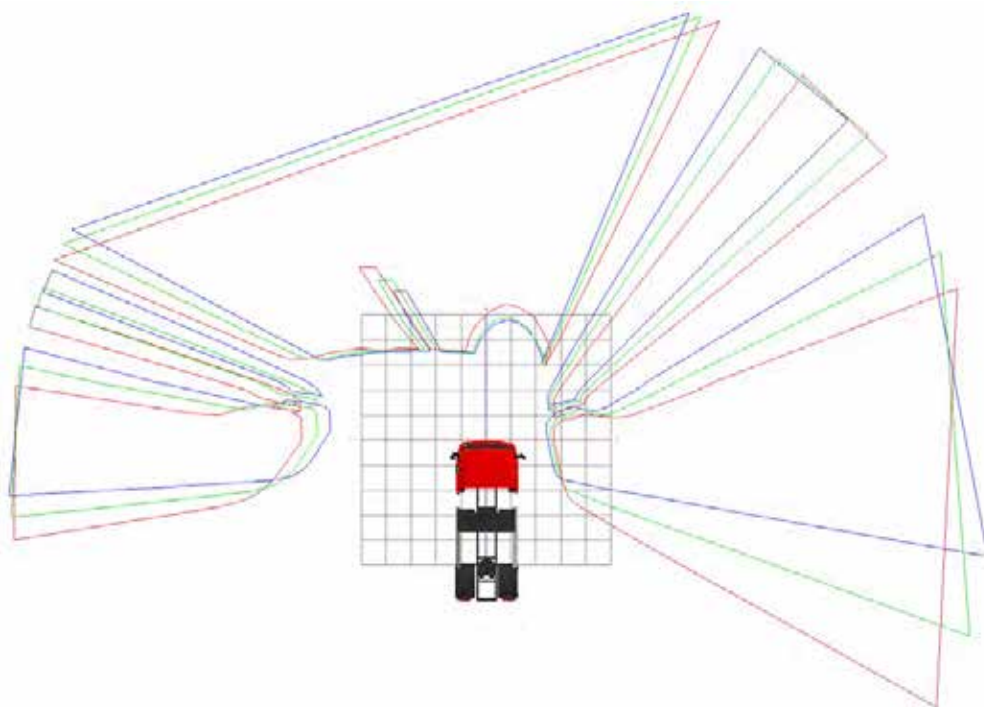


Figure 747. A plan view of the projection of the windscreen and side windows onto the ground plane for the Mercedes Antos N3 for a range of driver eye positions. Red=smallest driver (5thile UK female stature), Green=average sized driver (50thile UK male stature), and Blue=tallest driver (95thile UK male stature).

Figure 747 shows 2D ground plane projections for the three eye points determined for the research: 5th %ile UK female (red), 50th %ile UK male (green) and 95th %ile UK male (blue). Across all vehicles trends can be identified. For the 5th %ile UK female driver, the eye point is furthest forward in the vehicle. This results in a FOV that extends further rearwards than those seen for the 50th and 95th %ile UK males whose eye points are further rearwards. Figure 748 shows that a smaller driver turning to look out of the offside door window, would have a field of view that extended further rearwards in comparison to a taller driver. The opposite is true for the FOV to the front, where the more rearward eye point of the larger driver provides an extended FOV from the offside door window in comparison to the smaller driver.

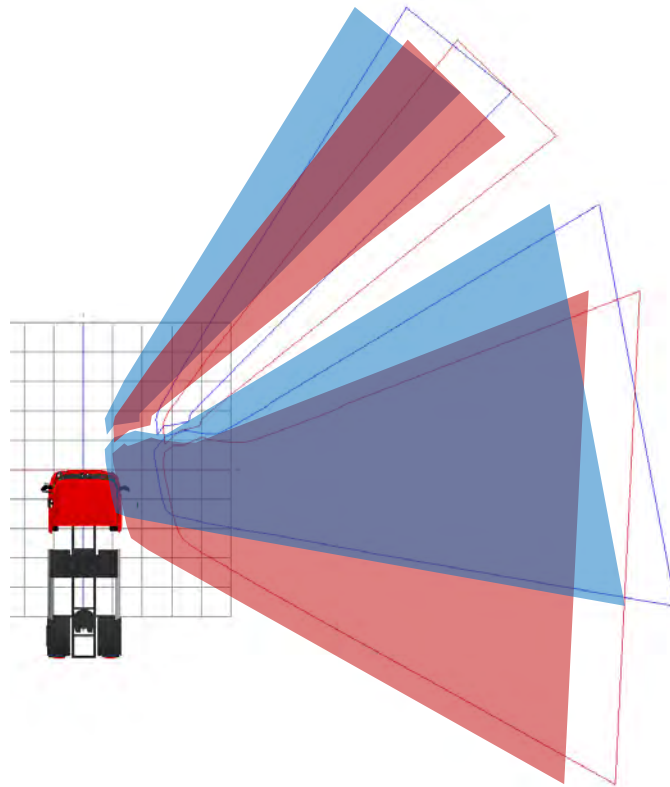


Figure 748. 2D ground plane projections of the offside door window for the 5th %ile UK female driver (red) and 95th %ile UK male driver (blue)

For forwards FOV the more rearwards eye point of the larger driver results in a narrower field of view through the windscreen in comparison to the smaller driver. However the higher eye point of the larger driver results in a FOV that is closer to the front of the vehicle. In the critical blind spot areas for VRU observation, in particular to the nearside of the vehicle the increased height of the eye point for the larger driver reduces the blind spot in this area. In some ways this may seem counter-intuitive as it is generally believed that the height of HGVs is one of the main characteristics that have a negative impact on FOV and thus the higher eye point of the taller driver could be seen to be part of that issue. However, the field of view is also significantly affected by the relationship between the eye point and the height of the lower edge of the windows as discussed in section 6.3.1. Figure 749 shows how for the larger driver, the additional height above the nearside window's lower edge provides a steeper projection of the FOV and thus the ability to see VRUs closer to the vehicle. For the smaller driver, the projection is shallower resulting in a larger blind spot adjacent to the vehicle.

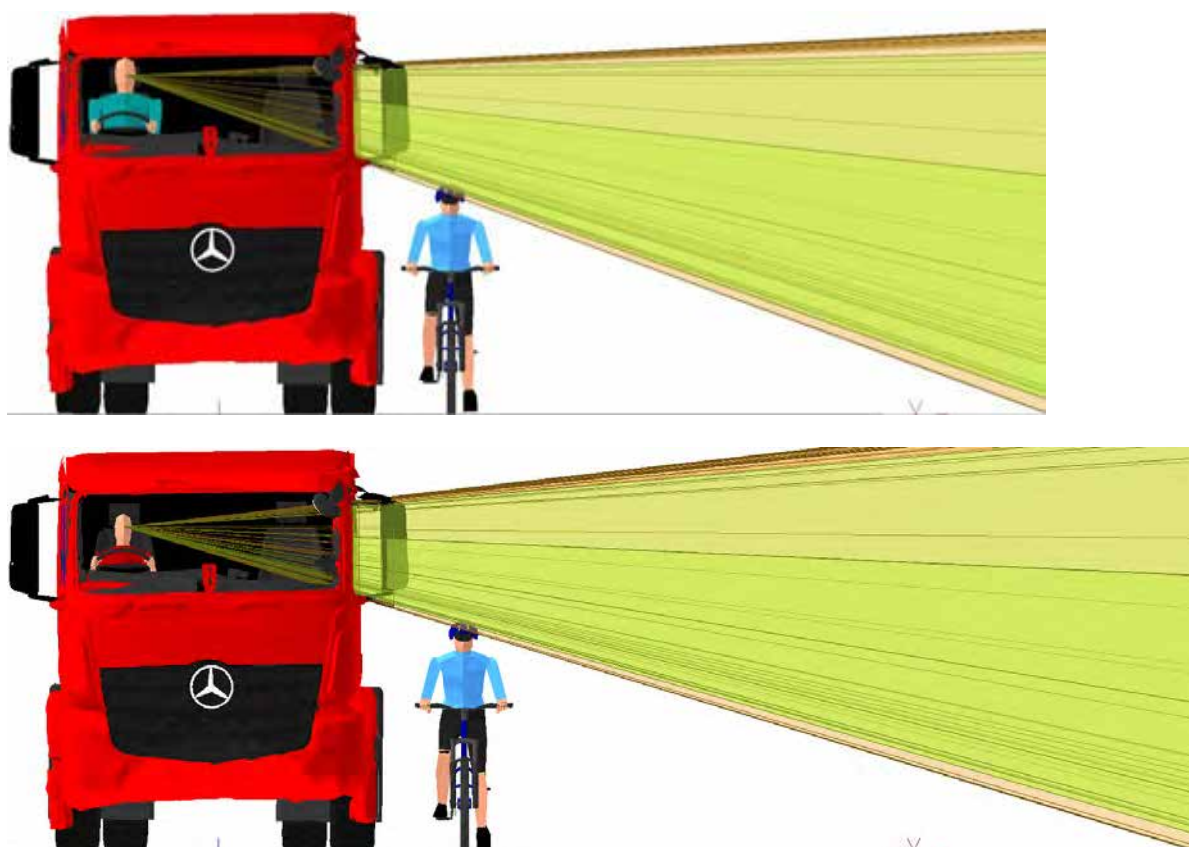


Figure 749. Nearside window projections for 95th %ile UK male driver (top) and 5th %ile UK female driver (bottom). The cyclist is positioned in a position where they are just not visible to the driver.

Human variability in driver size is not something that can be controlled and HGV packaging design does a very good job in accommodating a large range of driver size. The situation is very scenario specific, for example, for forward vision, smaller drivers have a slightly increased field of view. However direct vision blind spots exist but their size and position will vary depending upon the driver's eye point. The research reported here had the aim of comparing vehicle designs and specifications using a standardised assessment technique. The three eye positions that have been defined are all valid, in that they represent possible eye points that have been consistently defined for each vehicle. If the main testing had been performed using either the small or larger driver than the 50th %ile model used, the differences between the vehicle would have been highlighted in the same manner as the results shown in Tables 3, but the values for the distances away at which VRUs could be obscured would have varied.

6.3.5 THE IMPACT OF MIRROR ADJUSTMENT

For the purposes of this research mirrors were adjusted for each eye point to provide coverage of the mandated areas specified in 2003/97/EC as described in Section 3.3.2. Methodologically this provides a consistent basis from which to compare vehicles. However, this approach is unlikely to be truly representative of vehicles on the road. From discussions with those in the Industry it is widely acknowledged that mirrors may not always be adjusted to meet the standards due to difficulties associated with the process including: manual mirrors, the need for floor mats or marked mirror adjustment bays, regular changes of drivers etc. Without further research it is impossible to predict how mirrors may be adjusted if they are not compliant with the standards. However it is possible to assess the impact of mirror adjustment where correctly adjusted mirrors for one driver are then adopted by a second driver and not readjusted.

6.3.5.1 EXAMINING THE CASE OF A SHORT (5TH%ILE FEMALE) DRIVER AND A TALL (95TH%ILE MALE) DRIVER USING MIRRORS SETUP FOR A 50TH %ILE MALE DRIVER

In the first instance, mirrors adjusted for the 50th %ile UK male were assessed with the 5th %ile UK female and 95th %ile UK Male drivers. The examples below use a single vehicle (Volvo FH) as an example of these adjustment issues which are applicable to all vehicles tested.

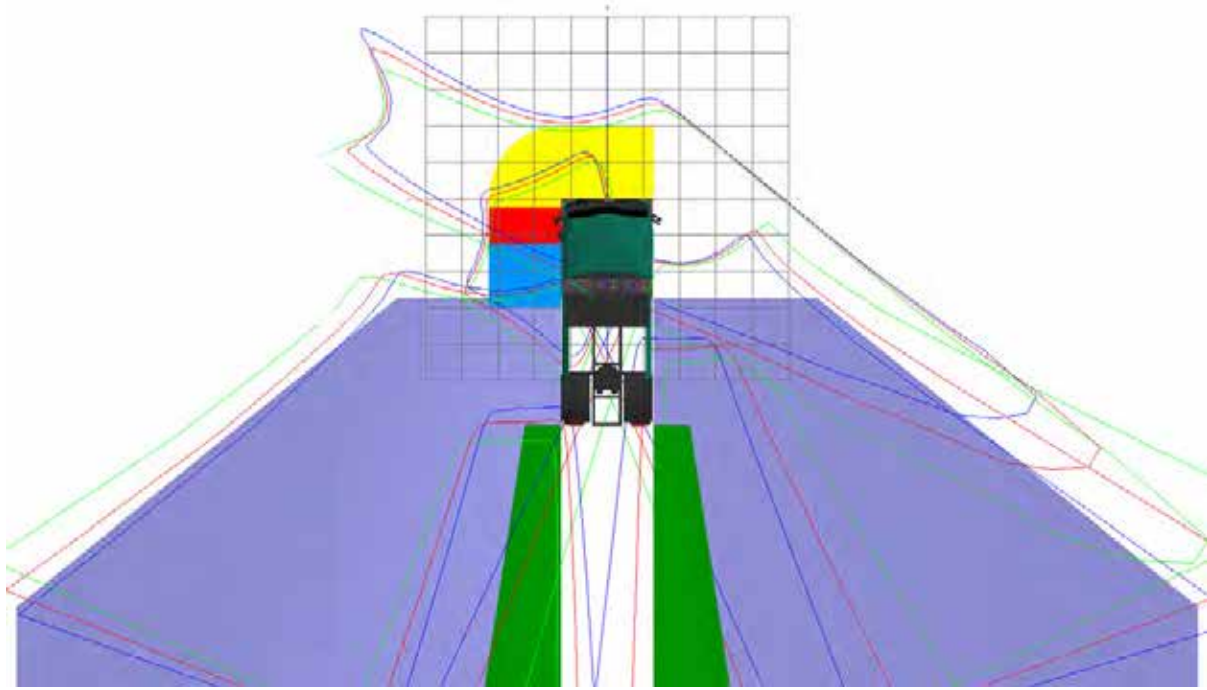


Figure 750. Combined projections showing the variation in field of view for mirrors adjusted for a 50th %ile UK male driver viewed by 5th %ile UK female (green), 50th %ile UK male (red) and 95th %ile UK male (blue) drivers

Figure 750 shows the differences in the 2D ground plane projections for a 5th %ile UK female (green) and 95th %ile UK male (blue) driver using mirrors adjusted for a 50th %ile UK male (red) driver. The differences in FOV coverage are greater for areas further away from the mirror and generally larger on the offside due to the proximity of the eye point to the mirrors on that side. The view towards the rear of the trailer for example shows the difference in FOV may be up to 1.5m laterally from the side of the vehicle for the Class II mirror and more for the Class IV mirror. Closer to the vehicle the FOV for the Class V and Class VI mirrors is only slightly affected in the critical areas. However the coverage for the Class V and Class VI mirrors for the smaller female driver using mirrors adjusted for an averaged sized male driver would no longer meet the regulations.

6.3.5.2 EXAMINING THE CASE OF A SHORT (5TH%ILE FEMALE) DRIVER USING MIRRORS SETUP FOR A TALL (95TH%ILE MALE) DRIVER

Mirrors were also adjusted for a 95th %ile UK male and assessed for FOV with a 5th %ile UK female driver. Figure 751 shows the difference in the 2D ground plane areas. As with the previous analysis the differences are greater on the offside due to the proximity of the eye point to the mirrors on that side. The coverage of the offside Class II mirror is particularly affected no longer covering any of the regulated area for that mirror. In addition, the coverage of the Class V and Class VI mirrors of the regulated areas is reduced in a manner that may affect the ability to see VRUs in proximity to the vehicle.

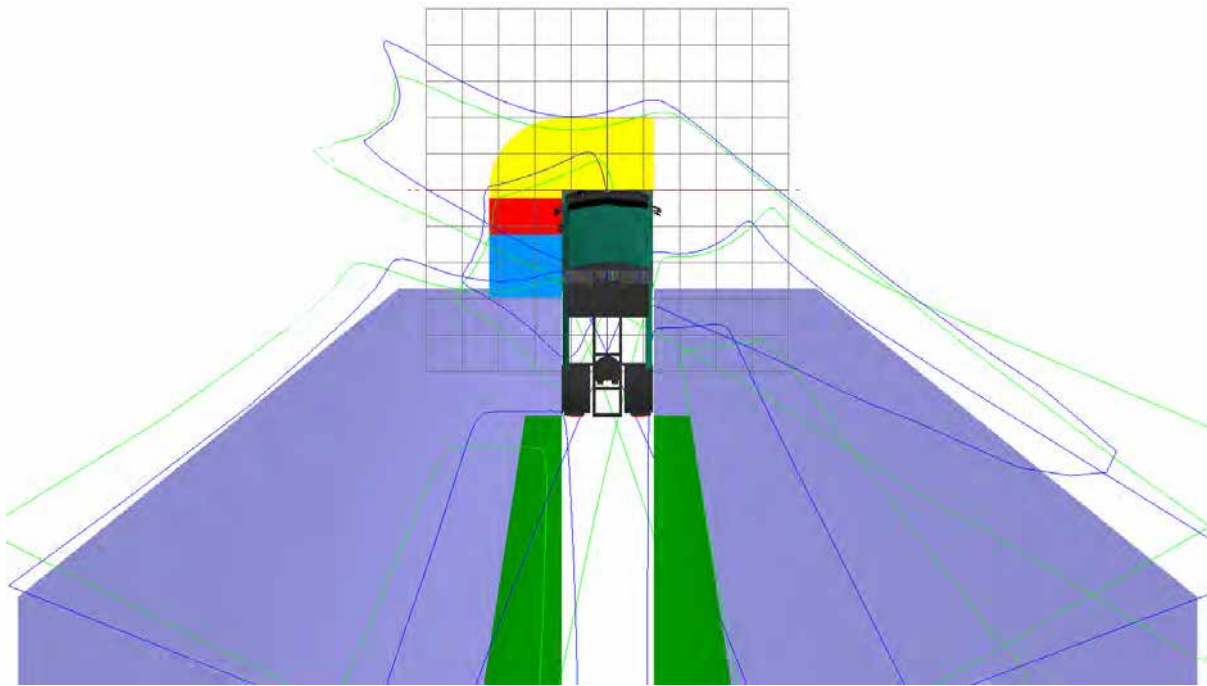


Figure 751. Combined projections showing the variation in field of view for mirrors adjusted for a 95th %ile UK male driver viewed by 5th %ile UK female (green) and 95th %ile UK male (blue) drivers

Figure 752 shows how the view of pedestrian VRUs to the front would be compromised in the Class VI mirror. In this case the middle (green) and left (red) pedestrians could be hidden from indirect view in the locations shown. However, they are visible via direct vision in these locations. If a smaller pedestrian was located in these areas, within the regulated area they could be hidden from both direct and indirect vision.



Figure 752. 3D volumetric projection showing the visibility of pedestrian VRUs to the front of a vehicle with a 5th %ile UK female driver using the Class VI mirror adjusted for a 95th %ile UK male

Figure 753 shows how cyclist VRUs to the nearside would still be partially visible in the Class V mirror. As with the analysis of the Class VI mirror to the front the FOV of the mirror is reduced in its coverage of the

mandated area. Only a small amount of the VRUs would be visible at the extremes of the mandated area, though the tops of their heads would just be visible via direct vision in these locations.



Figure 753. 3D volumetric projection showing the visibility of cyclist VRUs to the nearside of a vehicle with a 5th %ile UK female driver using the Class V mirror adjusted for a 95th %ile UK male

In summary, the situation of a smaller driver using mirrors set up for a larger driver could adversely affect the FOV in critical areas to the front and nearside of the vehicle and increase the size of the blind spots.

6.3.5.3 EXAMINING THE CASE OF A TALL (95TH%ILE MALE) DRIVER USING MIRRORS SETUP FOR A SHORT (5TH%ILE FEMALE) DRIVER

Mirrors were also adjusted for a 5th %ile UK female and assessed for FOV with a 95th %ile UK male driver. Figure 754 shows the difference in the 2D ground plane areas. In this instance the coverage of the Class IV mirrors is compromised laterally no longer providing a view of the regulated areas furthest away from the vehicle. The coverage of the Class V and class VI mirrors are affected but the FOV is extended away from the vehicle and does not compromise vision of the regulated areas.

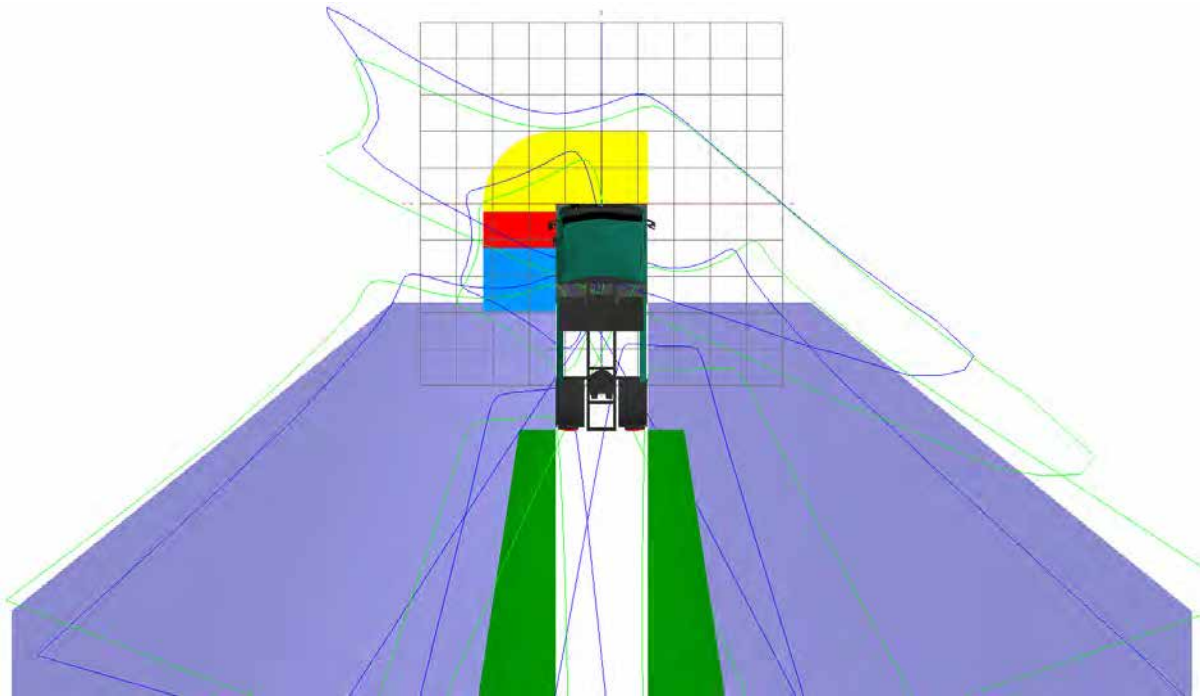


Figure 754. Combined projections showing the variation in field of view for mirrors adjusted for a 5th %ile UK female driver viewed by 5th %ile UK female (green) and 95th %ile UK male (blue) drivers

Figure 755 shows how pedestrian VRUs to the front would still be visible in the Class VI mirror. In this situation the mirror provides a FOV further out from the vehicle without compromising visibility directly adjacent to the cab. However, care should be taken in assuming this result applies to all vehicles especially those with smaller FOV for their Class VI mirror such as the MAN TGX, where the FOV of the area directly adjacent to the cab may be compromised.

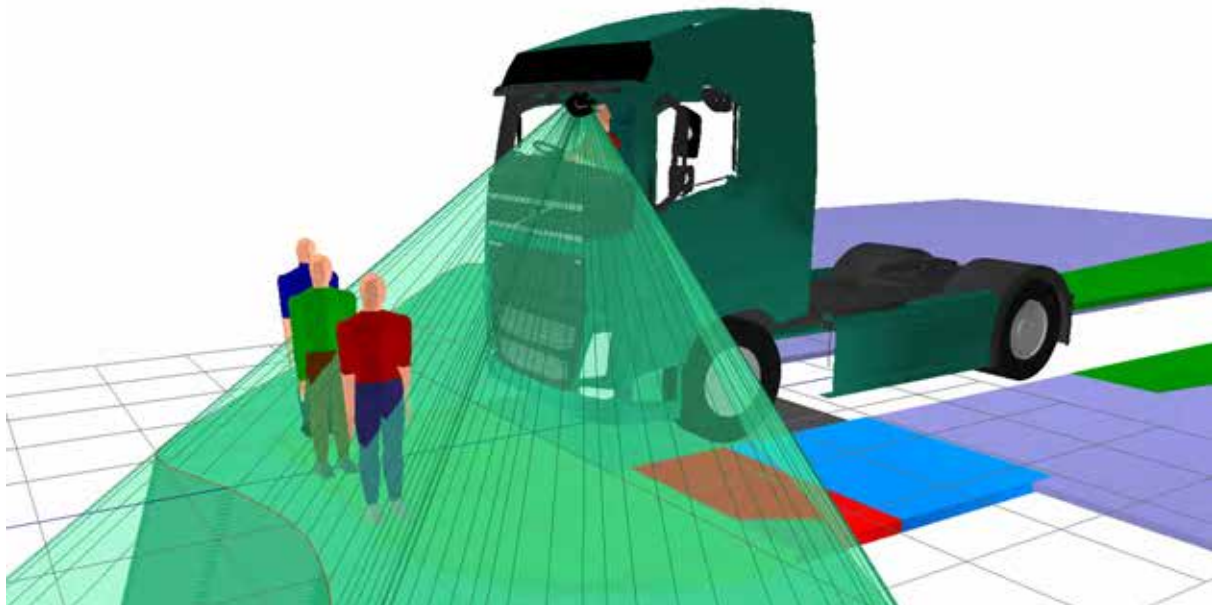


Figure 755. 3D volumetric projection showing the visibility of pedestrian VRUs to the front of a vehicle with a 95th %ile UK male driver using the Class VI mirror adjusted for a 5th %ile UK female

Figure 756 shows how cyclist VRUs to the nearside would still be visible in the Class V mirror. The situation is similar to that for the Class VI mirror to the front of the vehicle in that the Class V provides a FOV further out

from the vehicle without compromising visibility directly adjacent to the cab. As with the Class VI analysis care should be taken in assuming this result applies to all vehicles especially those with smaller FOV for their Class V mirror such as the DAF CF, where the FOV of the area directly adjacent to the cab may be compromised.

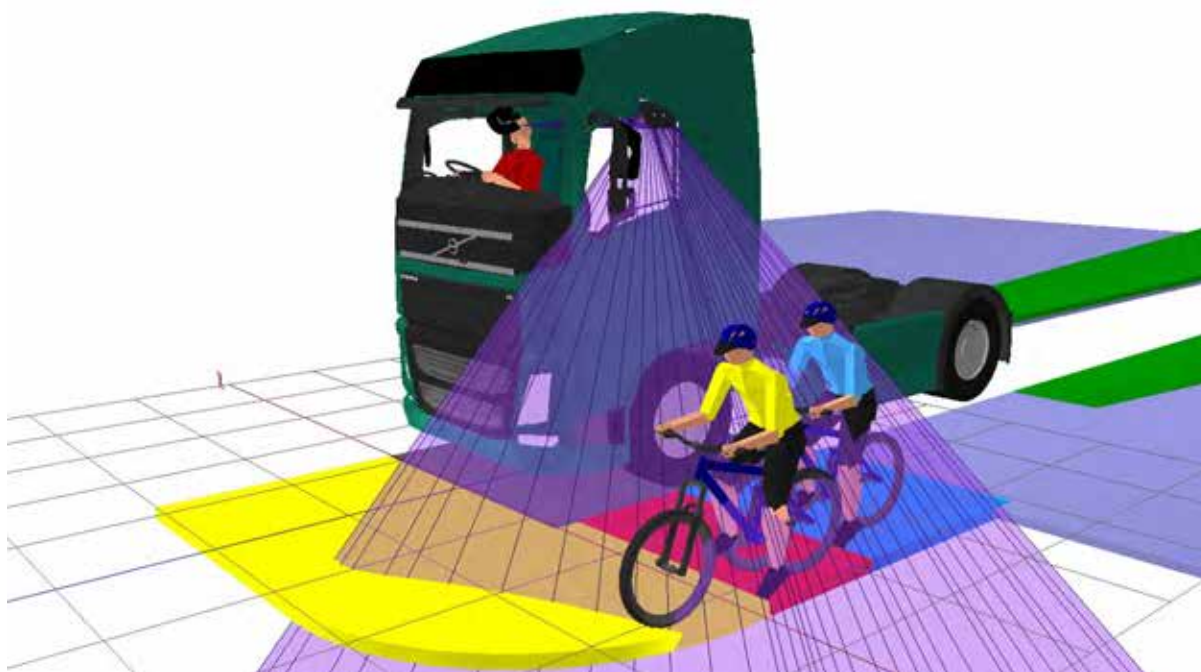


Figure 756. 3D volumetric projection showing the visibility of cyclist VRUs to the nearside of a vehicle with a 95th %ile UK male driver using the Class V mirror adjusted for a 5th %ile UK female

6.4 KEY FINDINGS FROM THE PROJECT

6.4.1 DIRECT VISION OF VULNERABLE ROAD USERS THROUGH WINDOWS

- Low entry cab designs provide greatly improved direct vision of the VRUs tested when compared to standard cab designs
- There are direct vision blind spots in all standard vehicle configurations
- The standard cab designs that have been tested show large variability in the distance at which VRUs can be hidden from the direct vision of the driver
 - The difference in the distances at which VRUs can be hidden has been shown to correlate with the height of the driver's eye position above the ground, and therefore the height of the vehicle cab
 - The design of the window apertures and their location with reference to the driver's eye position can affect the size of the VRU direct vision blind spots
 - The construction (N3G) configurations all showed higher cabs than the distribution variants (N3)
- Direct vision of VRUs can be supported by additional glazed areas below the passenger window as demonstrated by the Volvo FE LEC

- Narrower cab designs have improved direct vision when compared to the same cab design with a wider configuration

6.4.2 INDIRECT VISION OF VULNERABLE ROAD USERS THROUGH MIRRORS

- In all but three cases the VRUs which are placed at the edge of the direct vision blind spot are at least partially visible to the driver in a least one of the six mirrors which are fitted to all vehicles
- The tests that have been performed involve specific initial locations and subsequent movements of the VRUs which do not include all possible locations in which a VRU may be hidden from both direct and indirect vision
- In a large number of cases only a small portion of the VRU is visible to the driver through a mirror, and at the edge of the mirror, i.e. the most visually distorted portion of the mirror
 - It is questionable if the driver is able to recognise the VRU in these locations where a small portion of the VRU is visible at the edge of a mirror.
 - Further research is required to provide an improved understanding of driver mirror use behaviour in high work load situations where six mirrors must be used in combination with direct vision to provide situational awareness
 - This, in conjunction with the fact that accidents are still occurring and on the increase between cyclists and HGVs, indicates that direct vision should be prioritised over indirect vision in the vehicle design process
 - However it is recognised that direct vision is not likely to be the only solution and advances in sensing and autonomous technology could play a role in reducing accidents
- The adjustment of mirrors for specific drivers is an important factor. The analysis of this issue highlights that when a smaller driver uses a mirror set that is adjusted for a larger driver, that gaps in mirror coverage are increased, effectively increasing the potential for blind spot areas to hide VRUs from the driver

6.4.3 FOV AREA PROJECTION AS A MEASURE OF DIRECT AND INDIRECT VISION

- The results for the FOV area projection of direct and indirect vision provide a means of comparing and contrasting specific design features of vehicles
 - The analysis of the VRU visibility using direct vision shows the same result for all low entry cabs. The FOV area projection results add further detail and can rank the LEC cabs in terms of their clipped direct vision areas i.e.
 1. Dennis Eagle Elite 6
 2. Mercedes Econic LEC
 3. Scania LEC
 4. Volvo LEC
 - The assessment of vehicle designs which include lower passenger door window apertures highlights the benefits of the spherical projection technique as a tool to assess the design of lower passenger door additional glazed areas

7 FURTHER WORK RECOMMENDATIONS BASED UPON THE RESEARCH FINDINGS

The project has highlighted a number of specific issues that require further research in order to support the improved design of HGVs.

An issue that has been identified through the project is the lack of standardisation with regard to what should be directly viewable from the cab of a HGV. The project results have highlighted variability in cab features such as window apertures, and the location of driver seating position with respect to the window apertures. The variability in these design features has been shown to increase the size of direct vision blind spots. A direct vision standard has the potential to define what should be visible directly from the cab of a HGV, and to allow the classification of existing vehicles in terms of their ability to allow the driver to directly view VRUs.

A key concern from the perspective of the LDS team is the lack of existing research which explores the issue of driver behaviour in the use of six mirrors in combination with direct vision through windows to gain situational awareness. There are a number of issues associated with this area of research which should be examined.

1. Is it possible for a driver to use multiple mirrors in conjunction with direct vision through multiple windows to recognise the presence of VRUs, in motion, in close proximity to the vehicle in all situations?
 - a. Is there variability in the behaviour of drivers in the use of the mirrors and direct vision?
 - b. Is there an ideal behaviour which could be embedded into driver training?
 - c. If it is not possible for a driver to use six mirrors to determine VRU presence in close proximity to a vehicle what are the key scenarios which should be addressed through other means, e.g. improved direct vision from a cab or additional technologies which allow the presence of a VRU to be communicated to a driver
 - d. How can additional technologies be added to a vehicle in a manner which does not increase the workload upon the driver?
2. The ability of the driver to recognise a small portion of a vulnerable road user through a window or a mirror. How much of a VRU is enough to allow recognition in different lighting conditions and workload contexts?

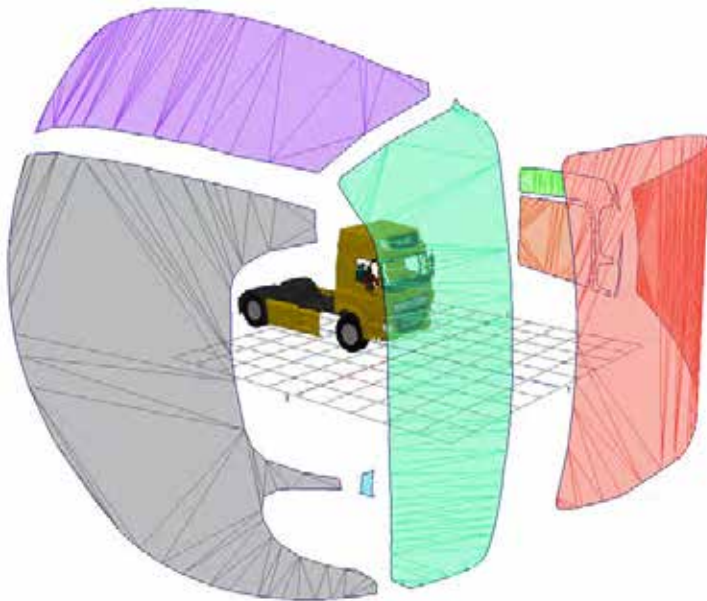
The tests that have been performed during the project have been designed to provide a mechanism for comparing the 19 vehicles in a manner which replicates the key scenarios identified from the accident data, however there are other blind spot areas and issues which have not been explicitly explored as shown in Figure 732 which illustrates the direct vision blind spots associated with the A-pillar and mirror mounting structures of the vehicle. In addition manufacturers have responded to the input from the CLOCS programme by offering optional lower door windows as shown in the Volvo FE LEC. These solutions were not available in time to allow analysis during the project. These solutions have potential to improve direct vision but their benefit would need to be quantified. Finally, the design of the assessment has included the analysis of the most sold configurations for each of the three standard vehicle categories that have been assessed. These represent the most common vehicles on the road in the UK, but do not represent the higher vehicles which are less common. An analysis of sales data to identify the higher configurations which are sold in volume would allow these vehicles to be modelled and tested as this would involve increasing the height of the existing CAD models in the SAMMIE DHM system. An analysis of these vehicles would be beneficial in determining the effect of these higher configurations on the ability of the driver to use direct vision to identify VRUs.

8.2 APPENDIX 2: FIELD OF VIEW – AREA PROJECTIONS

The following section provides FOV Area projections for 5th %ile UK female and 95th %ile UK male eye points. Note that shaded cells in the table highlight FOV area values that have changed for a given window or mirror during the clipping or combining processes from the original, unmodified area.

8.2.1 DIRECT VISION – 5TH %ILE FEMALE DRIVER

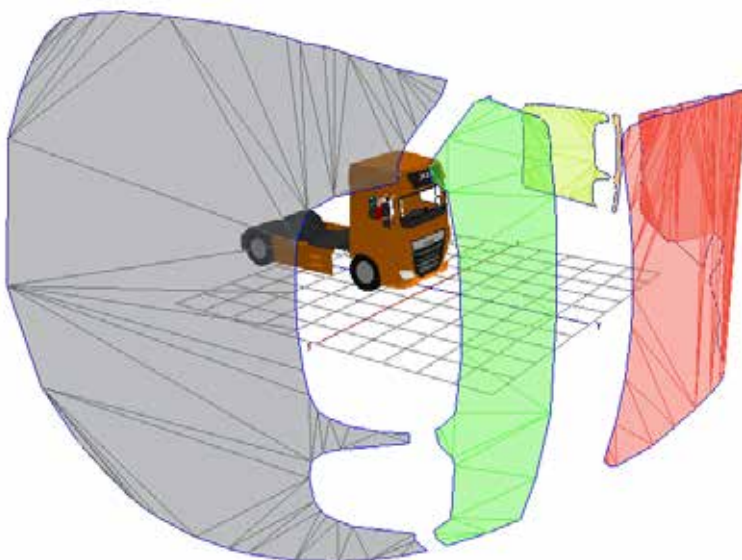
8.2.1.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	110.12
Passenger – p1	0.08
Passenger – p2	0.15
Passenger – p3	4.69
Passenger – p4	8.48
Driver – p1	100.84
Driver – p2	31.71
Driver – p3	25.92
Driver – p4	0.12
Total	282.12

Figure 758. FOV area projection for the DAF CF N3 / N3G

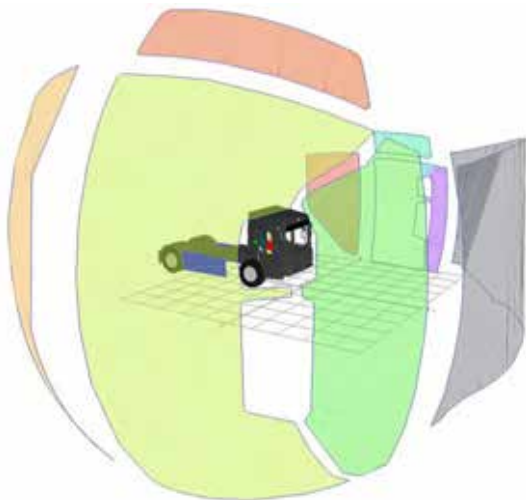
8.2.1.2 DAF XF CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	99.43
Passenger – p1	0.66
Passenger – p2	9.89
Driver – p1	17.78
Driver – p2	110.26
Total	238.02

Figure 759. FOV area projection for the DAF XF N3

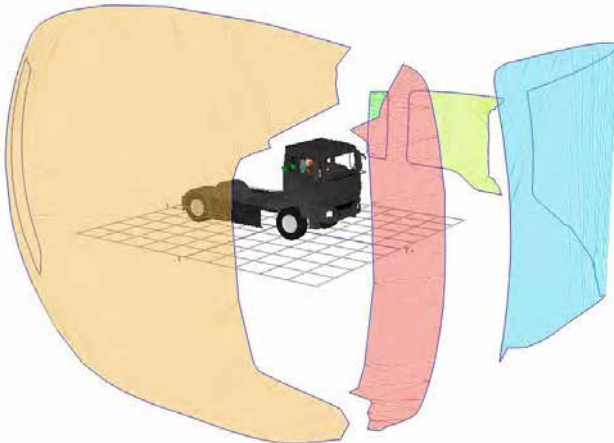
8.2.1.3 DENNIS EAGLE N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	103.26
Passenger – p1	12.73
Passenger – p2	14.58
Passenger – p3	4.64
Passenger – p4	3.42
Driver – p1	66.99
Driver – p2	77.54
Driver – p3	28.17
Driver – p4	11.91
Total	323.24

Figure 760. FOV area projection for the Dennis N3 LEC

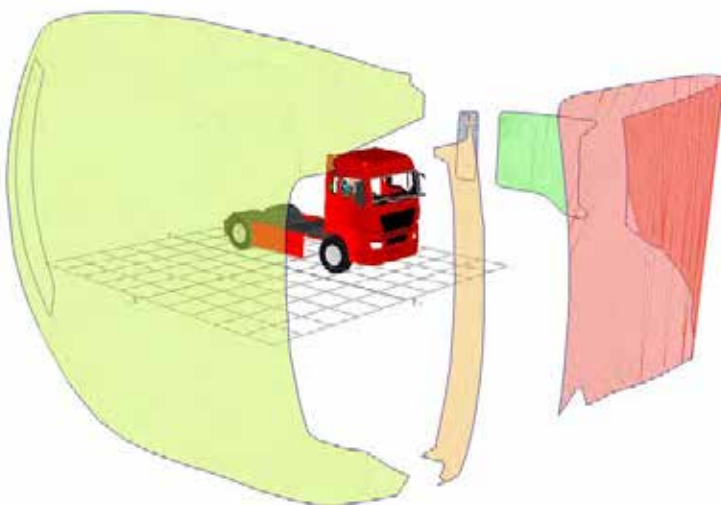
8.2.1.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	111.11
Passenger – p1	2.39
Passenger – p2	13.03
Driver – p1	15.78
Driver – p2	121.68
Driver – p3	9.19
Total	273.18

Figure 761. FOV area projection for the MAN TGS N3 / N3G

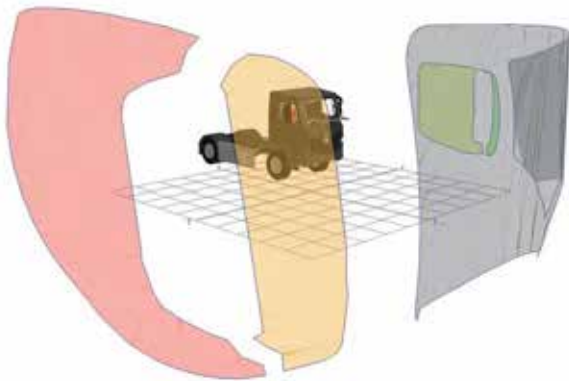
8.2.1.5 MAN TGX CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	97.07
Passenger – p1	10.68
Passenger – p2	2.03
Driver – p1	4.68
Driver – p2	113.54
Driver – p3	11.66
Total	239.66

Figure 762. FOV area projection for the MAN TGX N3 / N3G

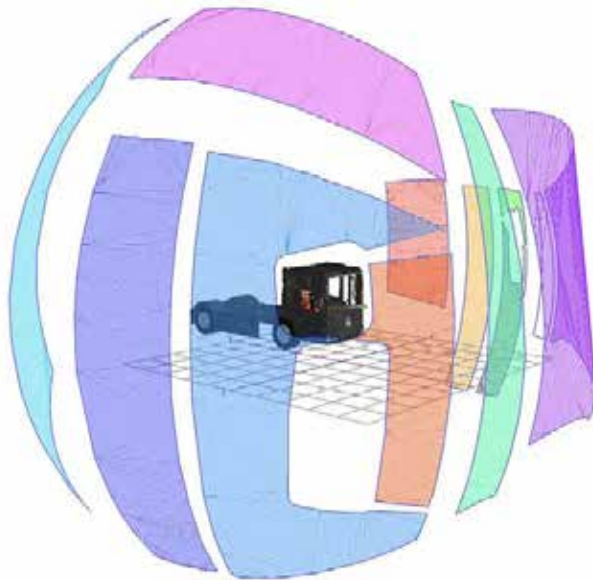
8.2.1.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	101.21
Passenger – p1	1.37
Passenger – p2	12.09
Driver – p1	19.99
Driver – p2	101.53
Total	236.19

Figure 763. FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

8.2.1.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	99.76
Passenger – p1	3.81
Passenger – p2	5.96
Passenger – p3	1.27
Passenger – p4	0.35
Passenger – p5	10.88
Passenger – p6	14.48
Driver – p1	11.84
Driver – p2	11.41
Driver – p3	39.10
Driver – p4	25.86
Driver – p5	36.02
Driver – p6	93.53
Total	357.27

Figure 764. FOV area projection for the Mercedes Econic N3 LEC

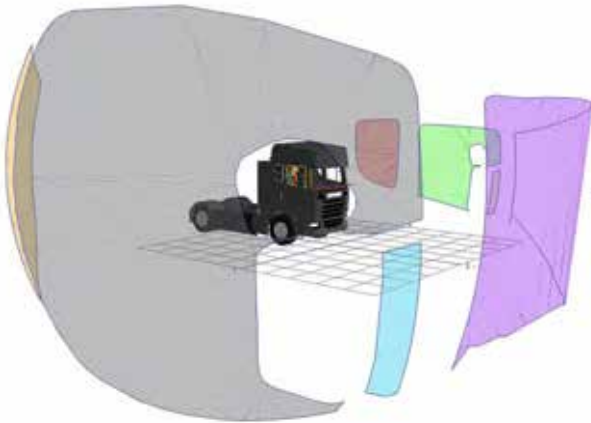
8.2.1.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	91.11
Passenger – p1	2.65
Passenger – p2	11.28
Passenger – p3	0.72
Driver – p1	112.74
Driver – p1	4.33
Total	222.83

Figure 765. FOV area projection for the Scania P N3 / N3G

8.2.1.9 SCANIA R CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	99.50
Passenger – p1	0.71
Passenger – p2	11.28
Passenger – p3	27.56
Driver – p1	4.06
Driver – p2	110.16
Driver – p3	6.15
Total	259.42

Figure 766. FOV area projection for the Scania R N3

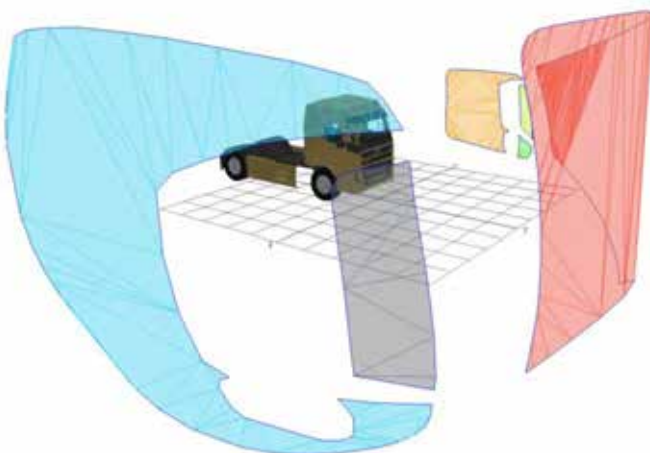
8.2.1.10 SCANIA P N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	85.37
Passenger – p1	0.67
Passenger – p2	10.54
Passenger – p3	5.31
Driver – p1	4.19
Driver – p2	135.30
Driver – p3	28.07
Total	269.45

Figure 767. FOV area projection for the Scania N3 LEC

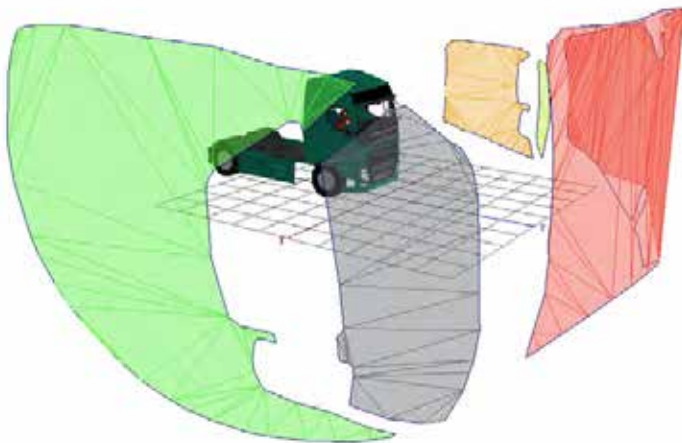
8.2.1.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Window	Area(m ²)
Windscreen	121.82
Passenger – p1	8.86
Passenger – p2	0.92
Passenger – p3	0.43
Driver – p1	114.28
Driver – p2	9.07
Total	255.38

Figure 768. FOV area projection for the Volvo FM N3 / FMX N3G

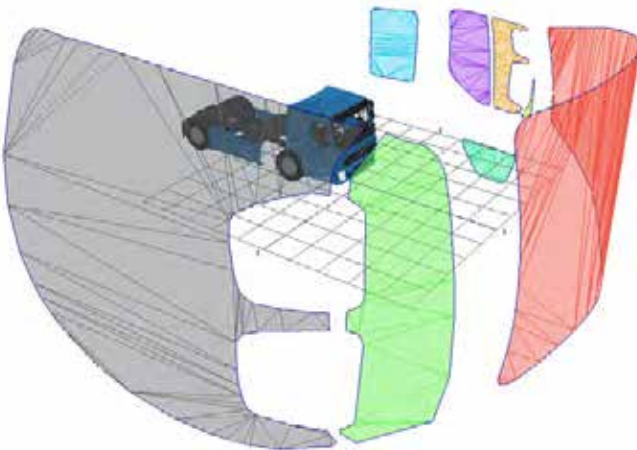
8.2.1.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	109.52
Passenger – p1	11.79
Passenger – p2	1.42
Driver – p1	102.08
Driver – p2	24.36
Total	249.17

Figure 769. FOV area projection for the Volvo FH N3

8.2.1.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

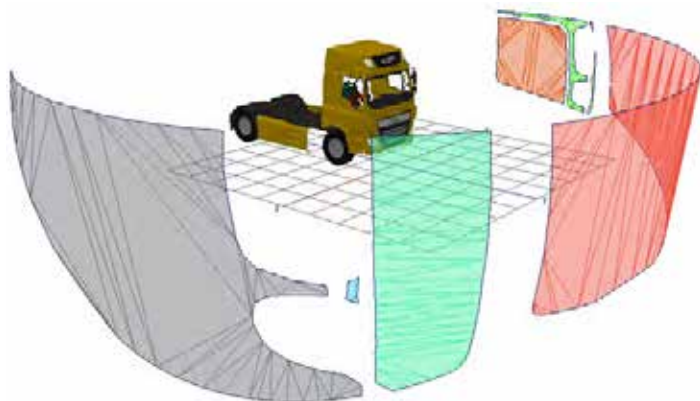


Window	Area(m ²)
Windscreen	107.90
Passenger – p1	5.94
Passenger – p2	3.50
Passenger – p3	0.26
Passenger - Cab	5.76
Passenger - Door	2.56
Driver – p1	99.70
Driver – p2	20.61
Total	246.23

Figure 770. FOV area projection for the Volvo FE N3 LEC

8.2.2 CLIPPED DIRECT VISION +7° – 5TH %ILE FEMALE DRIVER

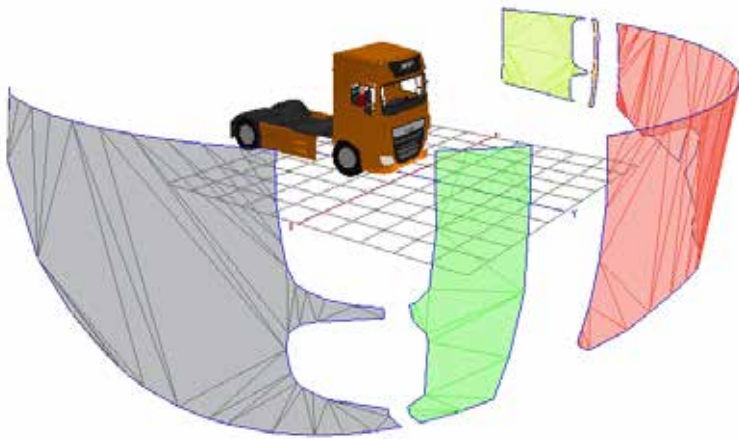
8.2.2.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	69.93
Passenger – p1	0.03
Passenger – p2	0.15
Passenger – p3	1.59
Passenger – p4	8.48
Driver – p1	73.76
Driver – p2	0.00
Driver – p3	15.42
Driver – p4	0.12
Total	169.48

Figure 771. Clipped FOV area projection for the DAF CF N3 / N3G

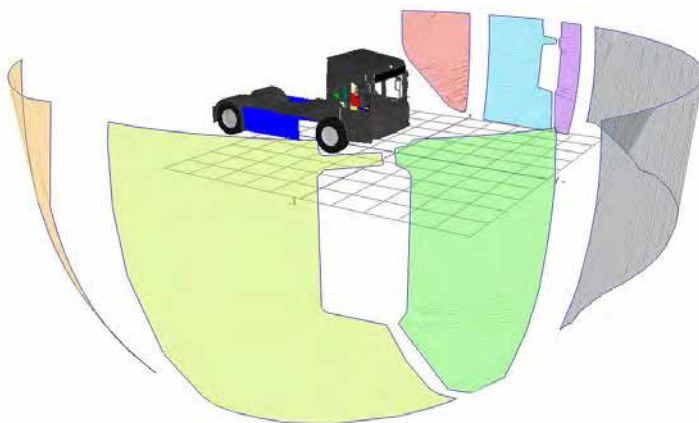
8.2.2.2 DAF XF CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	67.45
Passenger – p1	0.58
Passenger – p2	8.83
Driver – p1	11.94
Driver – p2	66.88
Total	155.69

Figure 772. Clipped FOV area projection for the DAF XF N3

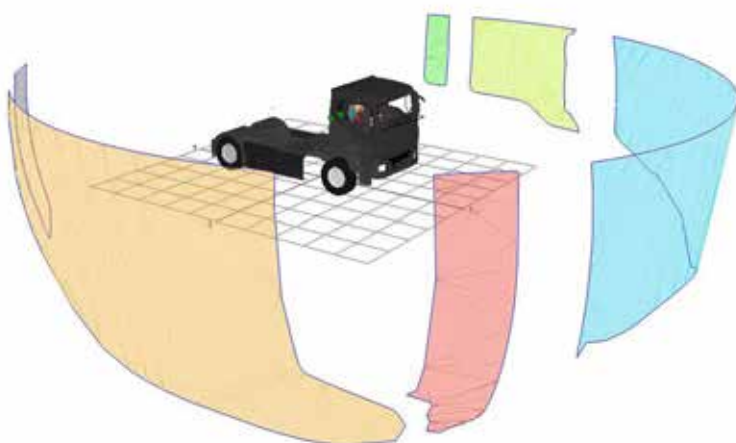
8.2.2.3 DENNIS EAGLE N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	65.1
Passenger – p1	9.18
Passenger – p2	11.46
Passenger – p3	3.86
Driver – p1	38.11
Driver – p2	47.49
Driver – p3	19.29
Driver – p4	0.00
Total	194.49

Figure 773. Clipped FOV area projection for the Dennis N3 LEC

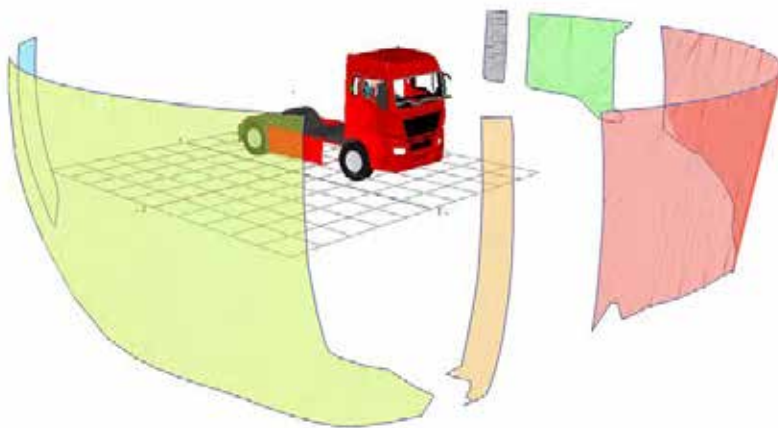
8.2.2.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	69.63
Passenger – p1	2.2
Passenger – p2	11.54
Driver – p1	11.92
Driver – p2	76.00
Driver – p3	6.42
Total	177.71

Figure 774. Clipped FOV area projection for the MAN TGS N3 / N3G

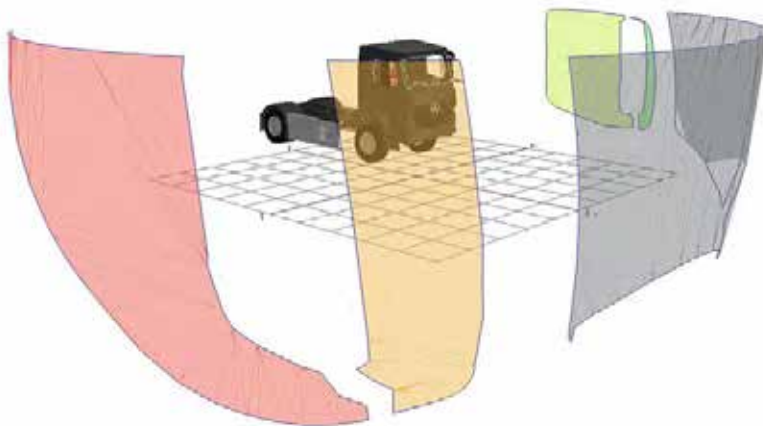
8.2.2.5 MAN TGX CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	67.07
Passenger – p1	10.18
Passenger – p2	2.0
Driver – p1	3.85
Driver – p2	72.27
Driver – p3	8.09
Total	163.46

Figure 775. Clipped FOV area projection for the MAN TGX N3 / N3G

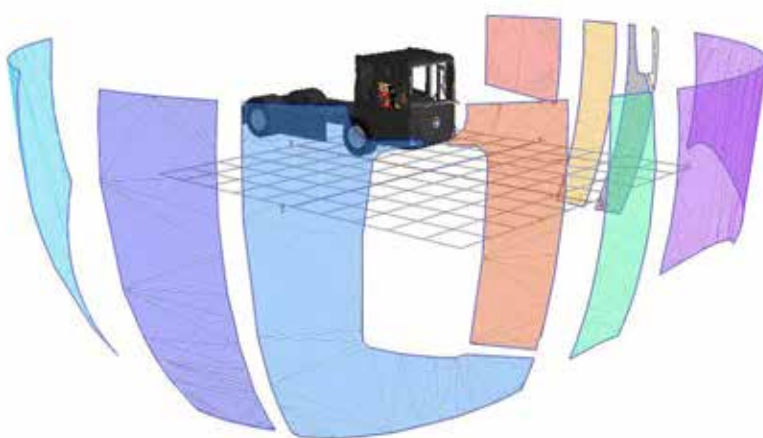
8.2.2.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	77.20
Passenger – p1	1.37
Passenger – p2	12.09
Driver – p1	17.64
Driver – p2	79.61
Total	187.91

Figure 776. Clipped FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

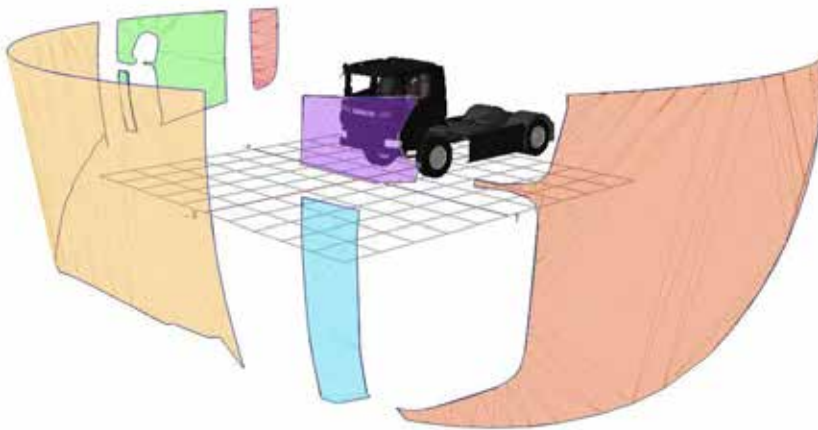
8.2.2.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	48.56
Passenger – p1	2.72
Passenger – p2	5.78
Passenger – p3	0.00
Passenger – p4	0.35
Passenger – p5	7.90
Passenger – p6	7.57
Driver – p1	7.19
Driver – p2	9.07
Driver – p3	27.24
Driver – p4	24.23
Driver – p5	0.00
Driver – p6	43.86
Total	157.23

Figure 777. Clipped FOV area projection for the Mercedes Econic N3 LEC

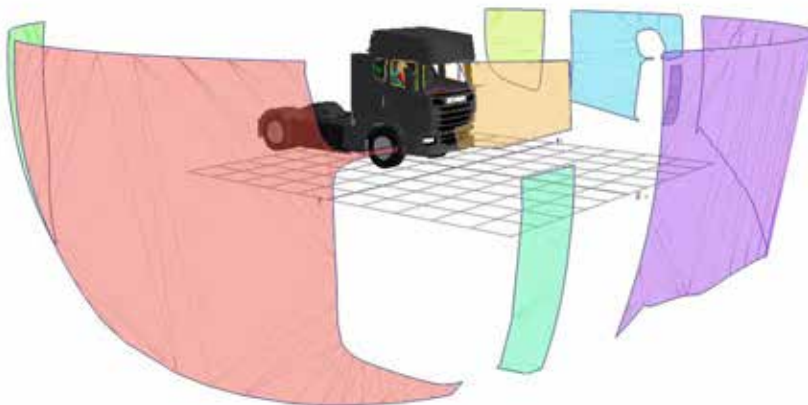
8.2.2.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	72.45
Passenger – p1	2.41
Passenger – p2	10.23
Passenger – p3	0.79
Driver – p1	4.33
Driver – p2	66.21
Total	156.41

Figure 778. Clipped FOV area projection for the Scania P N3 / N3G

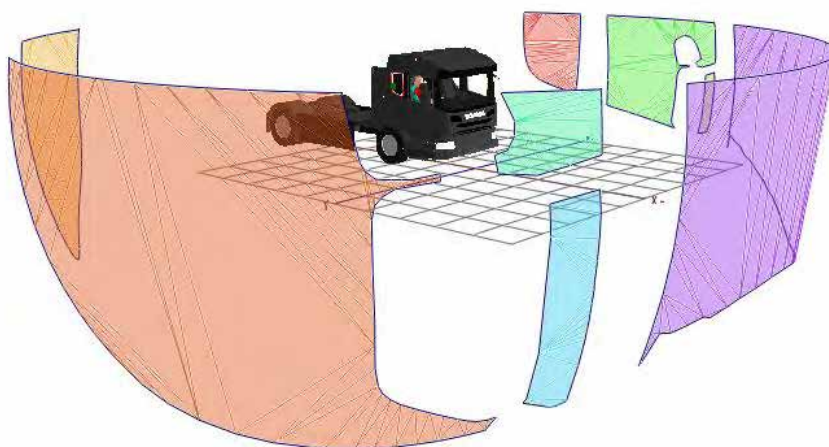
8.2.2.9 SCANIA R CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	73.79
Passenger – p1	0.82
Passenger – p2	10.16
Passenger – p3	16.92
Driver – p1	4.06
Driver – p2	65.86
Driver – p3	5.29
Total	176.9

Figure 779. Clipped FOV area projection for the Scania R N3

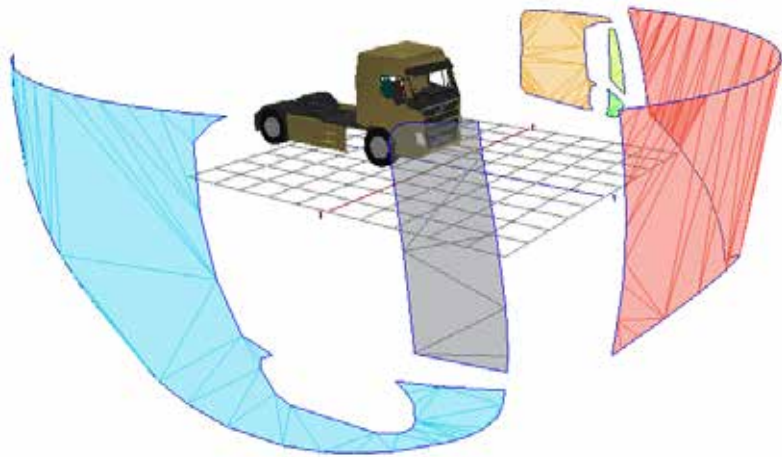
8.2.2.10 SCANIA P N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	67.76
Passenger – p1	0.67
Passenger – p2	9.63
Passenger – p3	4.55
Driver – p1	4.19
Driver – p2	78.24
Driver – p3	15.95
Total	180.99

Figure 780. Clipped FOV area projection for the Scania N3 LEC

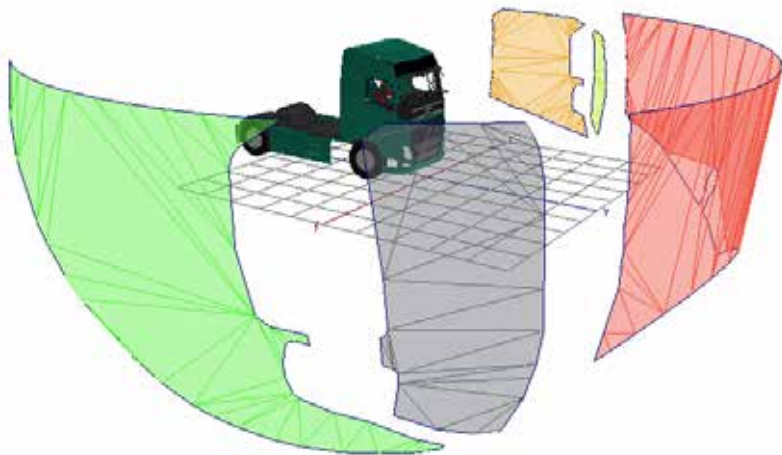
8.2.2.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Window	Area(m ²)
Windscreen	82.73
Passenger – p1	8.86
Passenger – p2	0.92
Passenger – p3	0.43
Driver – p1	84.67
Driver – p2	8.94
Total	186.55

Figure 781. Clipped FOV area projection for the Volvo FM N3 / FMX N3G

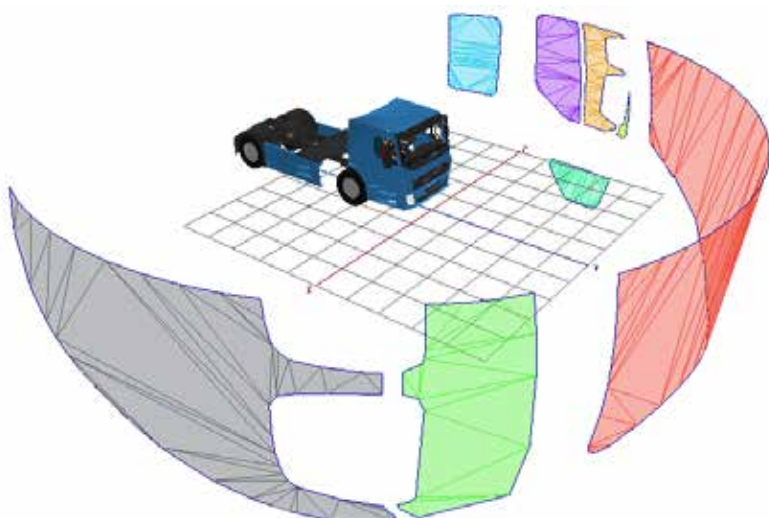
8.2.2.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	78.76
Passenger – p1	11.79
Passenger – p2	1.42
Driver – p1	80.67
Driver – p2	23.13
Total	195.78

Figure 782. Clipped FOV area projection for the Volvo FH N3

8.2.2.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

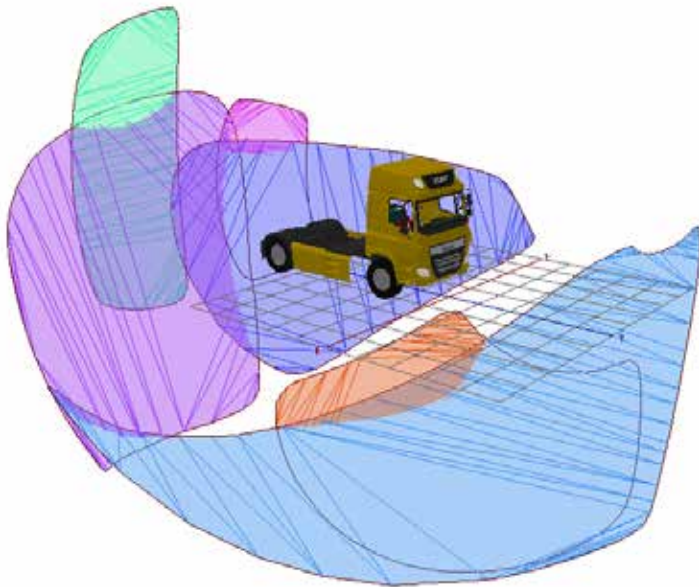


Window	Area(m ²)
Windscreen	75.76
Passenger – p1	5.93
Passenger – p2	3.50
Passenger – p3	0.26
Passenger - Cab	5.76
Passenger - Door	2.56
Driver – p1	64.64
Driver – p2	15.73
Total	174.14

Figure 783. Clipped FOV area projection for the Volvo FE N3 LEC

8.2.3 INDIRECT VISION – 5TH %ILE FEMALE DRIVER

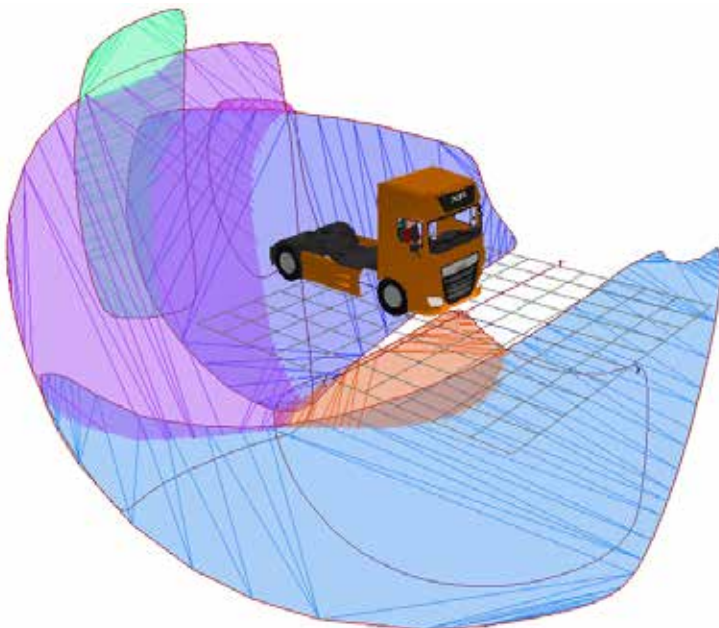
8.2.3.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	20.18
Class IV – Pass	96.67
Class II – Driver	42.20
Class IV – Driver	127.39
Class V	101.97
Class VI	250.86
Total	639.26

Figure 784. Indirect FOV area projection for the DAF CF N3 / N3G

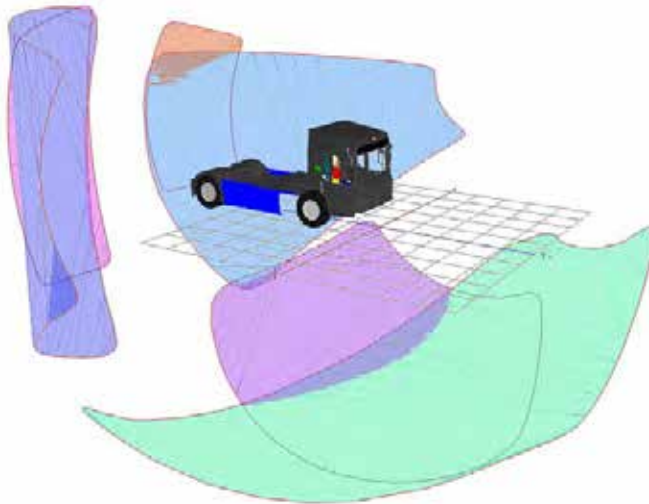
8.2.3.2 DAF XF CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	20.12
Class IV – Pass	111.62
Class II – Driver	43.03
Class IV – Driver	164.99
Class V	99.78
Class VI	250.19
Total	689.74

Figure 785. Indirect FOV area projection for the DAF XF N3

8.2.3.3 DENNIS EAGLE N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	21.58
Class IV – Pass	86.68
Class II – Driver	39.46
Class IV – Driver	121.40
Class V	109.66
Class VI	212.03
Total	590.81

Figure 786. Indirect FOV area projection for the Dennis N3 LEC

8.2.3.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	22.21
Class IV – Pass	74.63
Class II – Driver	45.81
Class IV – Driver	119.94
Class V	129.07
Class VI	194.22
Total	585.88

Figure 787. Indirect FOV area projection for the MAN TGS N3 / N3G

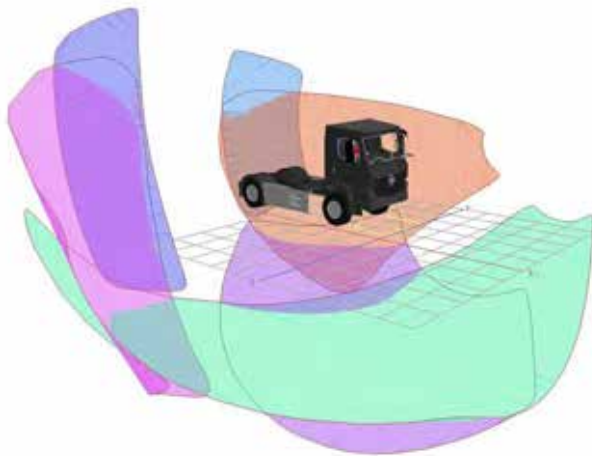
8.2.3.5 MAN TGX CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	21.81
Class IV – Pass	69.25
Class II – Driver	42.44
Class IV – Driver	127.93
Class V	134.63
Class VI	185.37
Total	581.43

Figure 788. Indirect FOV area projection for the MAN TGX N3 / N3G

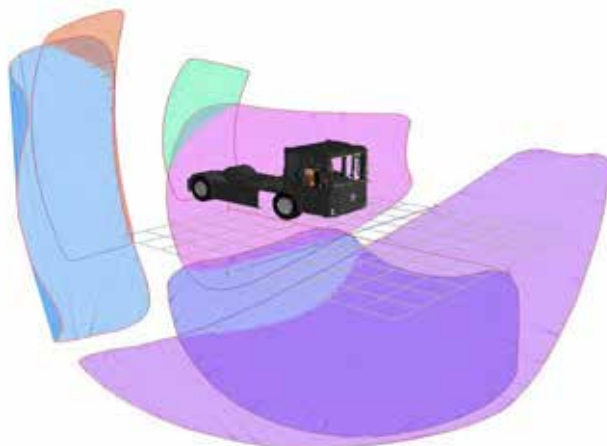
8.2.3.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	23.46
Class IV – Pass	82.36
Class II – Driver	46.90
Class IV – Driver	127.42
Class V	143.65
Class VI	279.93
Total	703.72

Figure 789. Indirect FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

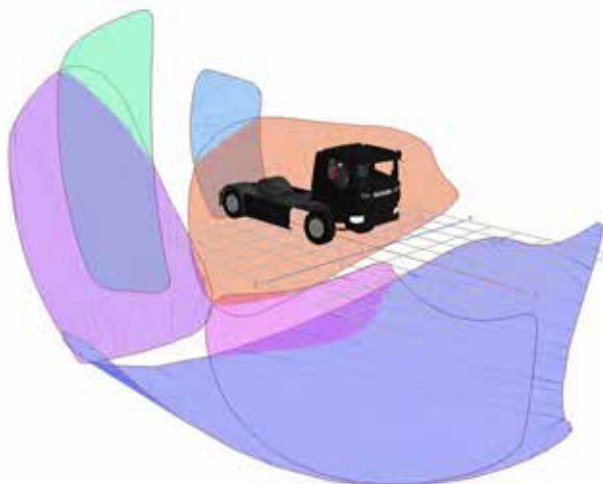
8.2.3.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	22.68
Class IV – Pass	82.98
Class II – Driver	49.64
Class IV – Driver	150.13
Class V	137
Class VI	257.88
Total	700.31

Figure 790. Indirect FOV area projection for the Mercedes Econic N3 LEC

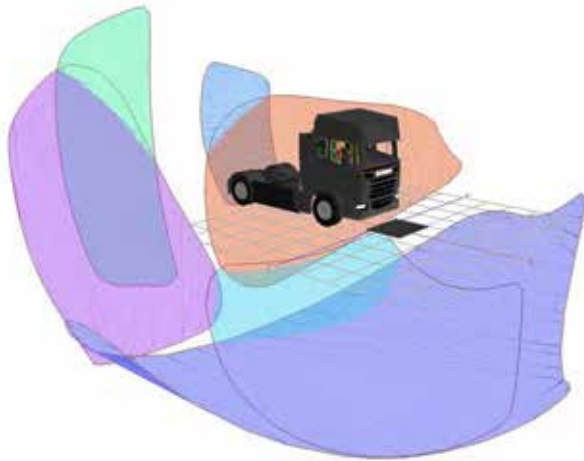
8.2.3.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	18.03
Class IV – Pass	75.23
Class II – Driver	51.13
Class IV – Driver	113.68
Class V	116.81
Class VI	243.04
Total	617.92

Figure 791. Indirect FOV area projection for the Scania P N3 / N3G

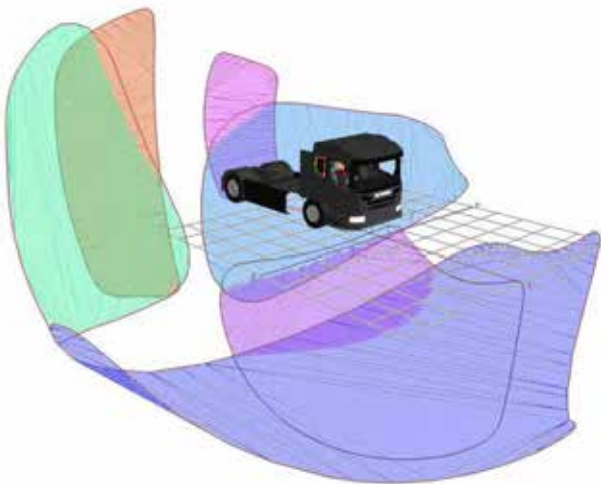
8.2.3.9 SCANIA R CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	17.74
Class IV – Pass	71.90
Class II – Driver	50.25
Class IV – Driver	112.33
Class V	117.16
Class VI	243.88
Total	613.26

Figure 792. Indirect FOV area projection for the Scania R N3

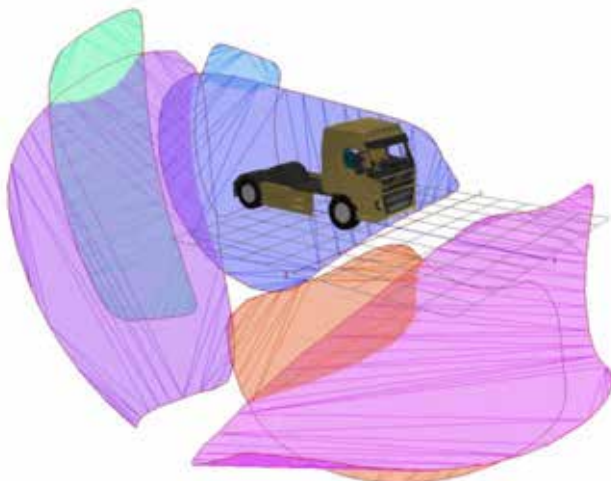
8.2.3.10 SCANIA P N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	17.82
Class IV – Pass	74.37
Class II – Driver	53.30
Class IV – Driver	112.30
Class V	105.76
Class VI	251.56
Total	615.11

Figure 793. Indirect FOV area projection for the Scania N3 LEC

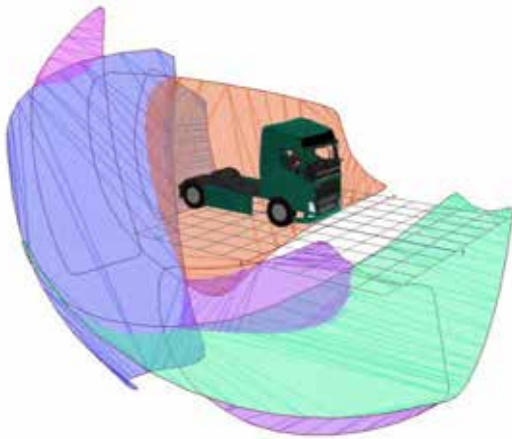
8.2.3.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	22.06
Class IV – Pass	91.63
Class II – Driver	52.69
Class IV – Driver	136.96
Class V	117.38
Class VI	202.16
Total	622.88

Figure 794. Indirect FOV area projection for the Volvo FM N3 / FMX N3G

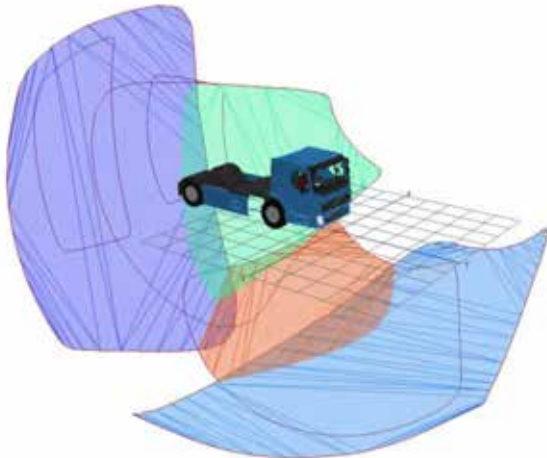
8.2.3.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	22.05
Class IV – Pass	101.93
Class II – Driver	50.53
Class IV – Driver	162.14
Class V	117.82
Class VI	242.56
Total	697.04

Figure 795. Indirect FOV area projection for the Volvo FH N3

8.2.3.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

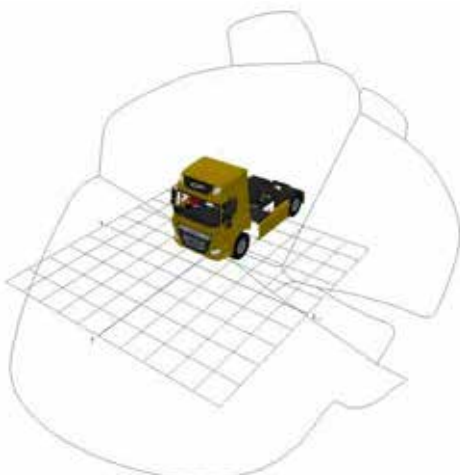


Mirror	Area(m ²)
Class II – Pass	19.40
Class IV – Pass	114.35
Class II – Driver	39.02
Class IV – Driver	183.79
Class V	108.63
Class VI	183.13
Total	648.33

Figure 796. Indirect FOV area projection for the Volvo FE N3 LEC

8.2.4 COMBINED INDIRECT VISION – 5TH %ILE FEMALE DRIVER

8.2.4.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	3.61
Class IV – Pass	69.21
Class II – Driver	11.00
Class IV – Driver	114.02
Class V	12.66
Class VI	246.92
Total	457.42

Figure 797. Combined indirect FOV area projection for the DAF CF N3 / N3G

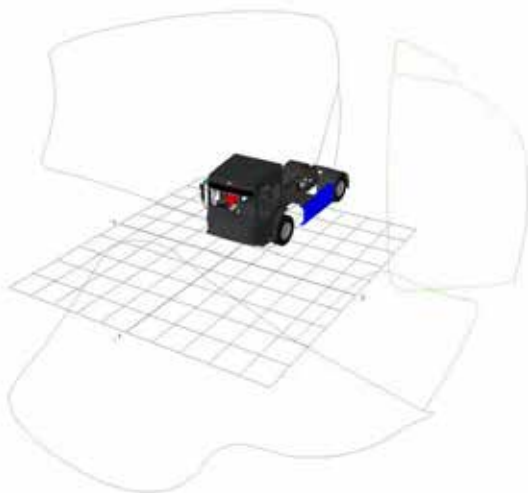
8.2.4.2 DAF XF CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	0.07
Class IV – Pass	56.92
Class II – Driver	6.61
Class IV – Driver	146.24
Class V	14.65
Class VI	238.88
Total	463.39

Figure 798. Combined indirect FOV area projection for the DAF XF N3

8.2.4.3 DENNIS EAGLE N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	4.04
Class IV – Pass	85.07
Class II – Driver	3.6
Class IV – Driver	120.37
Class V	42.56
Class VI	210.22
Total	465.86

Figure 799. Combined indirect FOV area projection for the Dennis N3 LEC

8.2.4.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	3.81
Class IV – Pass	74.07
Class II – Driver	7.39
Class IV – Driver	118.96
Class V	30.74
Class VI	191.69
Total	426.66

Figure 800. Combined indirect FOV area projection for the MAN TGS N3 / N3G

8.2.4.5 MAN TGX CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	7.17
Class IV – Pass	68.91
Class II – Driver	7.78
Class IV – Driver	127.23
Class V & VI	217.53
Total	428.61

Figure 801. Combined indirect FOV area projection for the MAN TGX N3 / N3G

8.2.4.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	6.5
Class IV – Pass	69.17
Class II – Driver	37.37
Class IV – Driver	85.33
Class V	25.17
Class VI	242.47
Total	466.01

Figure 802. Combined indirect FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

8.2.4.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	13.46
Class IV – Pass	72.38
Class II – Driver	32.38
Class IV – Driver	123.27
Class V	22.84
Class VI	256.38
Total	520.71

Figure 803. Combined indirect FOV area projection for the Mercedes Econic N3 LEC

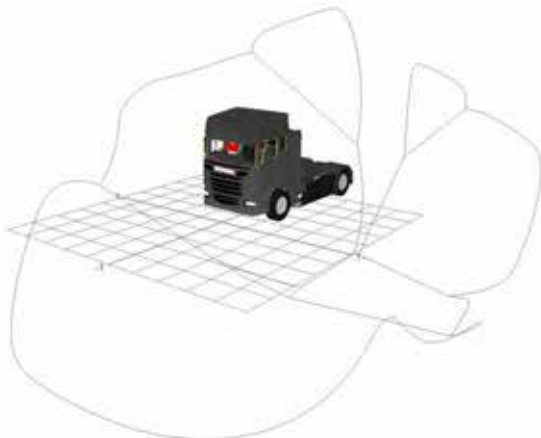
8.2.4.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	8.74
Class IV – Pass	71.34
Class II – Driver	18.10
Class IV – Driver	105.87
Class V	16.12
Class VI	241.43
Total	461.60

Figure 804. Combined indirect FOV area projection for the Scania P N3 / N3G

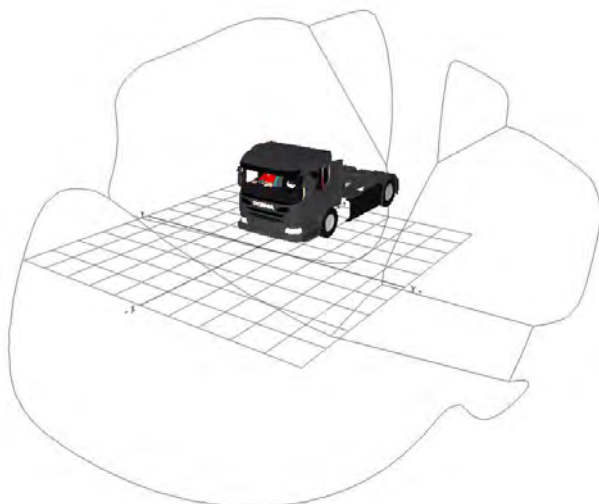
8.2.4.9 SCANIA R CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	8.12
Class IV – Pass	66.24
Class II – Driver	18.82
Class IV – Driver	102.26
Class V	22.93
Class VI	241.47
Total	459.84

Figure 805. Combined indirect FOV area projection for the Scania R N3

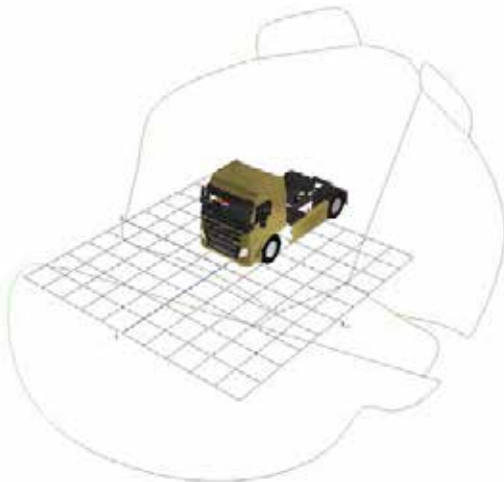
8.2.4.10 SCANIA P N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	9.43
Class IV – Pass	68.73
Class II – Driver	12.22
Class IV – Driver	109.31
Class V	26.34
Class VI	249.68
Total	475.71

Figure 806. Combined indirect FOV area projection for the Scania N3 LEC

8.2.4.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	4.37
Class IV – Pass	63.20
Class II – Driver	8.00
Class IV – Driver	130.09
Class V	24.99
Class VI	197.82
Total	428.46

Figure 807. Combined indirect FOV area projection for the Volvo FM N3 / FMX N3G

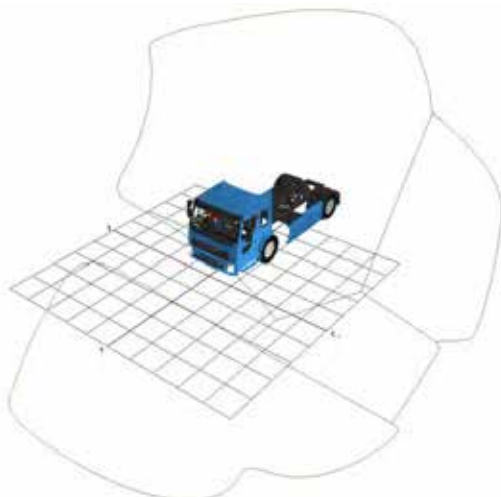
8.2.4.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	0.00
Class IV – Pass	62.26
Class II – Driver	5.97
Class IV – Driver	124.09
Class V	19.65
Class VI	239.87
Total	451.84

Figure 808. Combined indirect FOV area projection for the Volvo FH N3

8.2.4.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

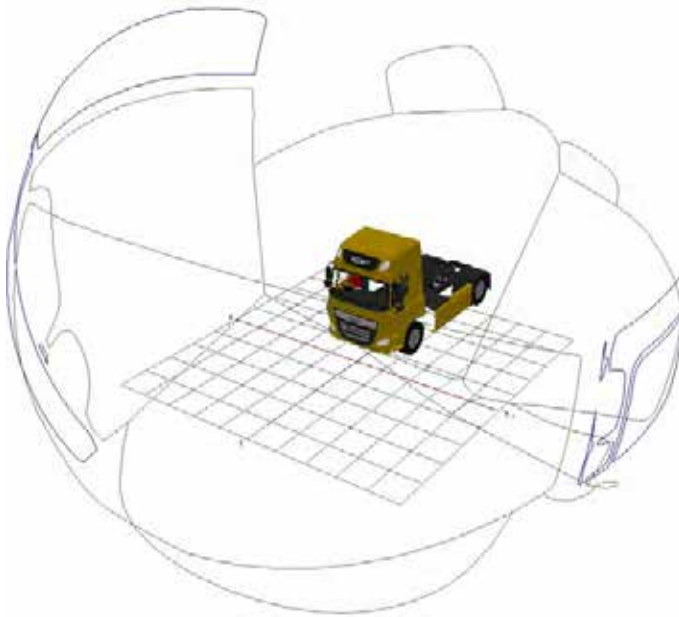


Mirror	Area(m ²)
Class II – Pass	0.03
Class IV – Pass	55.23
Class II – Driver	0.00
Class IV – Driver	174.35
Class V	39.84
Class VI	179.61
Total	449.06

Figure 809. Combined indirect FOV area projection for the Volvo FE N3 LEC

8.2.5 COMBINED DIRECT AND INDIRECT VISION – 5TH %ILE FEMALE DRIVER

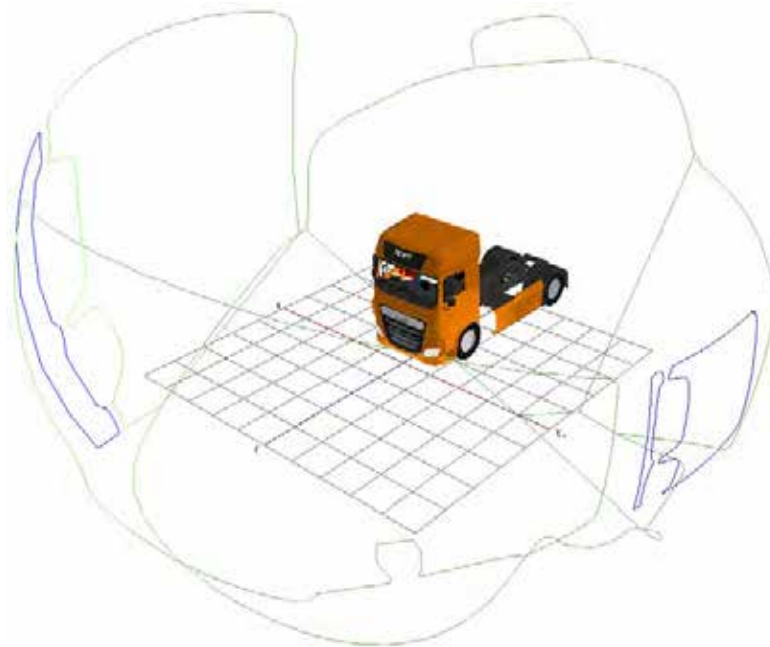
8.2.5.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	110.12
Passenger – p1	0.08
Passenger – p2	0.15
Passenger – p3	4.69
Passenger – p4	8.48
Driver – p1	98.01
Driver – p2	31.71
Driver – p3	25.92
Driver – p4	0.12
Class II – Pass	3.61
Class IV – Pass	69.21
Class II – Driver	11.00
Class IV – Driver	107.57
Class V	12.66
Class VI	234.82
Total	718.15

Figure 810. Combined direct and indirect FOV area projection for the DAF CF N3 / N3G

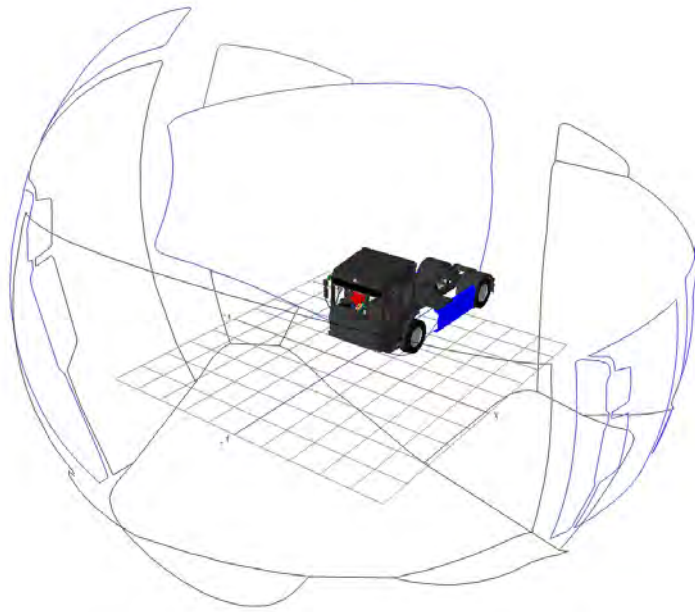
8.2.5.2 DAF XF CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	99.43
Passenger – p1	0.66
Passenger – p2	9.89
Driver – p1	17.78
Driver – p2	100.11
Class II – Pass	0.07
Class IV – Pass	56.92
Class II – Driver	6.61
Class IV – Driver	146.24
Class V	14.65
Class VI	238.82
Total	691.18

Figure 811. Combined direct and indirect FOV area projection for the DAF XF N3

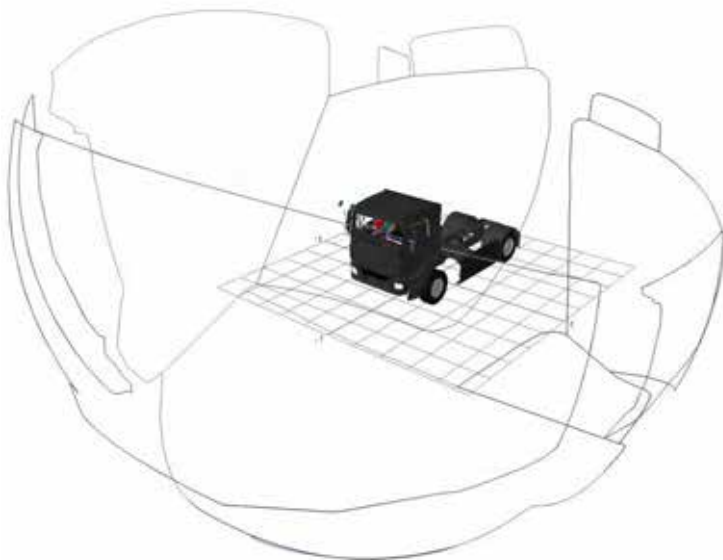
8.2.5.3 DENNIS EAGLE N3 LOW ENTRY CAB



Window	Area(m2)
Windscreen	103.24
Passenger – p1	2.86
Passenger – p2	1.38
Passenger – p3	14.58
Passenger – p4	4.64
Passenger – p5	3.15
Driver – p1	28.17
Driver – p2	74.52
Driver – p3	11.91
Driver – p4	7.2
Driver – p5	9.25
Class II – Pass	4.04
Class IV – Pass	85.07
Class II & IV– Driver	123.55
Class V	42.56
Class VI	209.37
Total	722.34

Figure 812. Combined direct and indirect FOV area projection for the Dennis N3 LEC

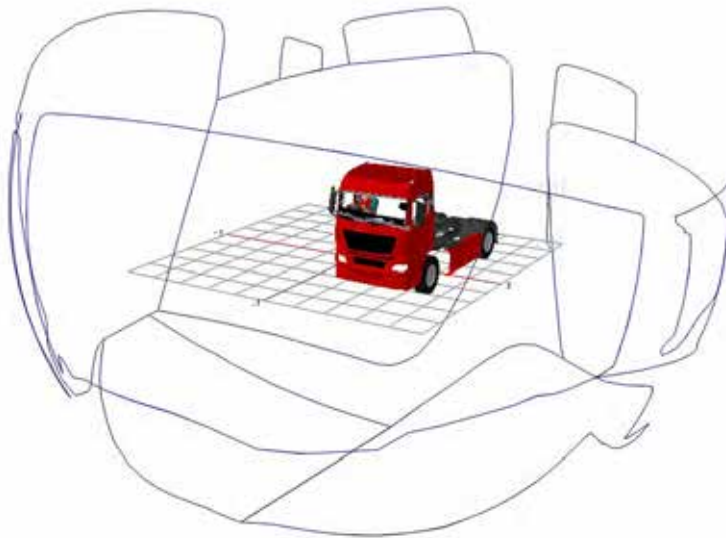
8.2.5.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m2)
Windscreen	81.58
Passenger – p1	1.06
Passenger – p2	13.03
Driver – p1	15.78
Driver – p2	110.62
Driver – p3	1.5
Class II – Pass	3.81
Class IV – Pass	74.07
Class II – Driver	7.39
Class IV– Driver	102.12
Class V	30.84
Class VI	185.66
Total	627.46

Figure 813. Combined direct and indirect FOV area projection for the MAN TGS N3 / N3G

8.2.5.5 MAN TGX CATEGORY N3 DISTRIBUTION



Window	Area(m2)
Windscreen	97.05
Passenger – p1	10.68
Passenger – p2	1.08
Driver – p1	4.68
Driver – p2	102.3
Driver – p3	1.9
Class II – Pass	7.17
Class IV – Pass	68.91
Class II – Driver	7.78
Class IV– Driver	127.23
Class V & VI	217.53
Total	646.31

Figure 814. Combined direct and indirect FOV area projection for the MAN TGX N3 / N3G

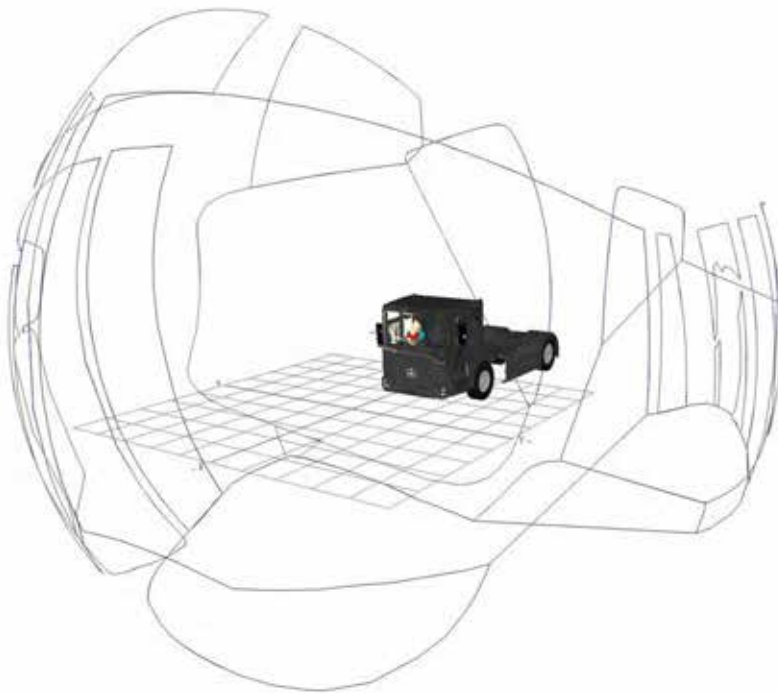
8.2.5.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Window	Area(m2)
Windscreen	101.21
Passenger – p1	1.37
Passenger – p2	10.83
Driver – p1	18.48
Driver – p2	46.72
Class II – Pass	6.5
Class IV – Pass	69.12
Class II – Driver	37.37
Class IV– Driver	85.33
Class V	25.17
Class VI	242.47
Total	644.57

Figure 815. Combined direct and indirect FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

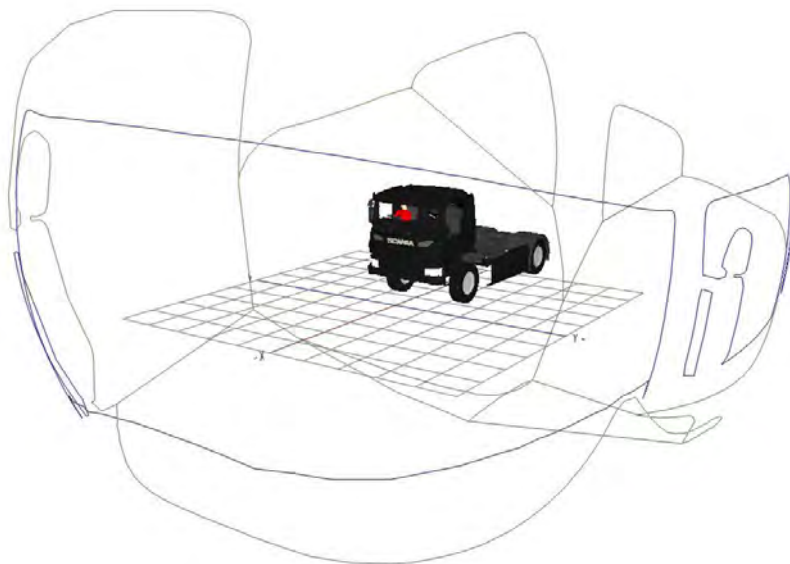
8.2.5.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Window	Area(m2)
Windscreen	96.91
Passenger – p1	1.87
Passenger – p2	1.27
Passenger – p3	0.21
Passenger – p4	0.81
Passenger – p5	7.24
Passenger – p6	13.04
Driver – p1	11.84
Driver – p2	11.41
Driver – p3	39.10
Driver – p4	25.86
Driver – p5	35.39
Driver – p6	27.07
Class II – Pass	13.46
Class IV – Pass	70.97
Class II – Driver	32.38
Class IV – Driver	123.27
Class V	22.84
Class VI	252.52
Total	787.46

Figure 816. Combined direct and indirect FOV area projection for the Mercedes Econic N3 LEC

8.2.5.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m2)
Windscreen	91.11
Passenger – p1	2.65
Passenger – p2	11.28
Passenger – p3	0.72
Driver – p1	110.59
Driver – p2	4.33
Class II – Pass	8.74
Class IV – Pass	71.34
Class II – Driver	18.1
Class IV – Driver	103.59
Class V	16.12
Class VI	227.44
Total	666.01

Figure 817. Combined direct and indirect FOV area projection for the Scania P N3 / N3G

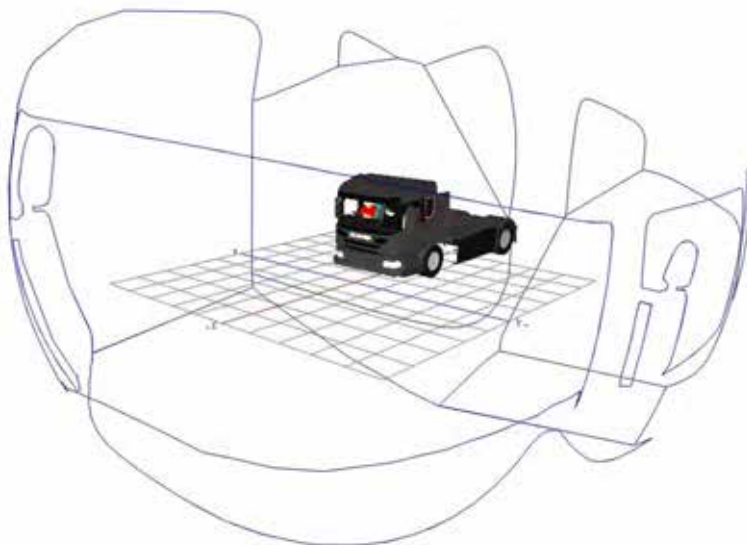
8.2.5.9 SCANIA R CATEGORY N3 DISTRIBUTION



Window	Area(m2)
Windscreen	88.5
Passenger – p1	0.71
Passenger – p2	11.28
Passenger – p3	8.31
Driver – p1	4.06
Driver – p2	105.9
Driver – p3	5.47
Class II – Pass	8.12
Class IV – Pass	65.83
Class II – Driver	18.82
Class IV– Driver	101.05
Class V	22.94
Class VI	229.78
Total	670.77

Figure 818. Combined direct and indirect FOV area projection for the Scania R N3

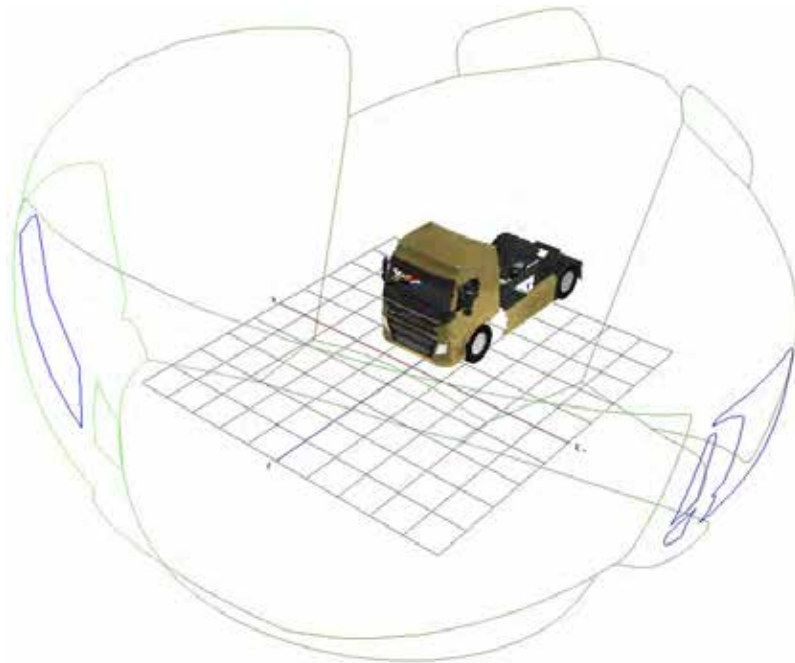
8.2.5.10 SCANIA P N3 LOW ENTRY CAB



Window	Area(m2)
Windscreen	85.37
Passenger – p1	0.67
Passenger – p2	10.54
Passenger – p3	5.19
Driver – p1	4.19
Driver – p2	124.56
Driver – p3	1.94
Class II – Pass	9.42
Class IV – Pass	68.64
Class II – Driver	12.22
Class IV– Driver	99.34
Class V	26.34
Class VI	230.51
Total	678.93

Figure 819. Combined direct and indirect FOV area projection for the Scania N3 LEC

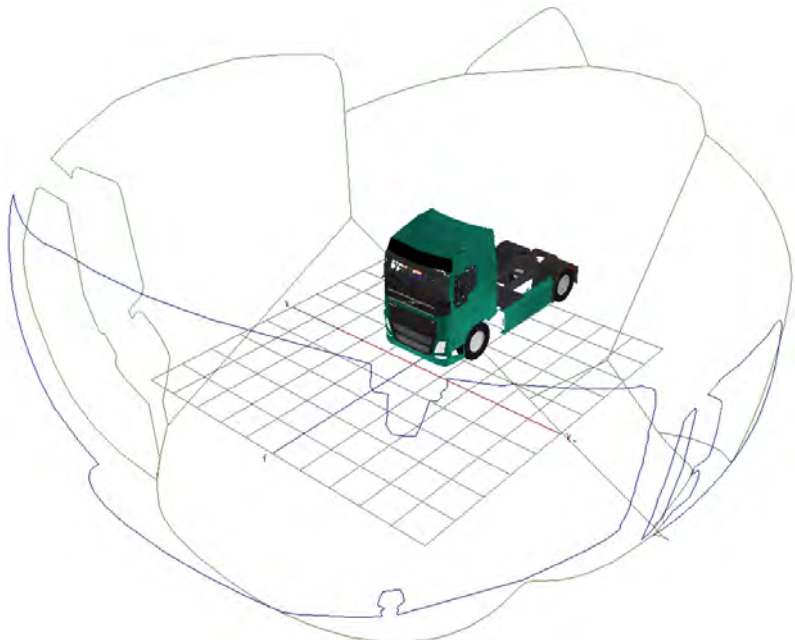
8.2.5.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Window	Area(m ²)
Windscreen	121.82
Passenger – p1	9.07
Passenger – p2	0.92
Passenger – p3	0.43
Driver – p1	97.16
Driver – p1a	2.27
Driver – p2	9.07
Class II – Pass	4.37
Class IV – Pass	63.20
Class II – Driver	8.00
Class IV – Driver	121.70
Class V	24.99
Class VI	197.17
Total	660.17

Figure 820. Combined direct and indirect FOV area projection for the Volvo FM N3 / FMX N3G

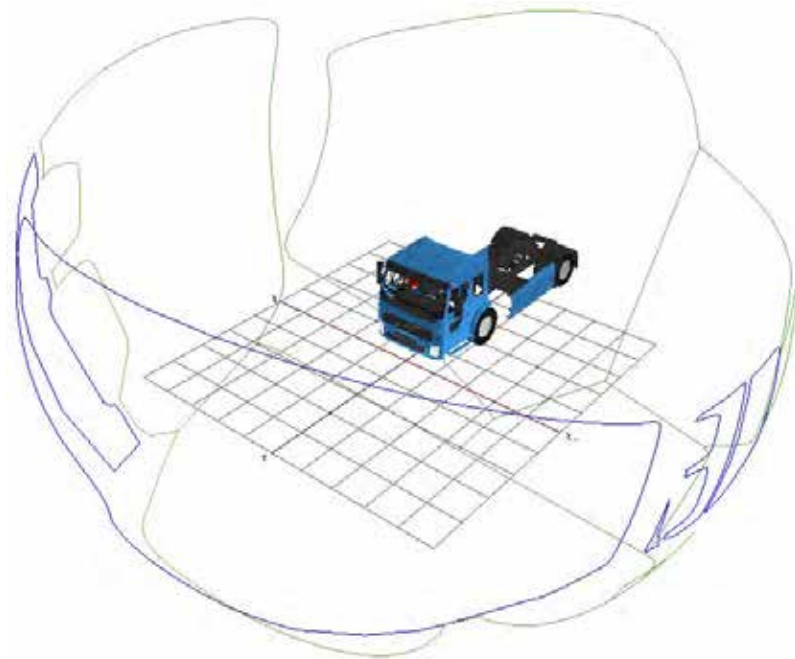
8.2.5.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	109.52
Passenger – p1	11.79
Passenger – p2	1.42
Driver – p1	78.12
Driver – p2	24.26
Class II – Pass	0.00
Class IV – Pass	62.26
Class II – Driver	5.97
Class IV – Driver	121.73
Class V	19.65
Class VI	229.86
Total	664.58

Figure 821. Combined direct and indirect FOV area projection for the Volvo FH N3

8.2.5.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

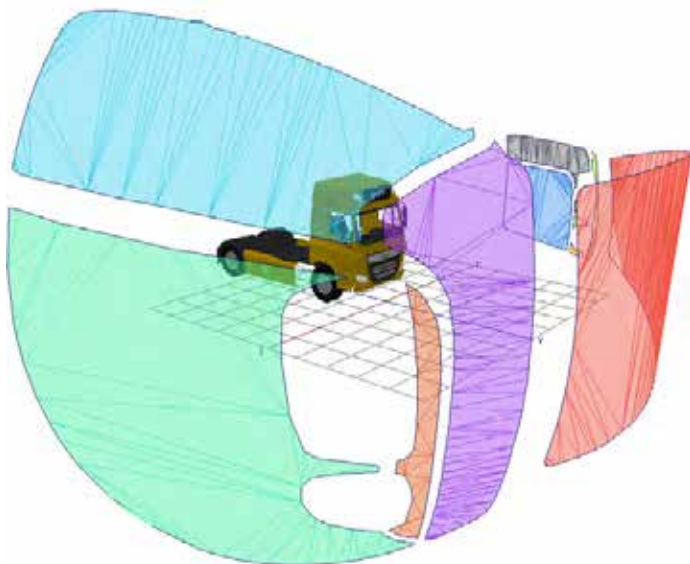


Window	Area(m ²)
Windscreen	107.90
Passenger – p1	5.94
Passenger – p2	3.50
Passenger – p3	0.26
Passenger - Cab	5.36
Passenger - Door	2.56
Driver – p1	98.17
Driver – p2	20.61
Class II – Pass	0.03
Class IV – Pass	55.28
Class II – Driver	0.00
Class IV – Driver	174.35
Class V	39.84
Class VI	177.92
Total	691.72

Figure 822. Combined direct and indirect FOV area projection for the Volvo FE N3 LEC

8.2.6 DIRECT VISION – 95TH %ILE MALE DRIVER

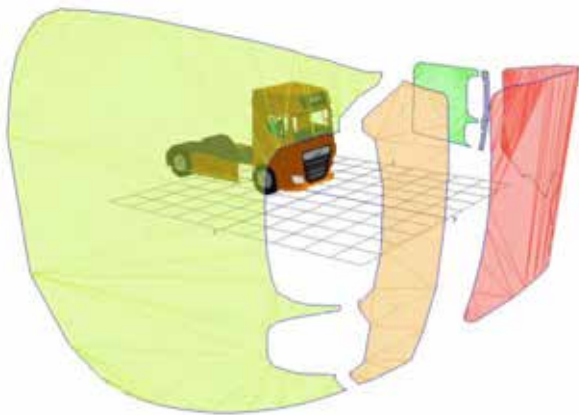
8.2.6.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	82.52
Passenger – p1	0.62
Passenger – p2	0.22
Passenger – p3	3.61
Passenger – p4	0.16
Passenger – p5	8.12
Driver – p1	67.75
Driver – p2	32.36
Driver – p3	16.34
Driver – p4	2.98
Total	214.68

Figure 823. FOV area projection for the DAF CF N3 / N3G

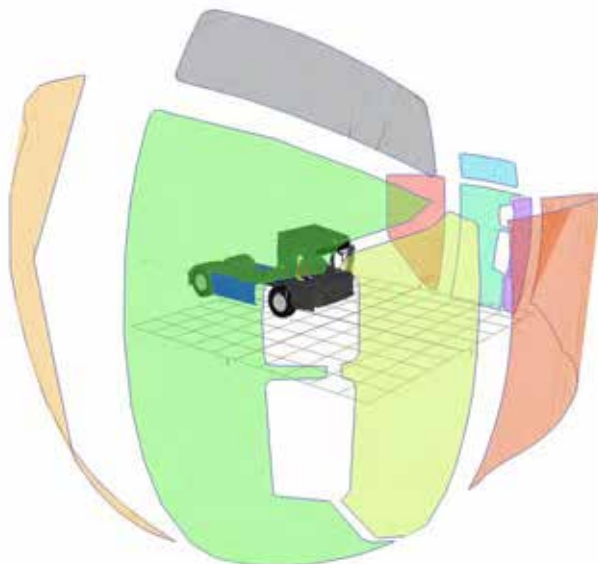
8.2.6.2 DAF XF CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	76.60
Passenger – p1	0.82
Passenger – p2	9.24
Driver – p1	13.24
Driver – p2	80.89
Total	180.79

Figure 824. FOV area projection for the DAF XF N3

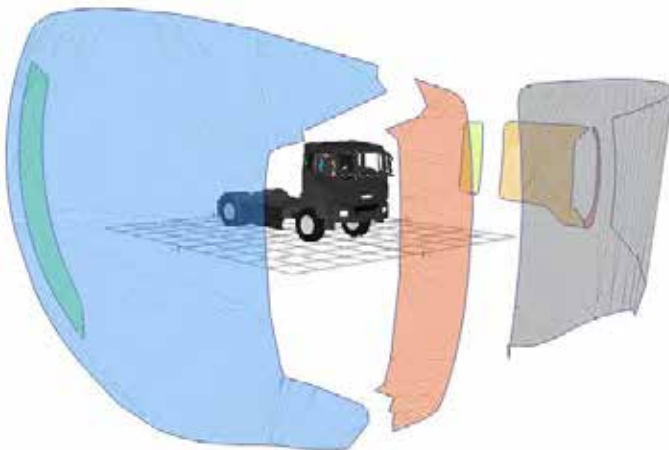
8.2.6.3 DENNIS EAGLE N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	81.66
Passenger – p1	3.18
Passenger – p2	4.75
Passenger – p3	11.90
Passenger – p4	12.19
Driver – p1	13.01
Driver – p2	25.06
Driver – p3	58.93
Driver – p4	103.21
Total	313.13

Figure 825. FOV area projection for the Dennis N3 LEC

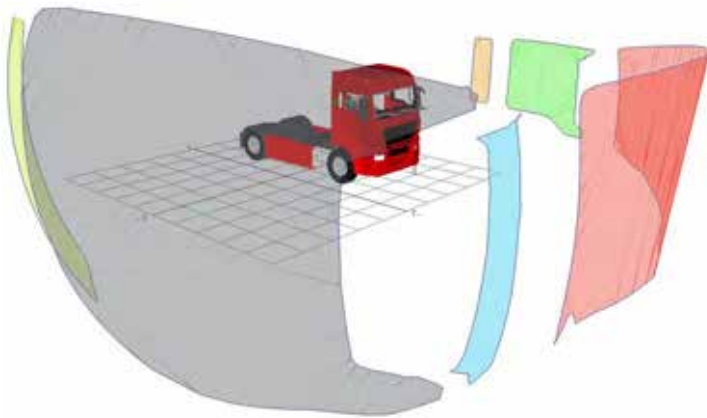
8.2.6.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	75.05
Passenger – p1	0.63
Passenger – p2	11.07
Passenger – p3	2.4
Driver – p1	11.72
Driver – p2	121.52
Driver – p3	18.18
Total	240.57

Figure 826. FOV area projection for the MAN TGS N3 / N3G

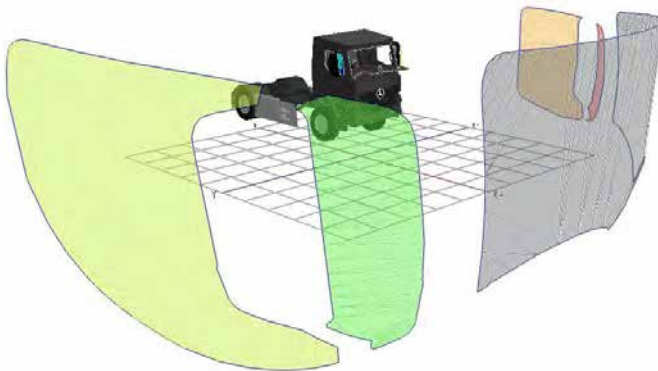
8.2.6.5 MAN TGX CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	75.68
Passenger – p1	10.05
Passenger – p2	2.15
Driver – p1	4.29
Driver – p2	85.31
Driver – p3	18.38
Total	195.86

Figure 827. FOV area projection for the MAN TGX N3 / N3G

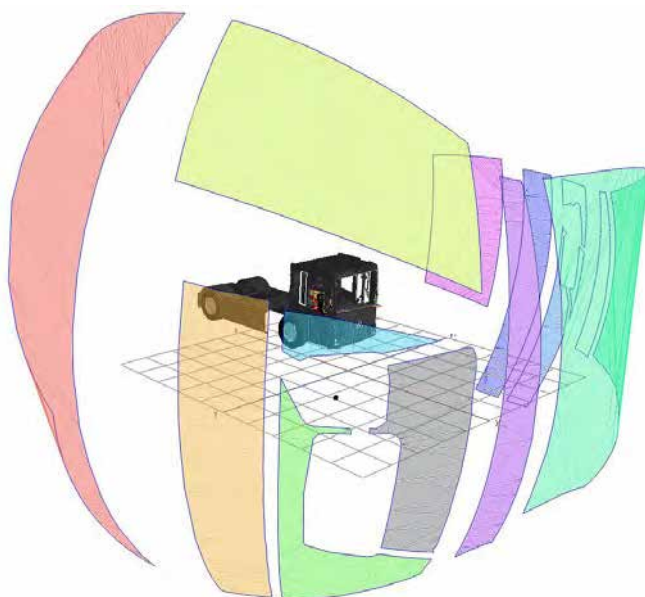
8.2.6.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	75.08
Passenger – p1	1.44
Passenger – p2	11.32
Driver – p1	15.20
Driver – p2	68.79
Total	171.83

Figure 828. FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

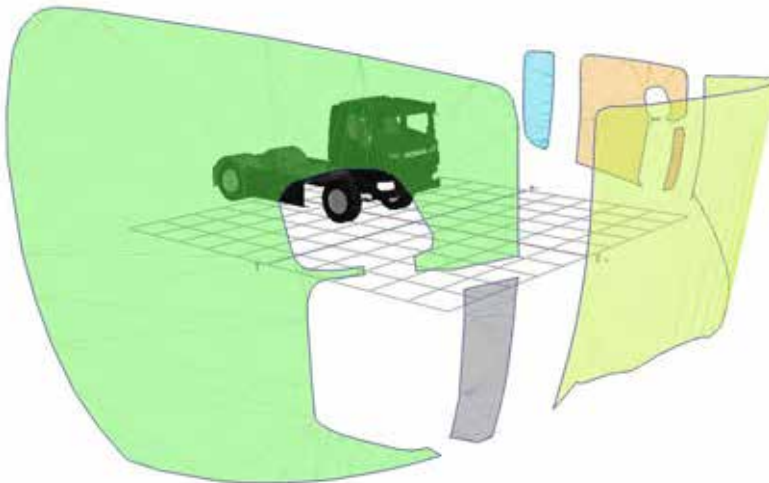
8.2.6.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	86.89
Passenger – p1	3.72
Passenger – p2	1.26
Passenger – p3	0.53
Passenger – p4	5.23
Passenger – p5	11.16
Passenger – p6	16.73
Driver – p1	8.23
Driver – p2	1.87
Driver – p3	8.6
Driver – p4	10.33
Driver – p5	23.17
Driver – p6	17.57
Driver – p7	128.17
Total	323.46

Figure 829. FOV area projection for the Mercedes Econic N3 LEC

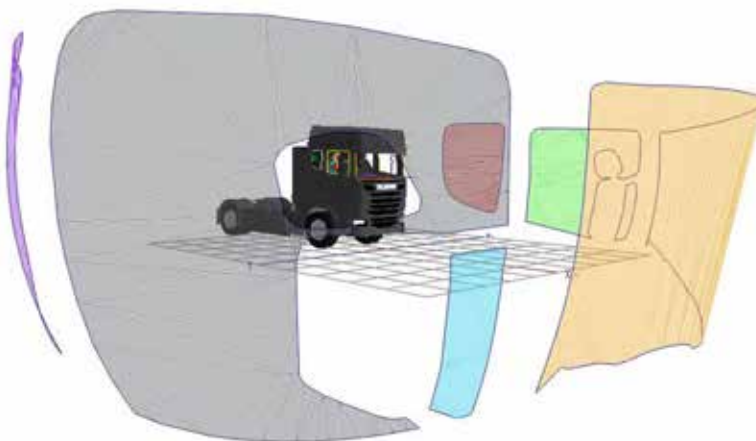
8.2.6.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	69.70
Passenger – p1	0.79
Passenger – p2	11.43
Passenger – p3	3.11
Driver – p1	2.94
Driver – p2	59.02
Total	146.99

Figure 830. FOV area projection for the Scania P N3 / N3G

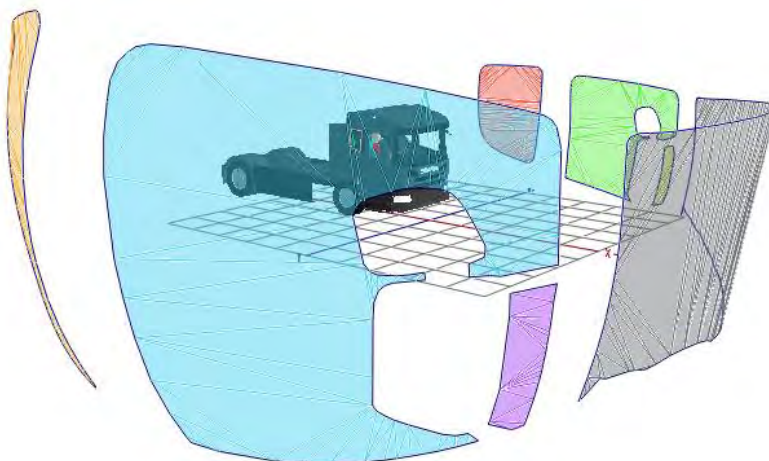
8.2.6.9 SCANIA R CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	69.69
Passenger – p1	0.79
Passenger – p2	11.43
Passenger – p3	7.34
Driver – p1	2.94
Driver – p2	59.02
Driver – p3	37.75
Total	188.96

Figure 831. FOV area projection for the Scania R N3

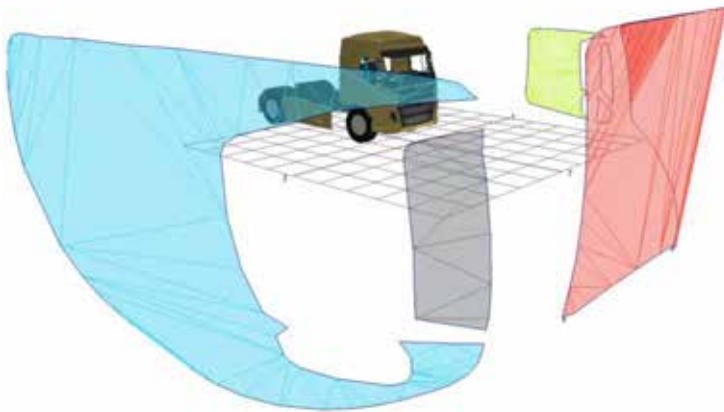
8.2.6.10 SCANIA P N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	69.70
Passenger – p1	0.79
Passenger – p2	11.43
Passenger – p3	6.71
Driver – p1	2.94
Driver – p2	59.02
Driver – p3	43.06
Total	193.65

Figure 832. FOV area projection for the Scania N3 LEC

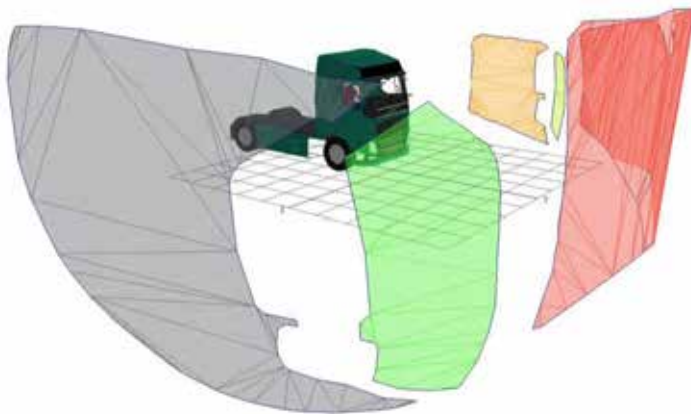
8.2.6.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Window	Area(m ²)
Windscreen	84.42
Passenger – p1	0.47
Passenger – p2	8.25
Passenger – p3	0.98
Driver – p1	85.67
Driver – p2	6.36
Total	186.15

Figure 833. FOV area projection for the Volvo FM N3 / FMX N3G

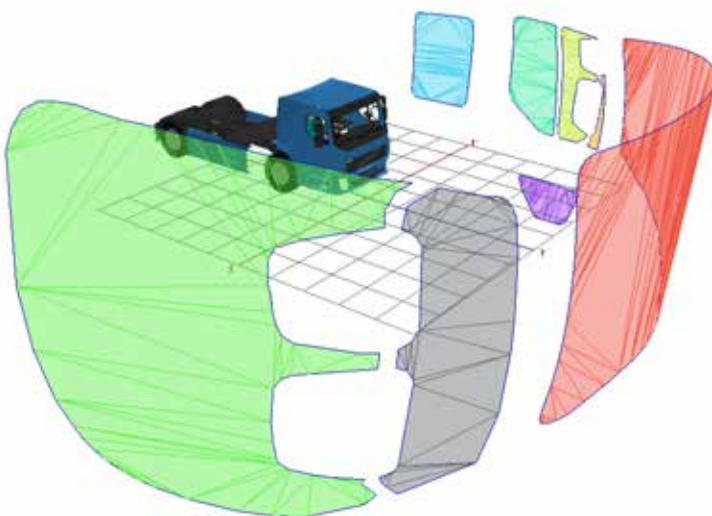
8.2.6.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	93.70
Passenger – p1	11.38
Passenger – p2	1.46
Driver – p1	90.43
Driver – p2	19.83
Total	216.80

Figure 834. FOV area projection for the Volvo FH N3

8.2.6.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

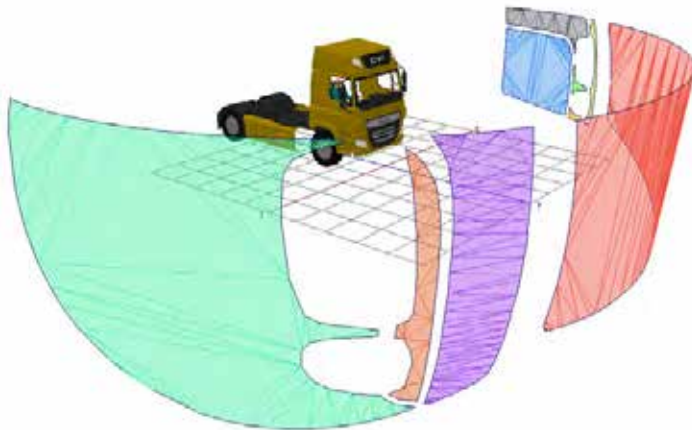


Window	Area(m ²)
Windscreen	79.56
Passenger – p1	5.73
Passenger – p2	2.71
Passenger – p3	0.49
Passenger - Cab	6.13
Passenger - Door	2.28
Driver – p1	60.91
Driver – p2	14.87
Total	172.68

Figure 835. FOV area projection for the Volvo FE N3 LEC

8.2.7 CLIPPED DIRECT VISION +7° – 95TH %ILE MALE DRIVER

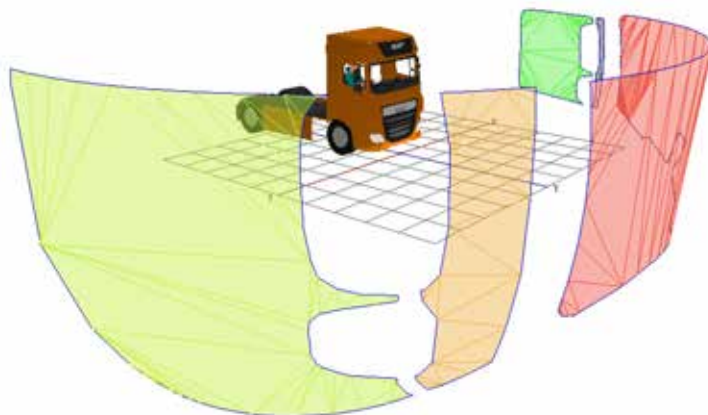
8.2.7.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	67.58
Passenger – p1	0.62
Passenger – p2	0.22
Passenger – p3	2.80
Passenger – p4	0.16
Passenger – p5	8.12
Driver – p1	64.58
Driver – p2	0.00
Driver – p3	10.94
Driver – p4	2.98
Total	157.99

Figure 836. Clipped FOV area projection for the DAF CF N3 / N3G

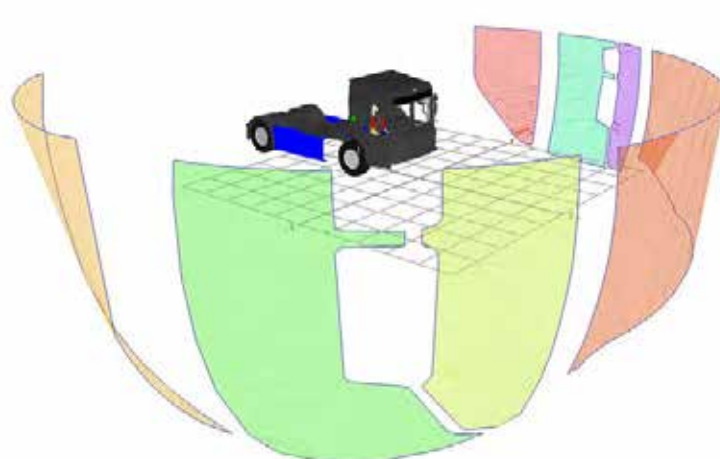
8.2.7.2 DAF XF CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	66.09
Passenger – p1	0.82
Passenger – p2	9.24
Driver – p1	11.05
Driver – p2	66.09
Total	145.90

Figure 837. Clipped FOV area projection for the DAF XF N3

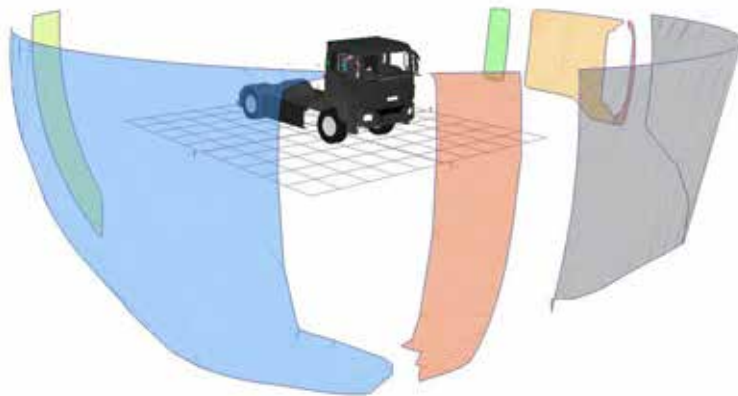
8.2.7.3 DENNIS EAGLE N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	63.77
Passenger – p1	0.00
Passenger – p2	4.58
Passenger – p3	10.85
Passenger – p4	10.44
Driver – p1	0.00
Driver – p2	19.94
Driver – p3	39.09
Driver – p4	65.36
Total	214.03

Figure 838. Clipped FOV area projection for the Dennis N3 LEC

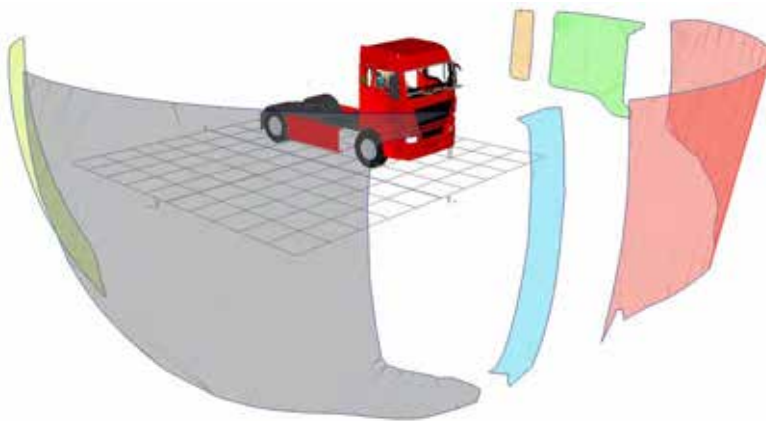
8.2.7.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	62.43
Passenger – p1	0.63
Passenger – p2	11.07
Passenger – p3	2.4
Driver – p1	11.07
Driver – p2	89.93
Driver – p3	14.78
Total	192.31

Figure 839. Clipped FOV area projection for the MAN TGS N3 / N3G

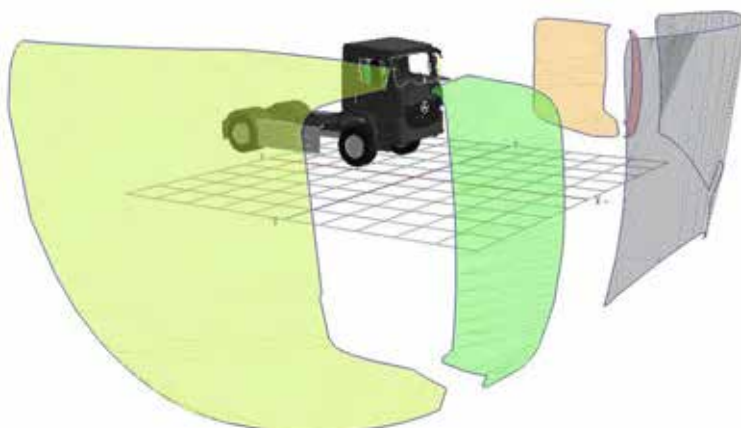
8.2.7.5 MAN TGX CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	67.79
Passenger – p1	10.05
Passenger – p2	2.15
Driver – p1	4.26
Driver – p2	67.45
Driver – p3	15.37
Total	167.07

Figure 840. Clipped FOV area projection for the MAN TGX N3 / N3G

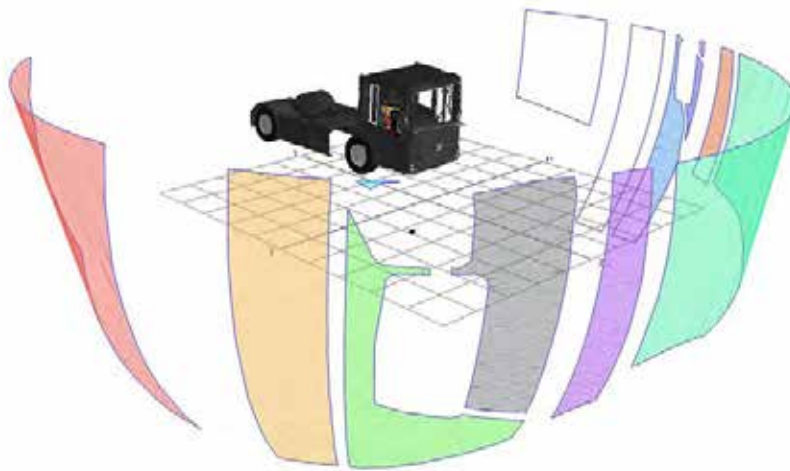
8.2.7.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	75.08
Passenger – p1	1.44
Passenger – p2	11.32
Driver – p1	15.20
Driver – p2	68.79
Total	171.83

Figure 841. Clipped FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3 Distribution. Note the vehicle and driver configuration is such that no clipping occurred in this instance as the 7° angle is above the upper boundaries of the window apertures.

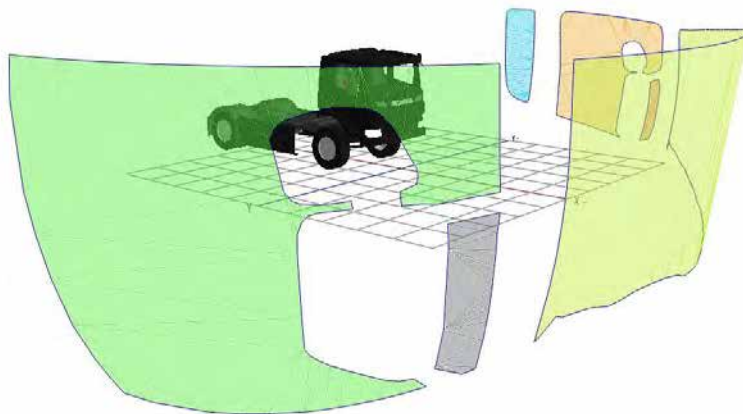
8.2.7.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	52.05
Passenger – p1	2.94
Passenger – p2	0.07
Passenger – p3	0.53
Passenger – p4	5.23
Passenger – p5	8.66
Passenger – p6	10.08
Driver – p1	5.72
Driver – p2	0.04
Driver – p3	8.54
Driver – p4	10.33
Driver – p5	0.00
Driver – p6	15.2
Driver – p7	67.35
Total	186.74

Figure 842. Clipped FOV area projection for the Mercedes Econic N3 LEC

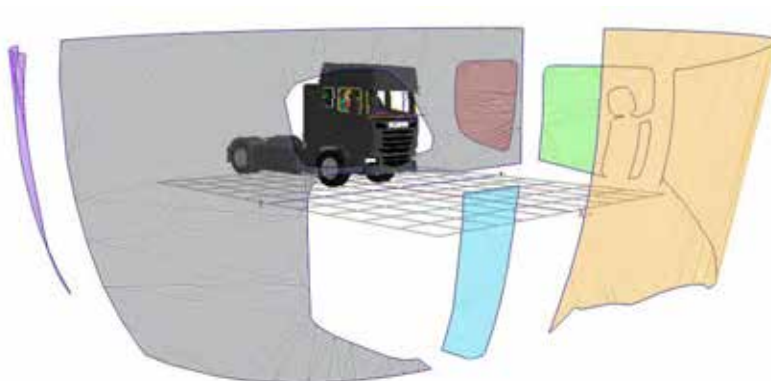
8.2.7.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	68.73
Passenger – p1	0.79
Passenger – p2	11.43
Passenger – p3	3.11
Driver – p1	2.94
Driver – p2	46.49
Total	133.49

Figure 843. Clipped FOV area projection for the Scania P N3 / N3G

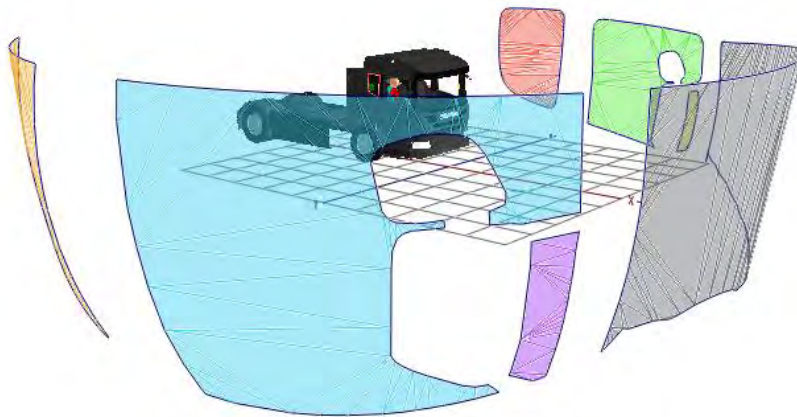
8.2.7.9 SCANIA R CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	68.73
Passenger – p1	0.79
Passenger – p2	11.43
Passenger – p3	7.34
Driver – p1	2.94
Driver – p2	46.48
Driver – p3	28.74
Total	166.45

Figure 844. Clipped FOV area projection for the Scania R N3

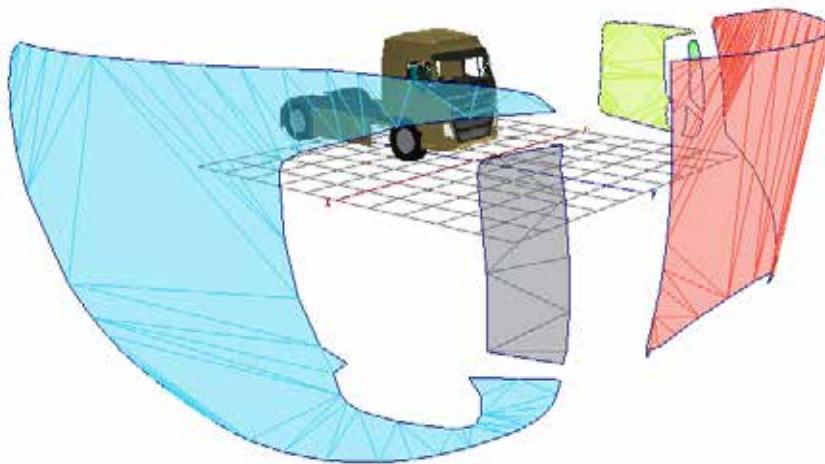
8.2.7.10 SCANIA P N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	68.73
Passenger – p1	0.79
Passenger – p2	11.43
Passenger – p3	6.71
Driver – p1	2.94
Driver – p2	46.49
Driver – p3	31.79
Total	168.88

Figure 845. Clipped FOV area projection for the Scania N3 LEC

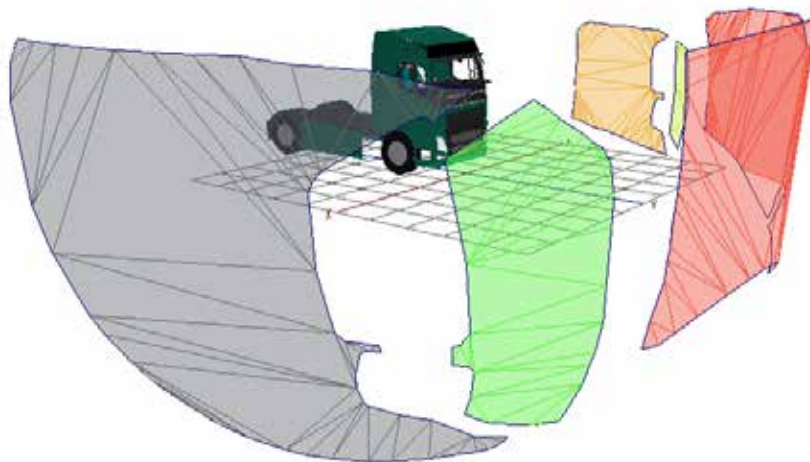
8.2.7.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Window	Area(m ²)
Windscreen	78.58
Passenger – p1	0.47
Passenger – p2	8.25
Passenger – p3	0.98
Driver – p1	84.60
Driver – p2	6.36
Total	179.24

Figure 846. Clipped FOV area projection for the Volvo FM N3 / FMX N3G

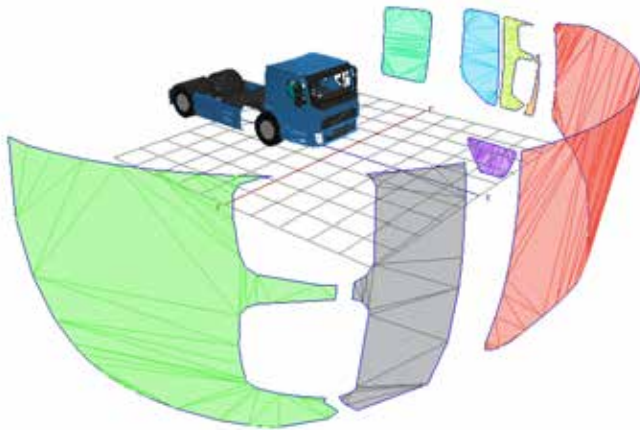
8.2.7.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	76.92
Passenger – p1	10.97
Passenger – p2	1.54
Driver – p1	76.32
Driver – p2	16.81
Total	182.56

Figure 847. Clipped FOV area projection for the Volvo FH N3

8.2.7.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

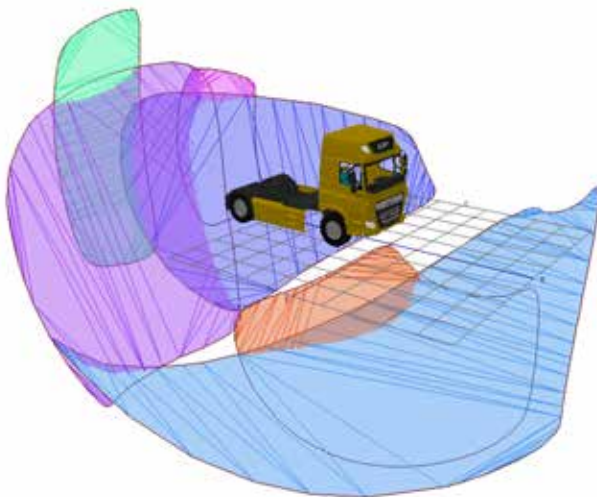


Window	Area(m ²)
Windscreen	70.89
Passenger – p1	5.73
Passenger – p2	2.71
Passenger – p3	0.49
Passenger - Cab	5.73
Passenger - Door	2.28
Driver – p1	48.66
Driver – p2	13.61
Total	150.51

Figure 848. Clipped FOV area projection for the Volvo FE N3 LEC

8.2.8 INDIRECT VISION – 95TH %ILE MALE DRIVER

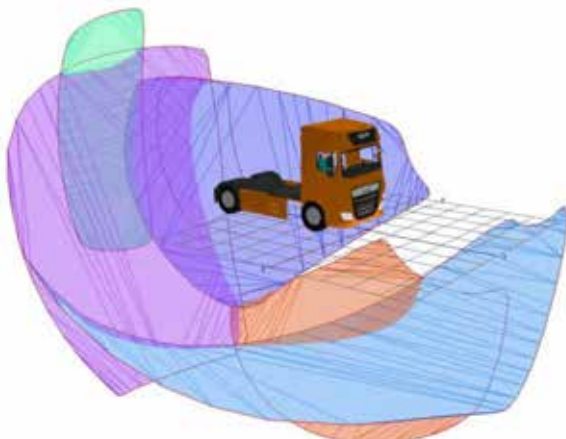
8.2.8.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	21.12
Class IV – Pass	102.87
Class II – Driver	40.74
Class IV – Driver	136.05
Class V	97.78
Class VI	240.19
Total	638.76

Figure 849. Spherical mirror projection for the DAF CF N3 / N3G

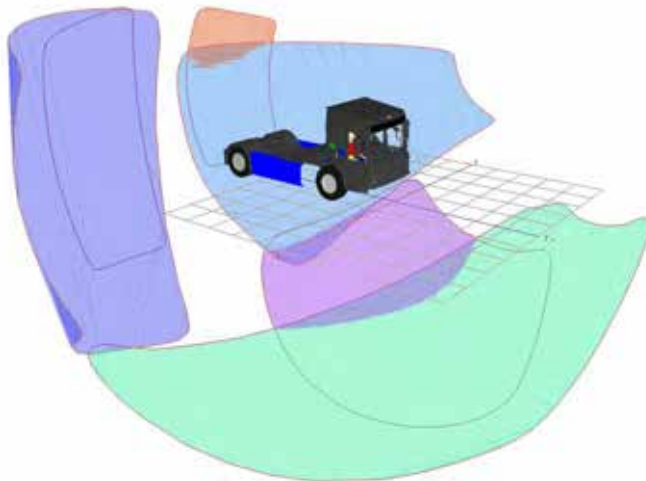
8.2.8.2 DAF XF CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	21.13
Class IV – Pass	116.37
Class II – Driver	41.68
Class IV – Driver	164.36
Class V	95.49
Class VI	235.42
Total	674.45

Figure 850. Spherical mirror projection for the DAF XF N3

8.2.8.3 DENNIS EAGLE N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	22.18
Class IV – Pass	91.49
Class II – Driver	40.62
Class IV – Driver	138.87
Class V	99.63
Class VI	205.53
Total	598.32

Figure 851. Spherical mirror projection for the Dennis N3 LEC

8.2.8.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	23.18
Class IV – Pass	79.17
Class II – Driver	46.52
Class IV – Driver	130.41
Class V	129.28
Class VI	186.41
Total	594.97

Figure 852. Spherical mirror projection for the MAN TGS N3 / N3G

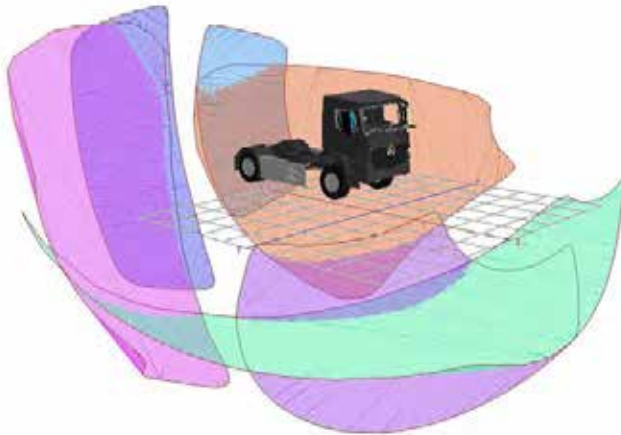
8.2.8.5 MAN TGX CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	23.12
Class IV – Pass	75.82
Class II – Driver	41.06
Class IV – Driver	131.74
Class V	126.36
Class VI	183.65
Total	581.75

Figure 853. Spherical mirror projection for the MAN TGX N3 / N3G

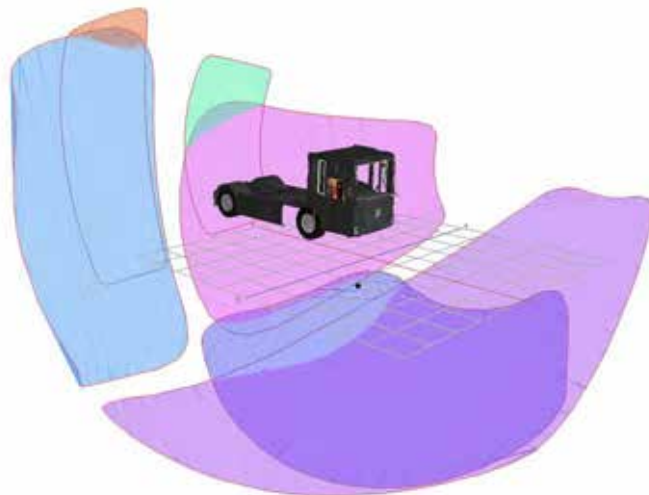
8.2.8.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	26.39
Class IV – Pass	94.27
Class II – Driver	48.58
Class IV – Driver	146.48
Class V	132.34
Class VI	254
Total	702.06

Figure 854. Spherical mirror projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

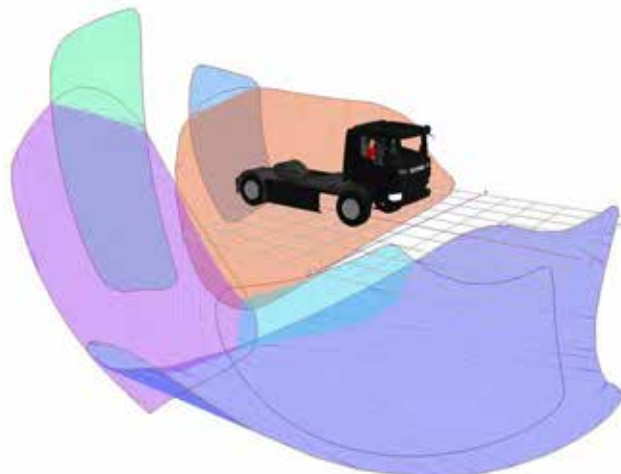
8.2.8.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	25.15
Class IV – Pass	95.08
Class II – Driver	44.42
Class IV – Driver	153.93
Class V	131.18
Class VI	247.32
Total	697.08

Figure 855. Spherical mirror projection for the Mercedes Econic N3 LEC

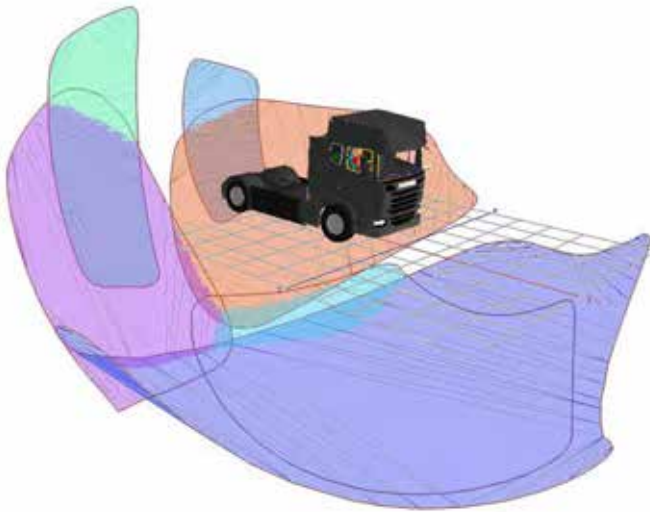
8.2.8.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	19.34
Class IV – Pass	86.45
Class II – Driver	44.73
Class IV – Driver	113.81
Class V	110.24
Class VI	236.17
Total	610.74

Figure 856. Spherical mirror projection for the Scania P N3 / N3G

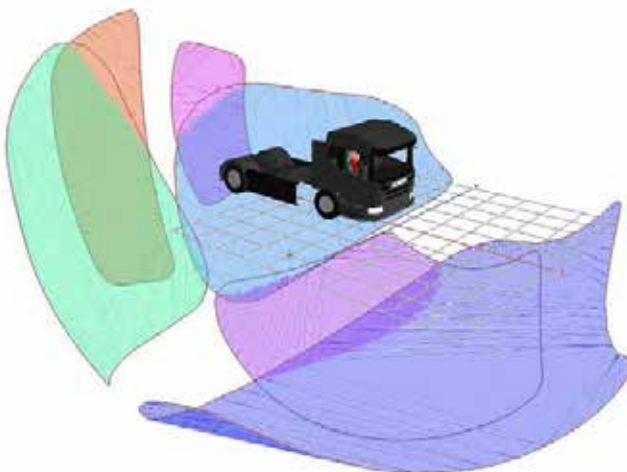
8.2.8.9 SCANIA R CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	19.32
Class IV – Pass	84.81
Class II – Driver	44.77
Class IV – Driver	111.81
Class V	112.72
Class VI	240.31
Total	613.74

Figure 857. Spherical mirror projection for the Scania R N3

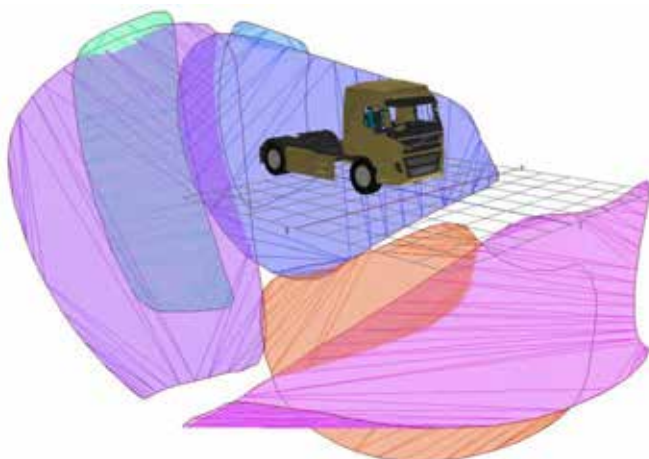
8.2.8.10 SCANIA P N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	20.54
Class IV – Pass	86.30
Class II – Driver	44.74
Class IV – Driver	110.66
Class V	105.09
Class VI	213.32
Total	580.65

Figure 858. Spherical mirror projection for the Scania N3 LEC

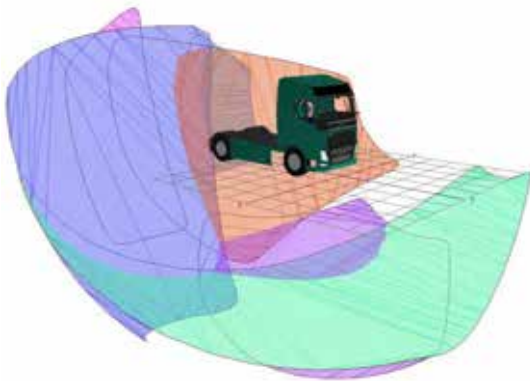
8.2.8.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	23.42
Class IV – Pass	96.44
Class II – Driver	49.43
Class IV – Driver	137.14
Class V	110.18
Class VI	193.80
Total	610.40

Figure 859. Spherical mirror projection for the Volvo FM N3 / FMX N3G

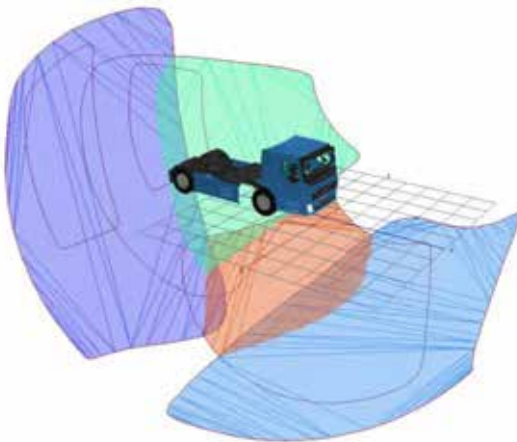
8.2.8.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	23.37
Class IV – Pass	120.03
Class II – Driver	47.86
Class IV – Driver	164.03
Class V	112.27
Class VI	233.82
Total	701.38

Figure 860. Spherical mirror projection for the Volvo FH N3

8.2.8.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

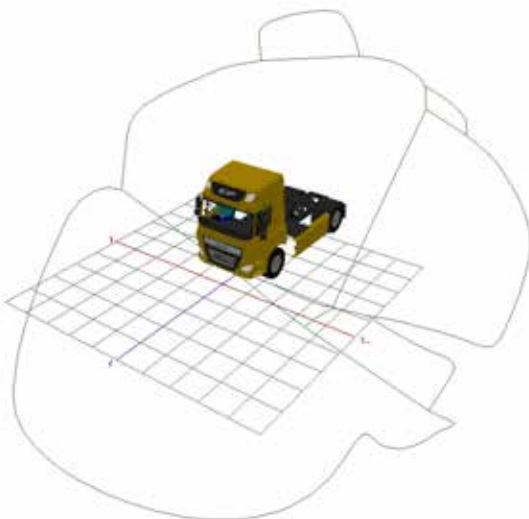


Mirror	Area(m ²)
Class II – Pass	20.57
Class IV – Pass	119.54
Class II – Driver	36.84
Class IV – Driver	186.90
Class V	103.01
Class VI	162.66
Total	629.53

Figure 861. Spherical mirror projection for the Volvo FE N3 LEC

8.2.9 COMBINED INDIRECT VISION – 95TH %ILE MALE DRIVER

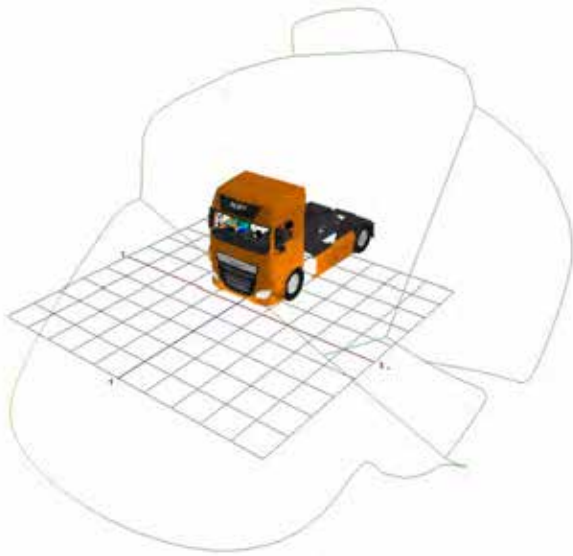
8.2.9.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	1.90
Class IV – Pass	63.29
Class II – Driver	8.42
Class IV – Driver	122.31
Class V	16.36
Class VI	237.71
Total	450.00

Figure 862. Combined indirect FOV area projection for the DAF CF N3 / N3G

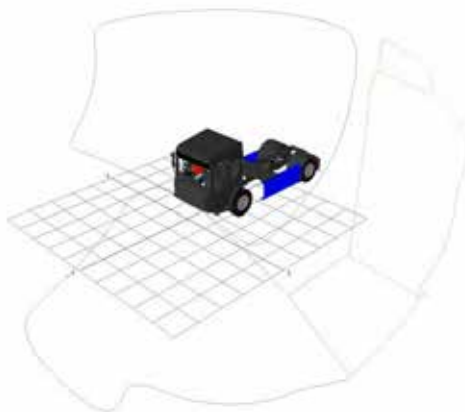
8.2.9.2 DAF XF CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	0.00
Class IV – Pass	63.08
Class II – Driver	7.14
Class IV – Driver	143.42
Class V	19.53
Class VI	223.69
Total	456.87

Figure 863. Combined indirect FOV area projection for the DAF XF N3

8.2.9.3 DENNIS EAGLE N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	4.99
Class IV – Pass	87.12
Class II & IV – Driver	138.89
Class V	33.15
Class VI	203.92
Total	468.07

Figure 864. Combined indirect FOV area projection for the Dennis N3 LEC

8.2.9.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	3.34
Class IV – Pass	77.94
Class II – Driver	5.12
Class IV – Driver	129.71
Class V	27.12
Class VI	186.38
Total	429.61

Figure 865. Combined indirect FOV area projection for the MAN TGS N3 / N3G

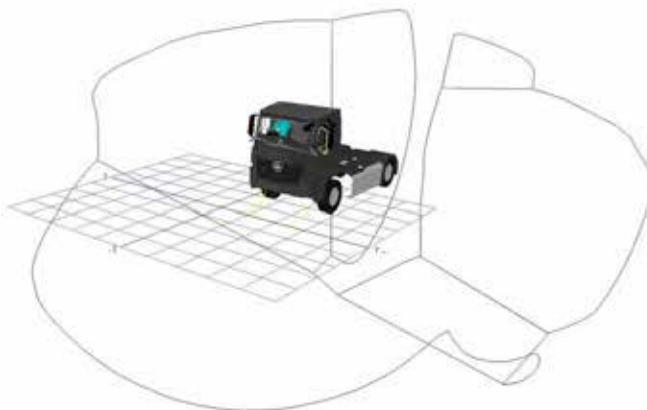
8.2.9.5 MAN TGX CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	5.24
Class IV – Pass	73.46
Class II – Driver	4.61
Class IV – Driver	131.42
Class V & VI	211.53
Total	426.26

Figure 866. Combined indirect FOV area projection for the MAN TGX N3 / N3G

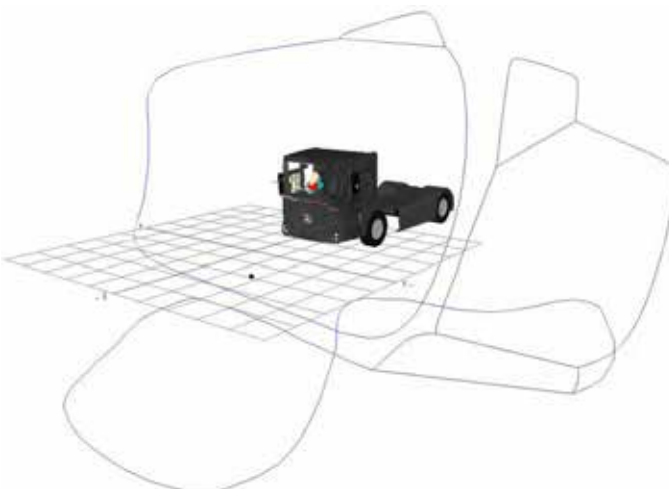
8.2.9.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	6.15
Class IV – Pass	81.97
Class II – Driver	29.99
Class IV – Driver	99.09
Class V	26.29
Class VI	232.03
Total	475.52

Figure 867. Combined indirect FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

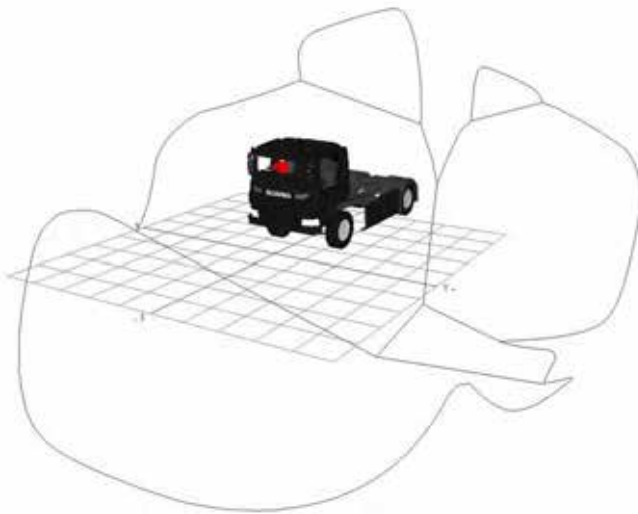
8.2.9.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	10.33
Class IV – Pass	88.20
Class II – Driver	3.47
Class IV – Driver	152.75
Class V	18.93
Class VI	244.46
Total	518.14

Figure 868. Combined indirect FOV area projection for the Mercedes Econic N3 LEC

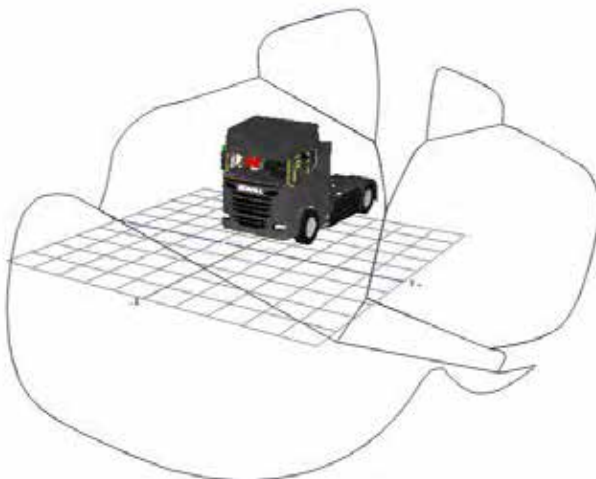
8.2.9.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	3.92
Class IV – Pass	78.72
Class II – Driver	15.60
Class IV – Driver	98.80
Class V	15.75
Class VI	230.37
Total	443.16

Figure 869. Combined indirect FOV area projection for the Scania P N3 / N3G

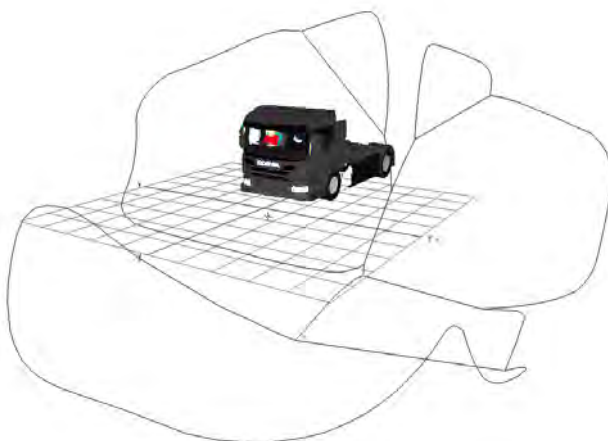
8.2.9.9 SCANIA R CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	6.52
Class IV – Pass	76.19
Class II – Driver	17.74
Class IV – Driver	91.95
Class V	12.26
Class VI	234.41
Total	439.07

Figure 870. Combined indirect FOV area projection for the Scania R N3

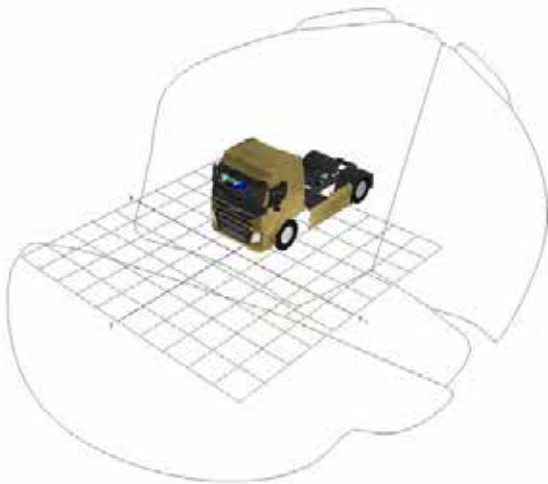
8.2.9.10 SCANIA P N3 LOW ENTRY CAB



Mirror	Area(m ²)
Class II – Pass	8.96
Class IV – Pass	81.65
Class II – Driver	10.81
Class IV – Driver	106.05
Class V	36.03
Class VI	209.50
Total	453.00

Figure 871. Combined indirect FOV area projection for the Scania N3 LEC

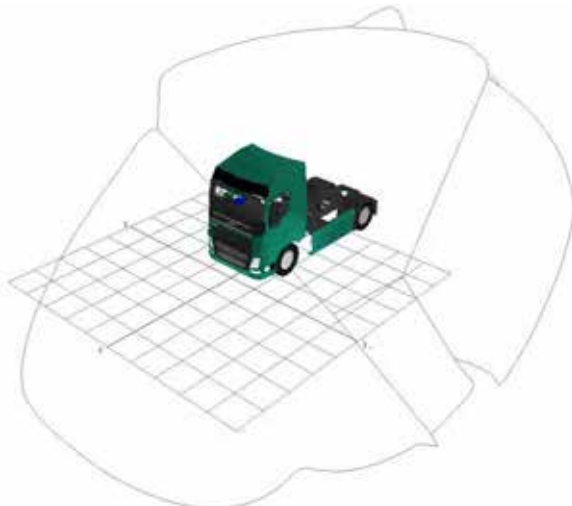
8.2.9.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Mirror	Area(m ²)
Class II – Pass	1.56
Class IV – Pass	73.42
Class II – Driver	2.10
Class IV – Driver	129.29
Class V	27.79
Class VI	188.68
Total	422.84

Figure 872. Combined indirect FOV area projection for the Volvo FM N3 / FMX N3G

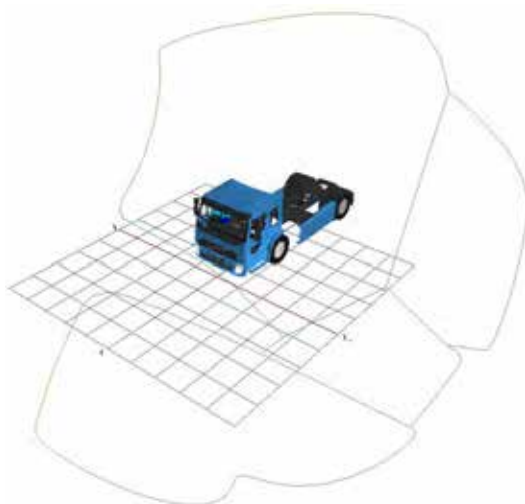
8.2.9.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Mirror	Area(m ²)
Class II – Pass	0.09
Class IV – Pass	68.29
Class II – Driver	1.27
Class IV – Driver	121.43
Class V	22.56
Class VI	228.78
Total	442.42

Figure 873. Combined indirect FOV area projection for the Volvo FH N3

8.2.9.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB

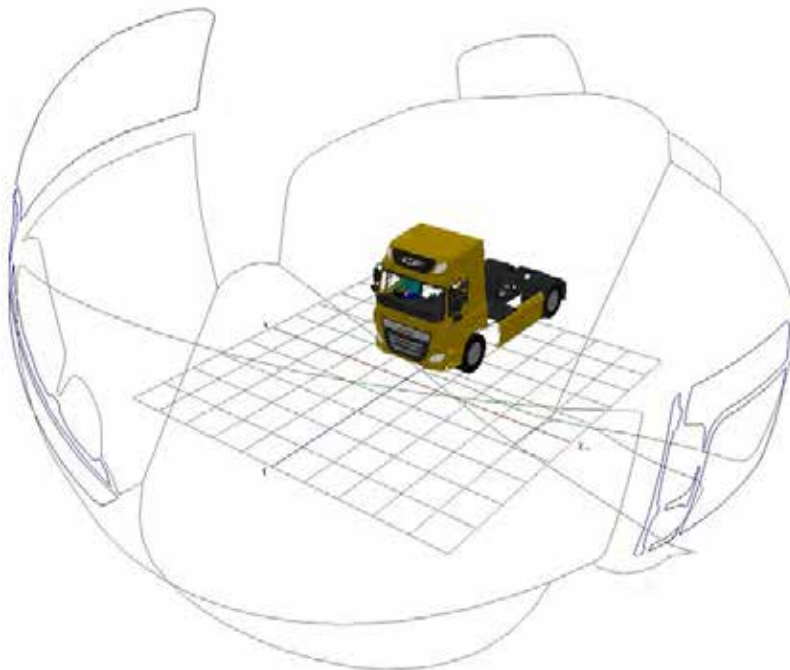


Mirror	Area(m ²)
Class II – Pass	0.00
Class IV – Pass	59.04
Class II – Driver	0.00
Class IV – Driver	179.70
Class V	40.86
Class VI	158.16
Total	437.75

Figure 874. Combined indirect FOV area projection for the Volvo FE N3 LEC

8.2.10 COMBINED DIRECT AND INDIRECT VISION – 95TH %ILE MALE DRIVER

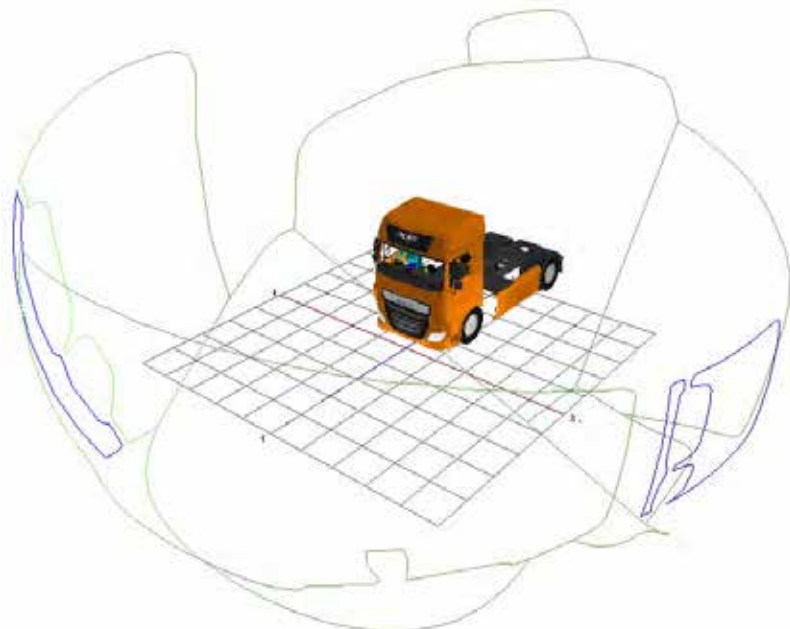
8.2.10.1 DAF CF CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	82.52
Passenger – p1	0.62
Passenger – p2	0.22
Passenger – p3	3.61
Passenger – p4	0.16
Passenger – p5	8.12
Driver – p1	54.46
Driver – p2	32.36
Driver – p3	16.34
Driver – p4	2.98
Class II – Pass	1.90
Class IV – Pass	63.29
Class II – Driver	8.42
Class IV – Driver	122.31
Class V	16.36
Class VI	238.09
Total	651.76

Figure 875. Combined direct and indirect FOV area projection for the DAF CF N3 / N3G

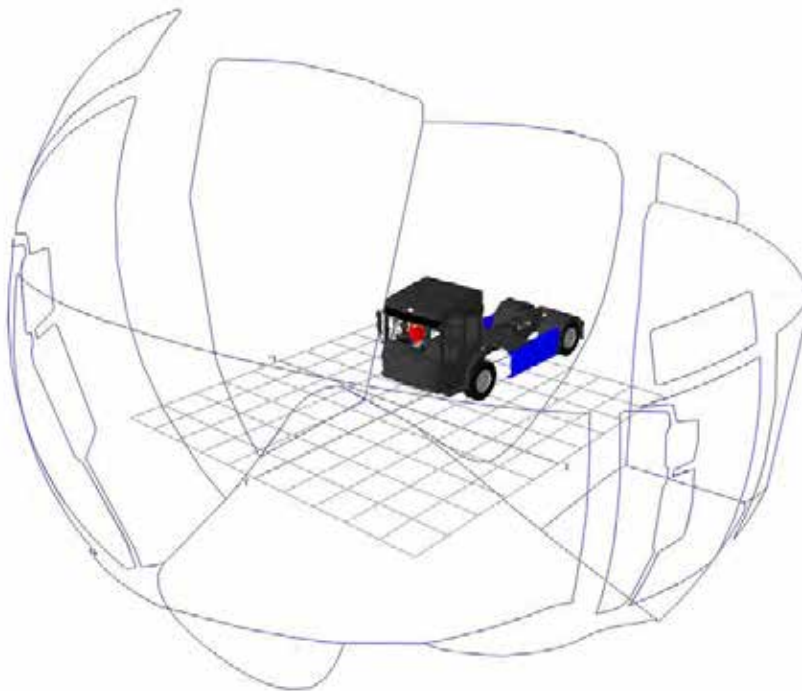
8.2.10.2 DAF XF CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	76.60
Passenger – p1	0.82
Passenger – p2	9.24
Driver – p1	13.24
Driver – p2	74.28
Class II – Pass	0.00
Class IV – Pass	63.08
Class II – Driver	7.14
Class IV – Driver	143.42
Class V	19.53
Class VI	223.64
Total	630.99

Figure 876. Combined direct and indirect FOV area projection for the DAF XF N3

8.2.10.3 DENNIS EAGLE N3 LOW ENTRY CAB



Window	Area(m2)
Windscreen	81.58
Passenger – p1	3.18
Passenger – p2	4.75
Passenger – p3	11.9
Passenger – p4	10.44
Driver – p1	13.01
Driver – p2	25.26
Driver – p3	56.44
Driver – p4	90.33
Class II – Pass	4.99
Class IV – Pass	83.5
Class II & IV– Driver	88.78
Class V	33.15
Class VI	202.74
Total	710.05

Figure 877. Combined direct and indirect FOV area projection for the Dennis N3 LEC

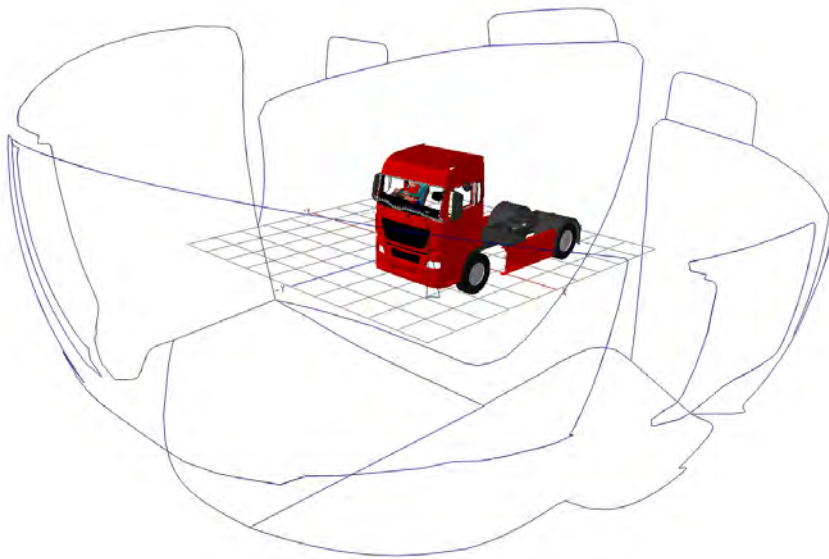
8.2.10.4 MAN TGS CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m2)
Windscreen	75.24
Passenger – p1	0.63
Passenger – p2	11.07
Passenger – p3	1.95
Driver – p1	11.72
Driver – p2	121.13
Driver – p3	2.23
Class II – Pass	3.34
Class IV – Pass	77.94
Class II – Driver	5.12
Class IV– Driver	117.51
Class V	3.24+23.88
Class VI	172.89
Total	627.89

Figure 878. Combined direct and indirect FOV area projection for the MAN TGS N3 / N3G

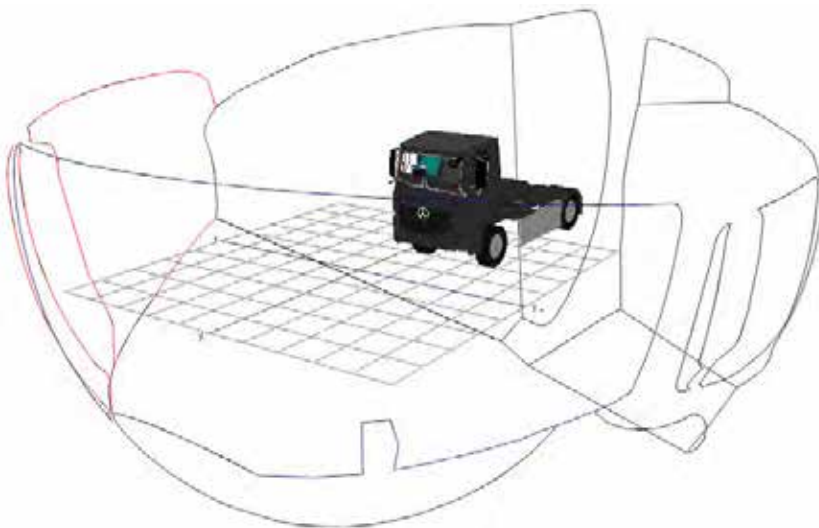
8.2.10.5 MAN TGX CATEGORY N3 DISTRIBUTION



Window	Area(m2)
Windscreen	75.68
Passenger – p1	10.05
Passenger – p2	1.94
Driver – p1	4.29
Driver – p2	84.51
Driver – p3	2.33
Class II – Pass	5.24
Class IV – Pass	73.49
Class II – Driver	4.61
Class IV– Driver	129.91
Class V & VI	206.21
Total	598.26

Figure 879. Combined direct and indirect FOV area projection for the MAN TGX N3 / N3G

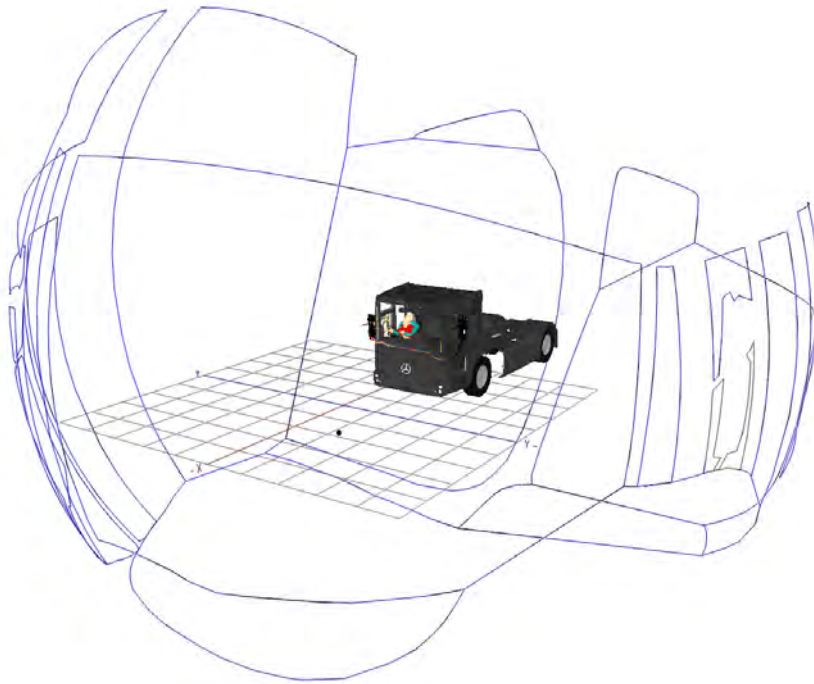
8.2.10.6 MERCEDES ANTOS CATEGORY N3 DISTRIBUTION / AROCS N3G CONSTRUCTION / ACTROS N3 DISTRIBUTION



Window	Area(m2)
Windscreen	75.08
Passenger – p1	1.44
Passenger – p2	11.32
Driver – p1	14.13
Driver – p2	40.34
Class II – Pass	6.15
Class IV – Pass	81.97
Class II – Driver	29.99
Class IV– Driver	99.09
Class V	26.29
Class VI	231.87
Total	617.67

Figure 880. Combined direct and indirect FOV area projection for the Mercedes Antos N3 / Arocs N3G / Actros N3

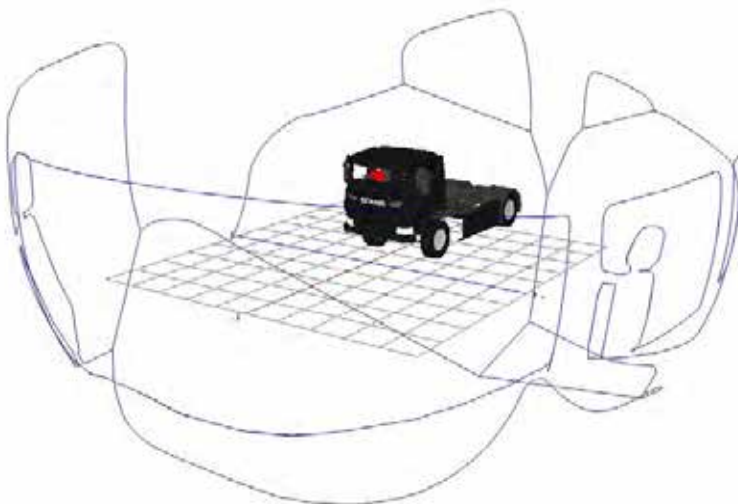
8.2.10.7 MERCEDES ECONIC N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	83.73
Passenger – p1	2.36
Passenger – p2	1.26
Passenger – p3	0.45
Passenger – p4	0.57
Passenger – p5	6.97
Passenger – p6	16.64
Driver – p1	8.23
Driver – p2	1.87
Driver – p3	8.6
Driver – p4	10.33
Driver – p5	23.17
Driver – p6	17.46
Driver – p7	112.76
Class II – Pass	10.33
Class IV – Pass	88.20
Class II – Driver	3.47
Class IV– Driver	109.60
Class V	18.93
Class VI	240.55
Total	765.48

Figure 881. Combined direct and indirect FOV area projection for the Mercedes Econic N3 LEC

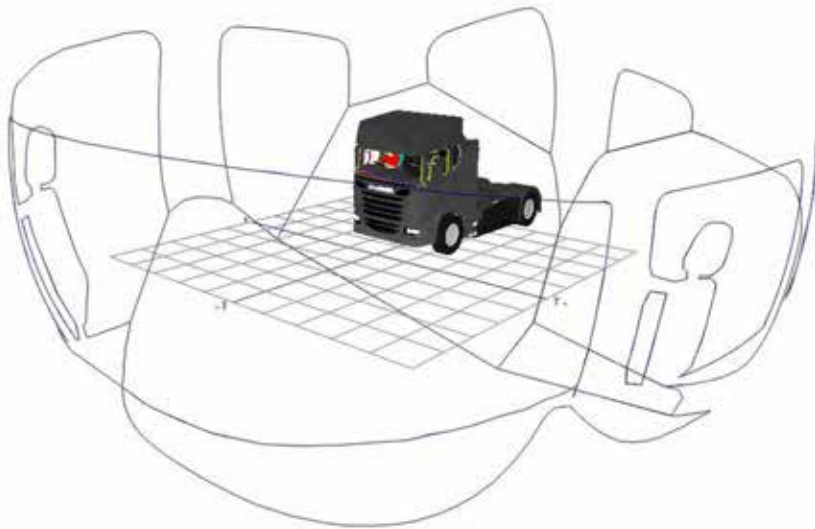
8.2.10.8 SCANIA P CATEGORY N3 / N3G, DISTRIBUTION / CONSTRUCTION



Window	Area(m ²)
Windscreen	69.7
Passenger – p1	0.79
Passenger – p2	11.43
Passenger – p3	3.11
Driver – p1	2.94
Driver – p2	53.08
Class II – Pass	3.92
Class IV – Pass	78.72
Class II – Driver	15.6
Class IV– Driver	98.8
Class V	15.75
Class VI	230.13
Total	583.97

Figure 882. Combined direct and indirect FOV area projection for the Scania P N3 / N3G

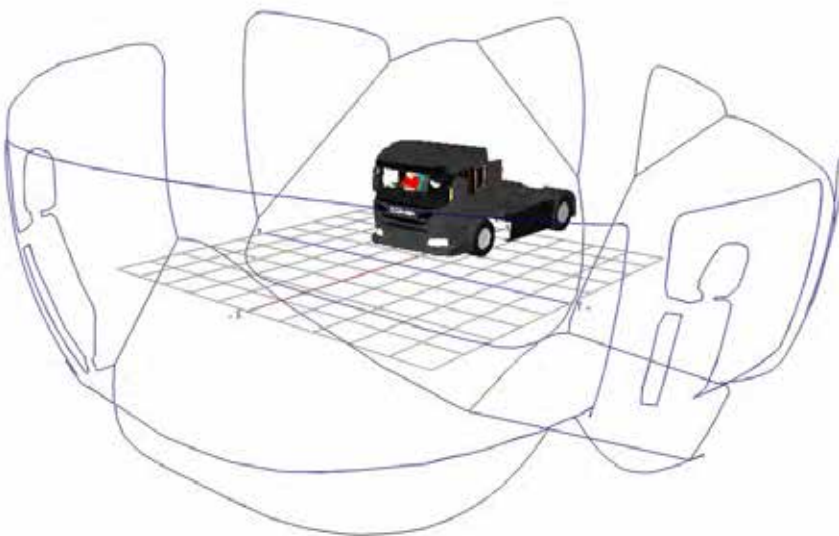
8.2.10.9 SCANIA R CATEGORY N3 DISTRIBUTION



Window	Area(m2)
Windscreen	69.69
Passenger – p1	0.79
Passenger – p2	11.43
Passenger – p3	7.34
Driver – p1	2.94
Driver – p2	53.56
Driver – p3	31.85
Class II – Pass	6.52
Class IV – Pass	76.19
Class II – Driver	17.74
Class IV– Driver	84.28
Class V	12.26
Class VI	234.25
Total	608.84

Figure 883. Combined direct and indirect FOV area projection for the Scania R N3

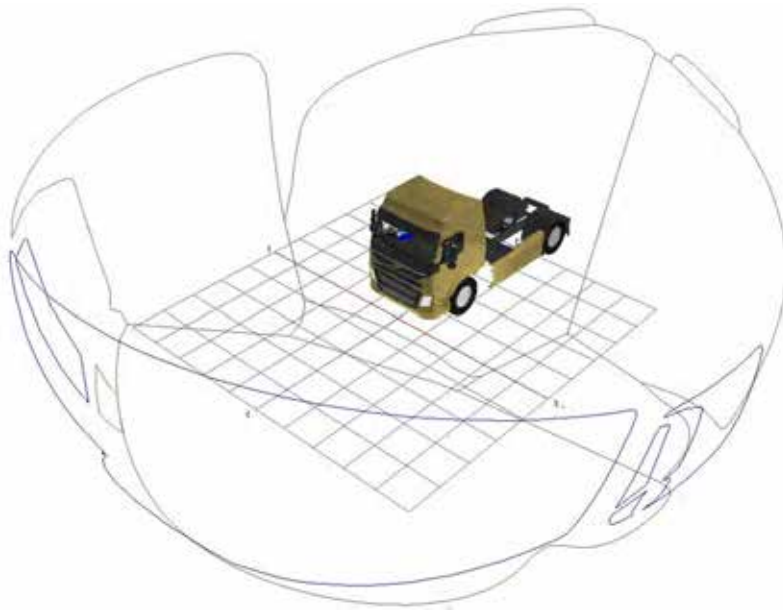
8.2.10.10 SCANIA P N3 LOW ENTRY CAB



Window	Area(m2)
Windscreen	69.7
Passenger – p1	0.79
Passenger – p2	11.43
Passenger – p3	6.62
Driver – p1	2.94
Driver – p2	50.8
Driver – p3	22.91
Class II – Pass	7.03
Class IV – Pass	75.42
Class II – Driver	10.81
Class IV– Driver	100.27
Class V	36.61
Class VI	219.67
Total	615.00

Figure 884. Combined direct and indirect FOV area projection for the Scania N3 LEC

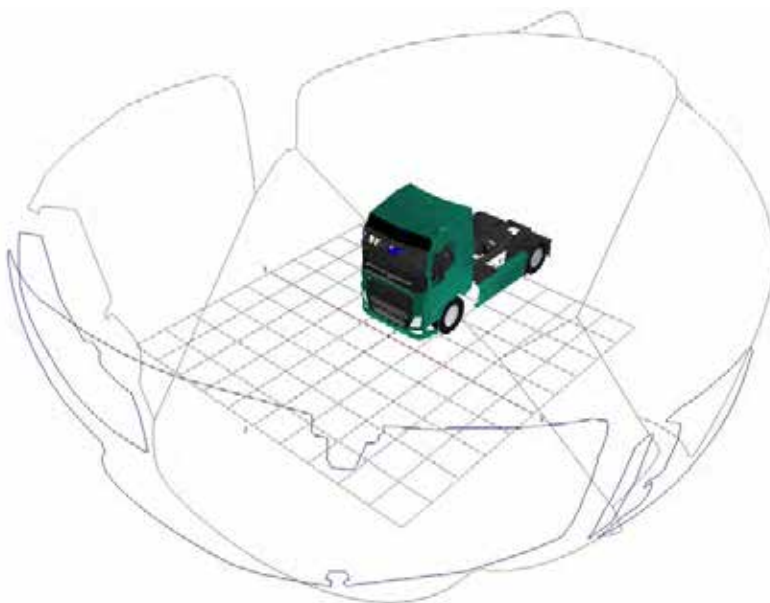
8.2.10.11 VOLVO FM CATEGORY N3 DISTRIBUTION / FMX N3G, CONSTRUCTION



Window	Area(m ²)
Windscreen	84.42
Passenger – p1	0.47
Passenger – p2	8.25
Passenger – p3	0.98
Driver – p1	71.48
Driver – p1a	1.53
Driver – p2	6.36
Class II – Pass	1.56
Class IV – Pass	73.42
Class II – Driver	2.10
Class IV – Driver	127.75
Class V	27.79
Class VI	184.91
Total	591.02

Figure 885. Combined direct and indirect FOV area projection for the Volvo FM N3 / FMX N3G

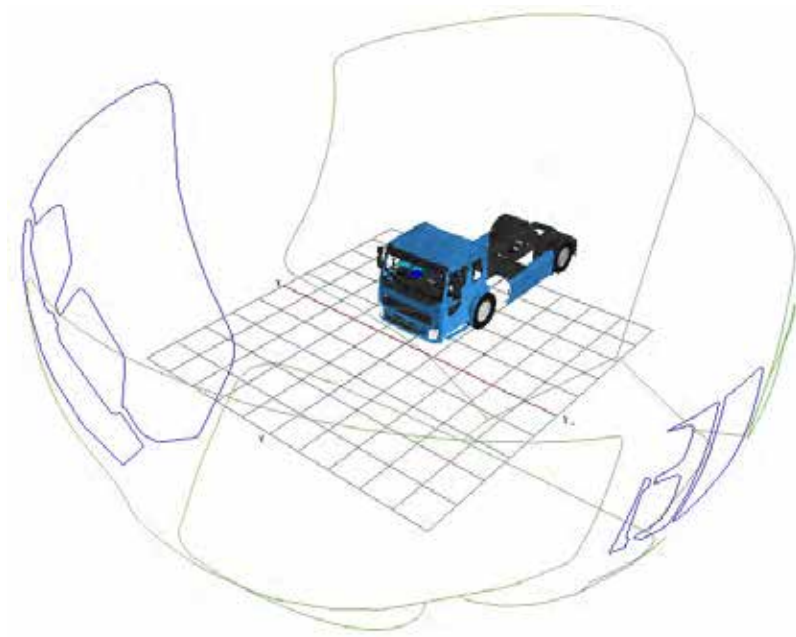
8.2.10.12 VOLVO FH CATEGORY N3 DISTRIBUTION



Window	Area(m ²)
Windscreen	82.71
Passenger – p1	10.97
Passenger – p2	1.54
Driver – p1	53.35
Driver – p2	16.81
Class II – Pass	0.09
Class IV – Pass	68.29
Class II – Driver	1.27
Class IV – Driver	121.43
Class V	22.56
Class VI	229.10
Total	608.12

Figure 886. Combined direct and indirect FOV area projection for the DAF CF N3 / N3G

8.2.10.13 VOLVO FE CATEGORY N3 LOW ENTRY CAB



Window	Area(m ²)
Windscreen	79.56
Passenger – p1	5.73
Passenger – p2	2.71
Passenger – p3	0.49
Passenger - Cab	5.91
Passenger - Door	1.94
Driver – p1	60.91
Driver – p2	14.87
Class II – Pass	0.00
Class IV – Pass	59.05
Class II – Driver	0.00
Class IV – Driver	179.70
Class V	40.86
Class VI	157.99
Total	609.72

Figure 887. Combined direct and indirect FOV area projection for the Volvo FE N3 LEC