June 2019

Direct Vision Standard: Pushing the Blind Spot Agenda

Transport for London Update

HGV safety permit scheme proposals for London

October 2019

Scheme ‘go-live’

October 2020

0-star banned unless

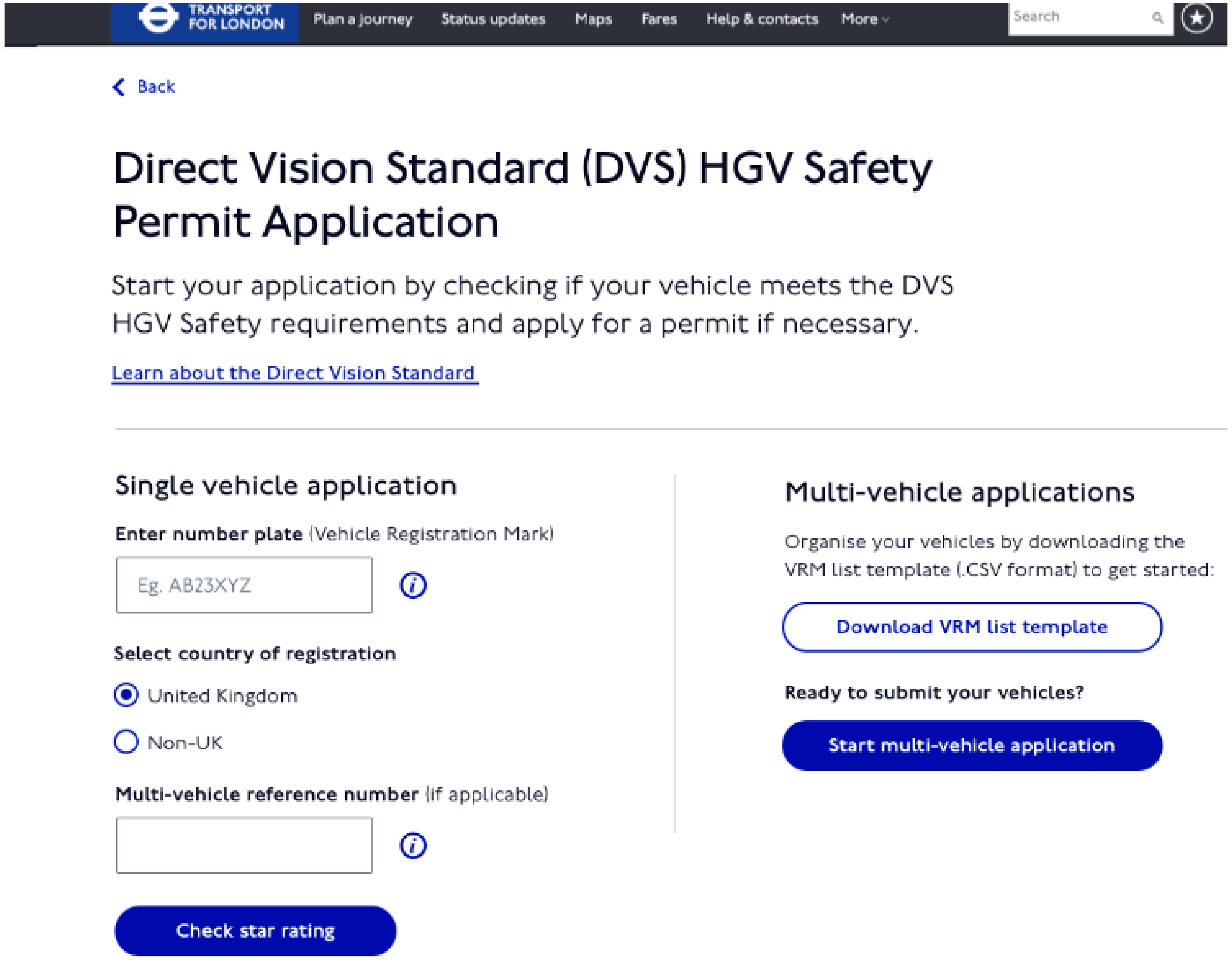
safe system met

October 2024

0-2 star banned
unless progressive
safe system met

+Procurement contracts

Permit application process – October 2019



Enforcement – from October 2020

ANPR reads VRM

↓

Is it an N3 HGV?

↓

Check against DVS permit database

↓

Issue PCN if not in database

+

On-street enforcement collaborations

Issue PCN if Safe System conditions breached

An international standard

UNECE

TfL remain fully committed to, and supportive of, the current GSR proposals.

Reducing blind spots to the **"greatest possible extent"** requires an ambitious minimum star rating for all categories of vehicles.

Achieving a meaningful reduction in serious and fatal collisions between trucks and pedestrians and cyclists, particularly in urban areas, demands an ambitious minimum star rating.

"Vehicles of categories M2, M3, N2 and N3 shall be designed and constructed so as to enhance the direct visibility of vulnerable road users from the driver seat, by reducing **to the greatest possible extent** the blind spots in front and to the side of the driver, while **taking into account the specificities of different categories of vehicles**".

Thank you

Website:
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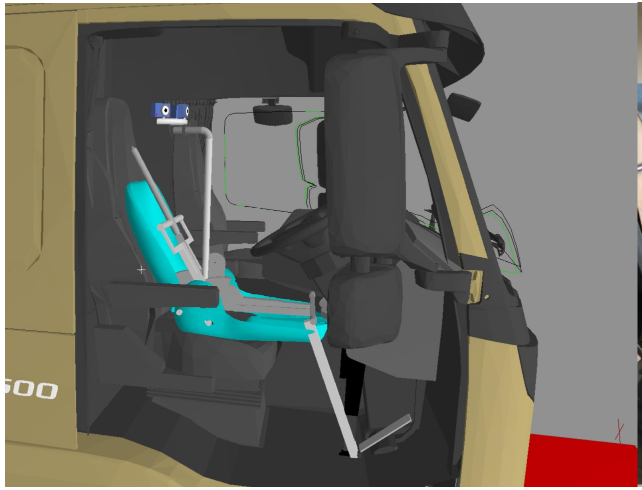
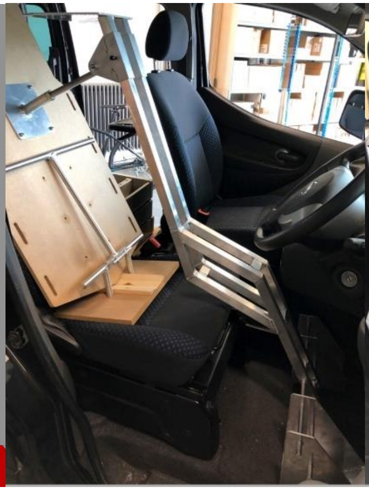
EVERY JOURNEY MATTERS

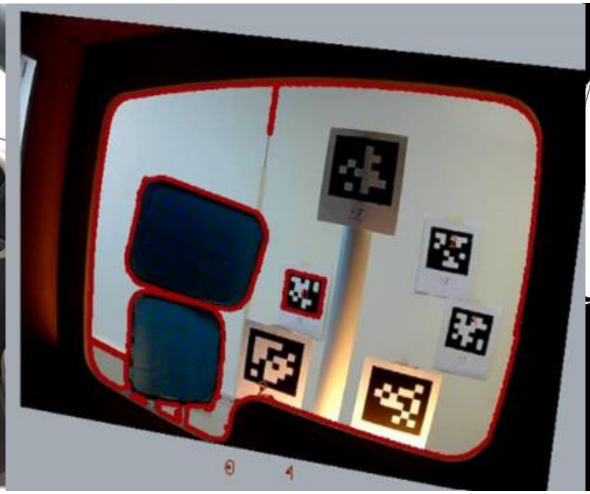
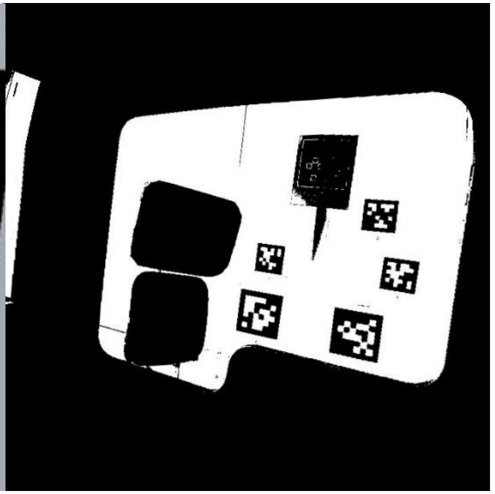
Definition and testing of a Direct Vision Standard for Trucks – A physical test to supplement the virtual DVS method

Loughborough University Design School: Design Ergonomics Research Group

Research Sponsored by Transport for London

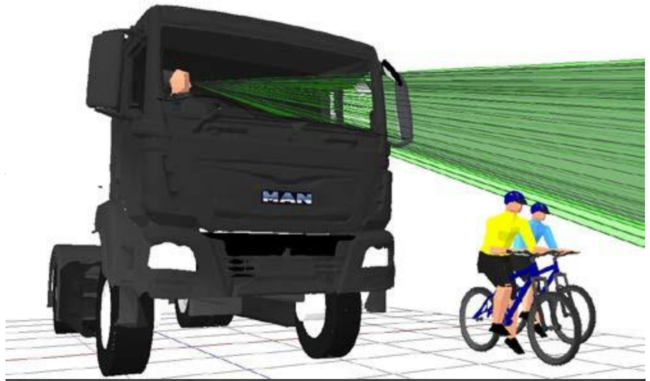
Dr. Steve Summerskill
Dr. Russell Marshall, Dr Abby Paterson, Antony Eland, James Lenard, Steve Reed

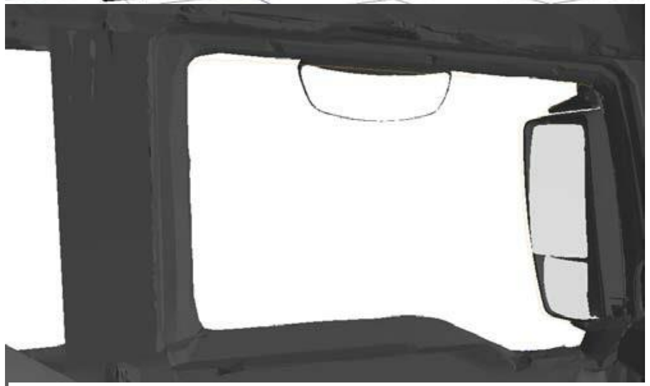



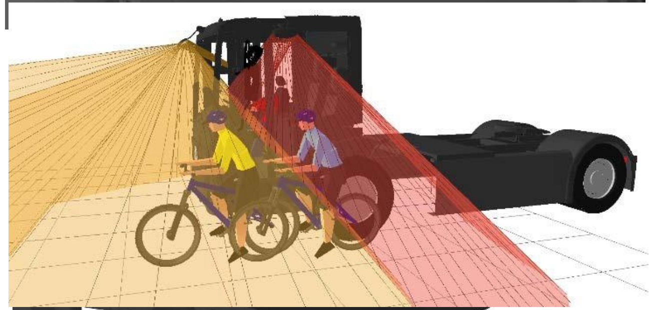



Contents

- A reminder of the fundamentals of the TfL DVS process
- An update on the development of physical test
- An analysis of the potential benefits of adding an aerodynamic front end to the HGV cab
- The LDS view of applicable of star ratings for the Category N2 and N3 vehicles in Europe





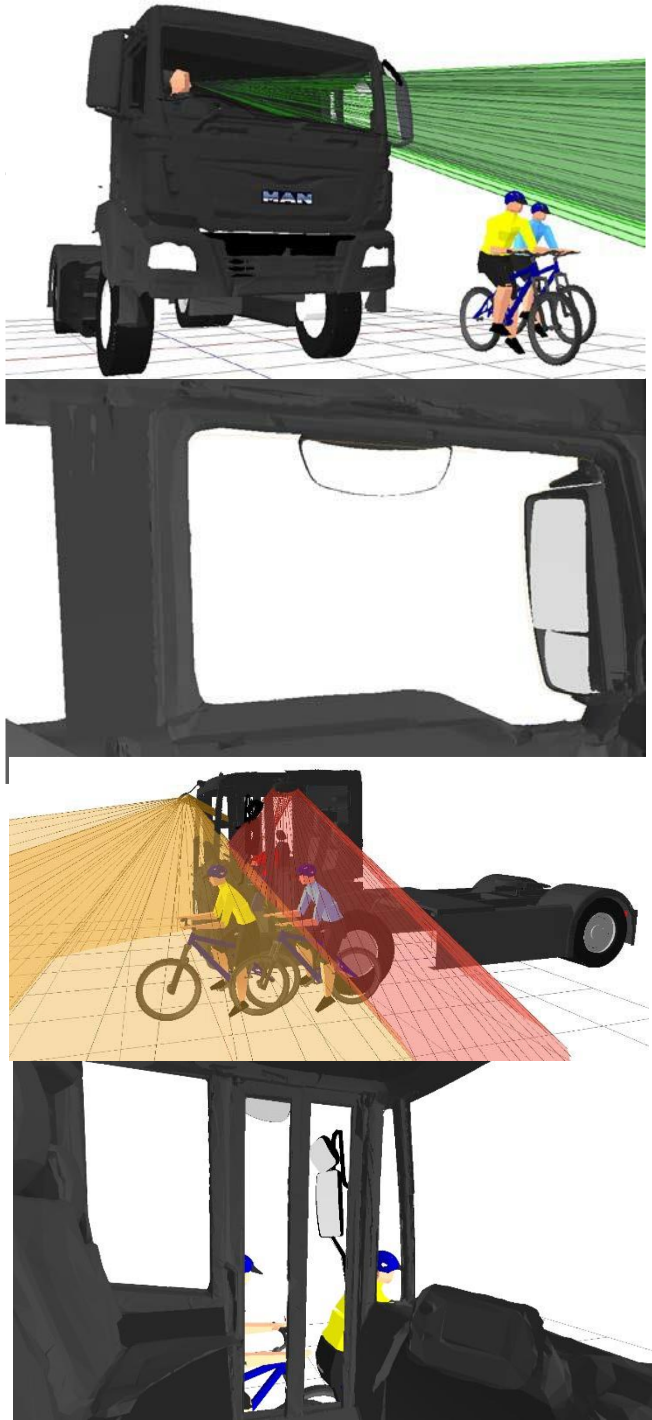


The definition of a ‘real world’ test that can be used for on the spot checks

- At the last VRU Proxy meeting we showed developments for a physical test method

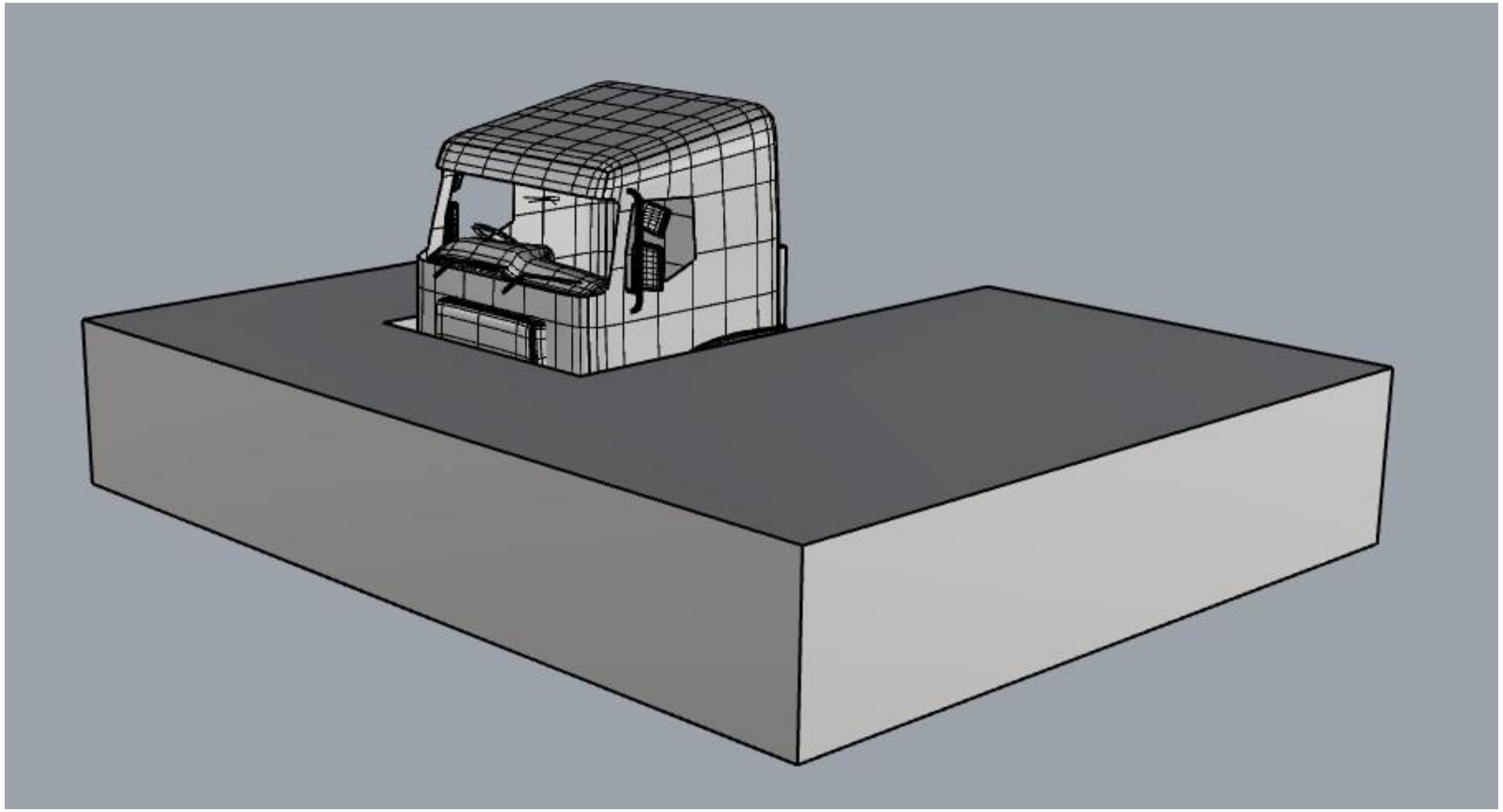
- As discussed at the last meeting the CAD approach should be seen as the gold standard in terms of the accuracy and ability to support the design process for improved direct vision, due to the high resolution nature of the test process

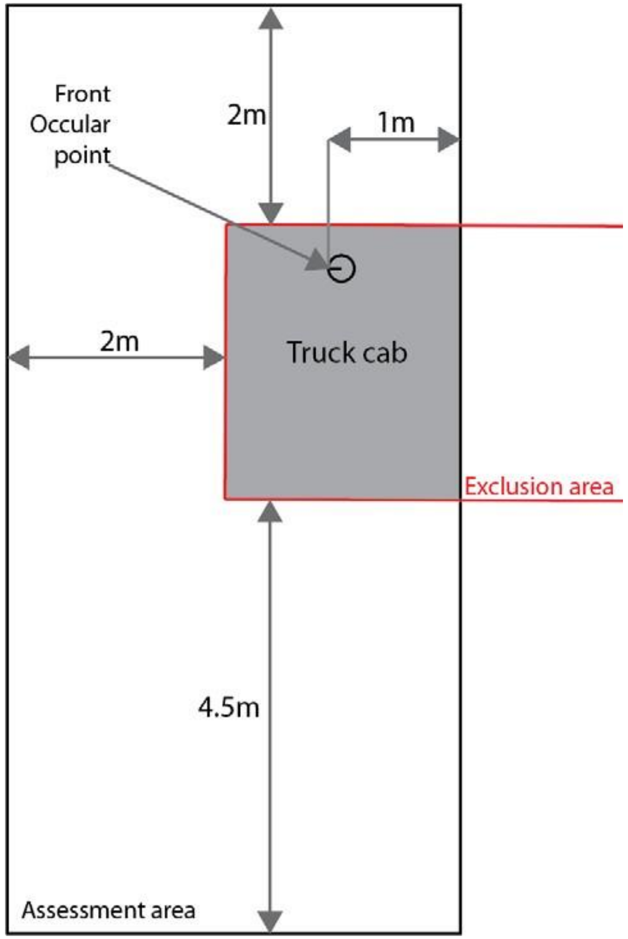
- The following content shows the development of the physical method which exploits the digital code and ability to generate results for multiple cab heights from a single cab analysis and data on the height range for the cab



Reminder – the digital DVS methodology

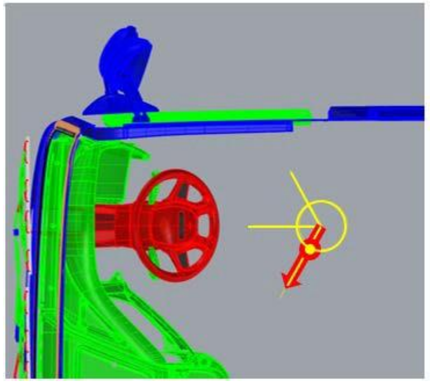
– The assessment volume is aligned to the truck sides and front

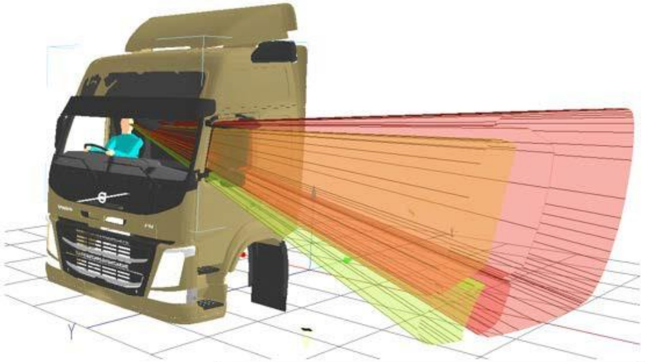


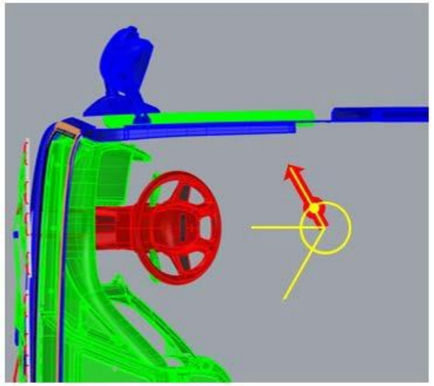


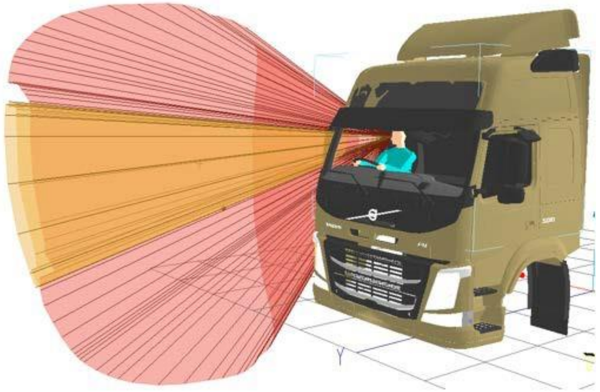
Reminder – the core DVS methodology

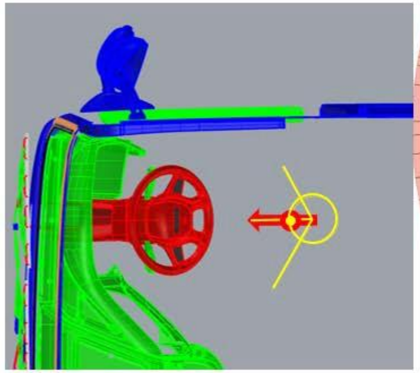
- The volume of space visible from the three defined eye points is projected through predefined window apetures

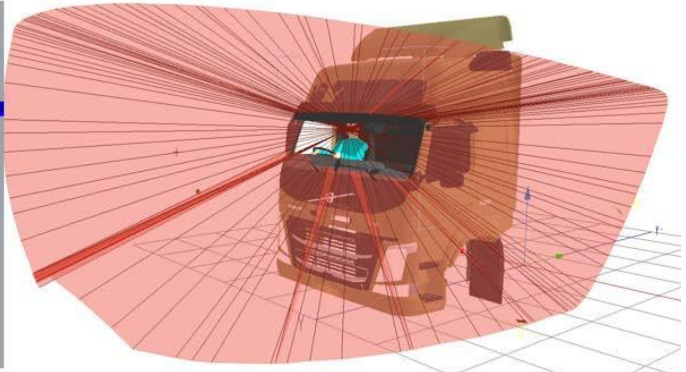






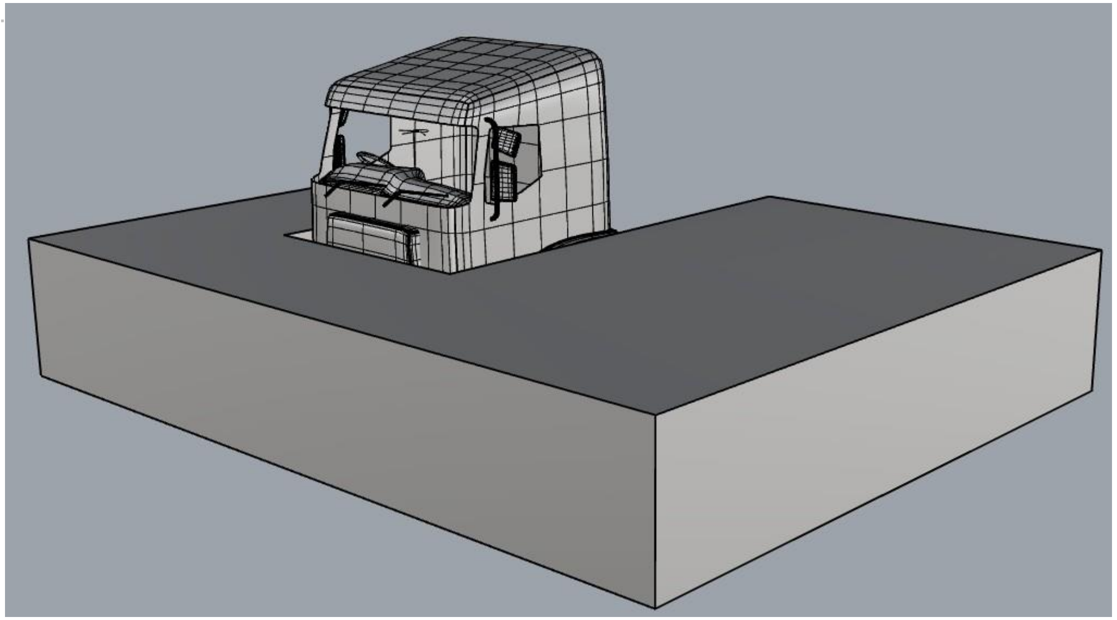


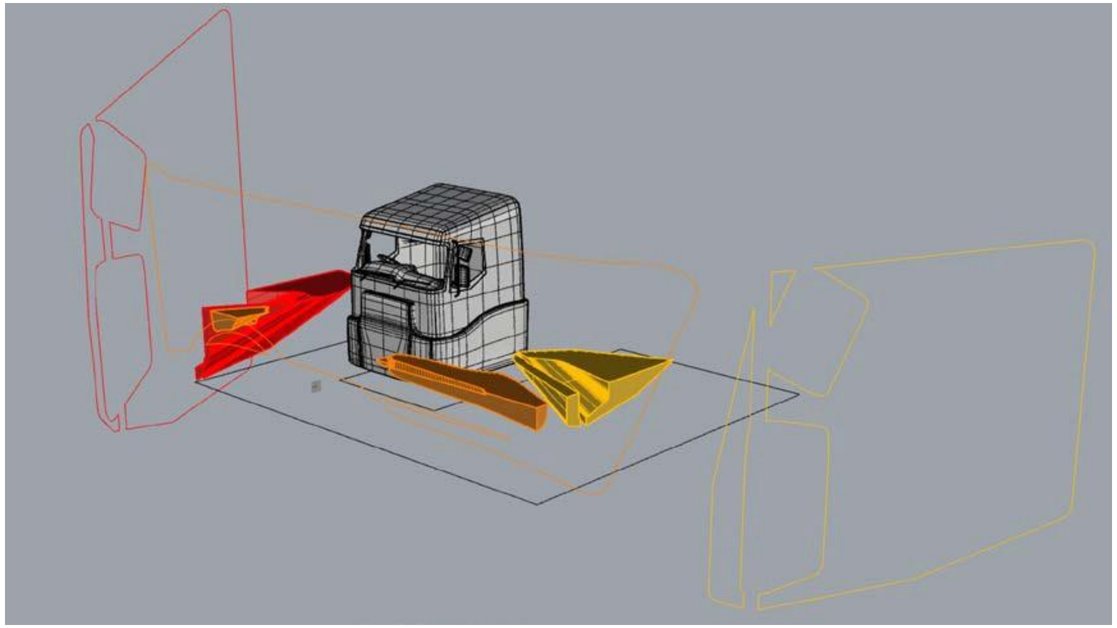




Reminder – the core DVS methodology

- The visible volumes are intersected with the assessment volume to allow the proportion of the assessment volume that is visible to the virtual driver to be calculated





Reminder – the core DVS methodology

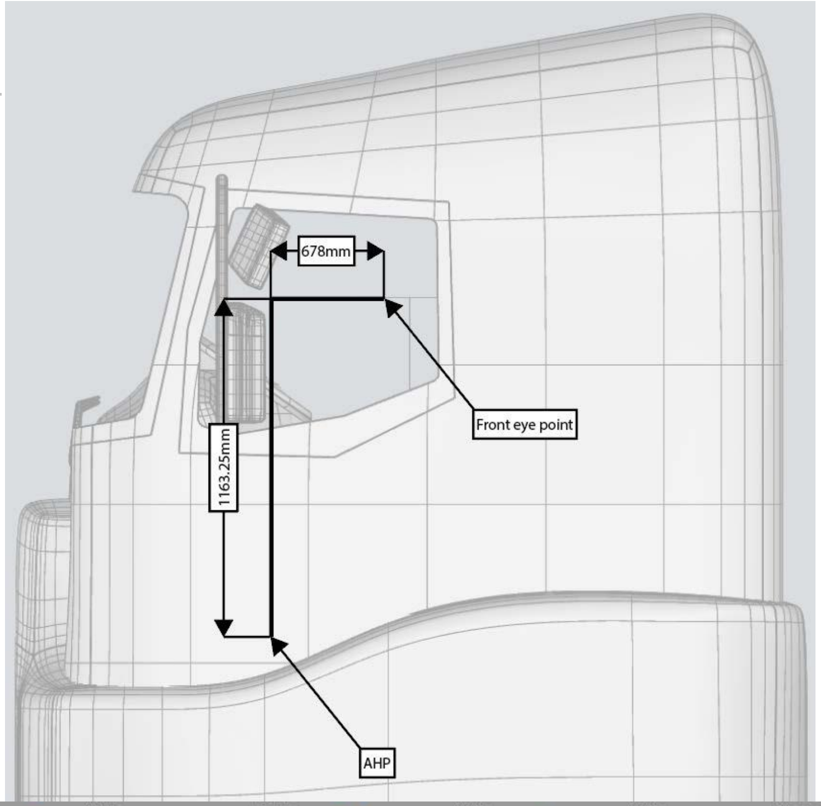
– The forward eye point is defined by an offset from the accelerator heel point (AHP)

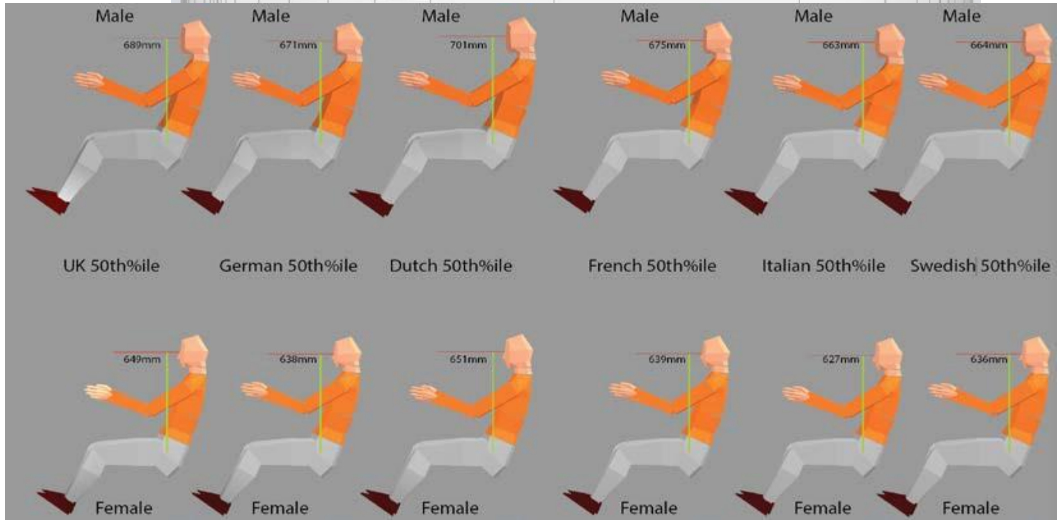
– This eye point was defined with the agreement of manufacturers and is a standardised eye point which can be used with any vehicle

- Multiple other options were considered including using standard hip point (SgRP) definitions and offsets for an eye point as defined in UNECE regulation 46, however these led to some manufacturers gaining an advantage when a full analysis of all trucks was performed due to variability in the use of the SgRP within the H-point envelope

– The eye point has been defined by taking into account the seat positions of all trucks (common h-point location identified), combined with an offset from the seat which replicates average European eye height for a truck driving posture

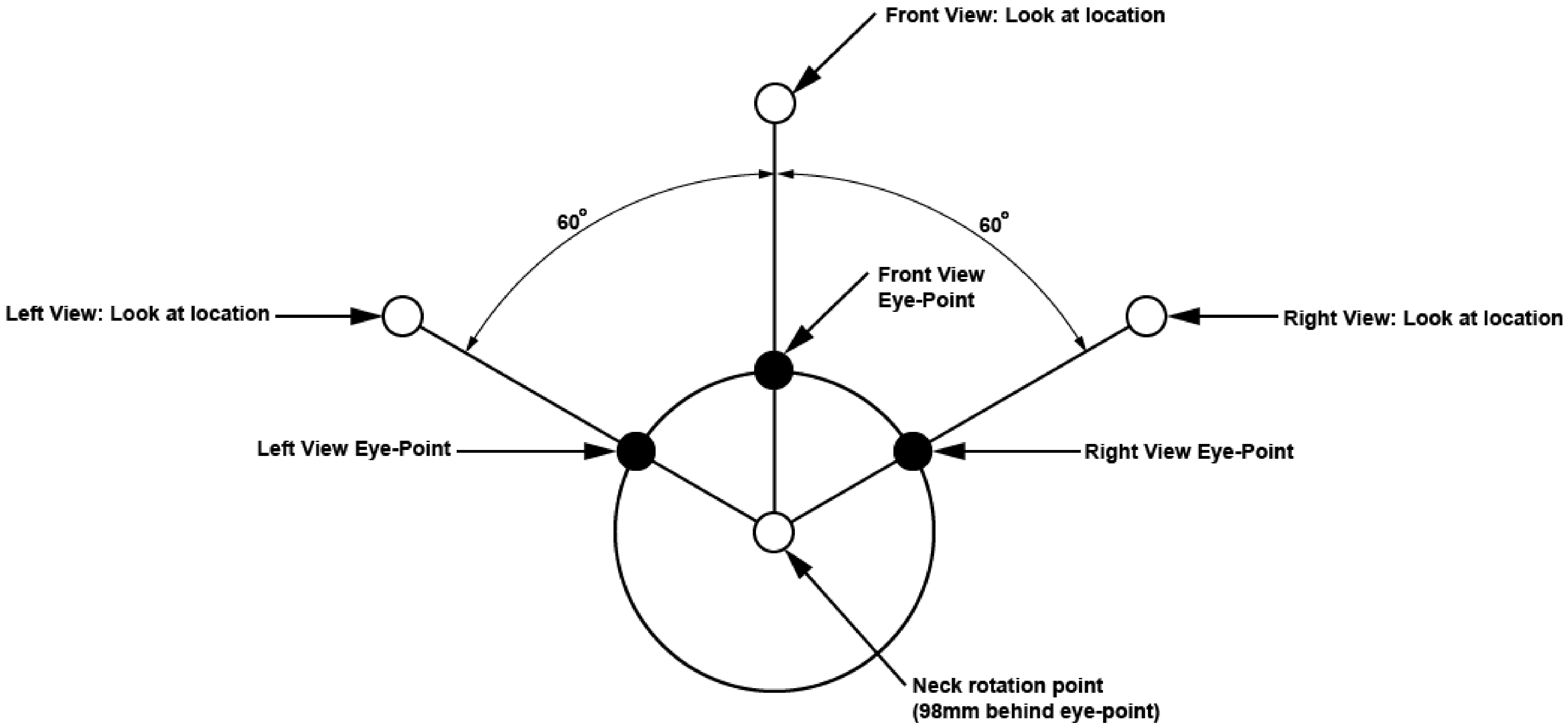
- 50th%ile male and female offsets identified for UK, Germany, Holland, France, Italy, Sweden and then this is averaged with a 90:10 male female split.



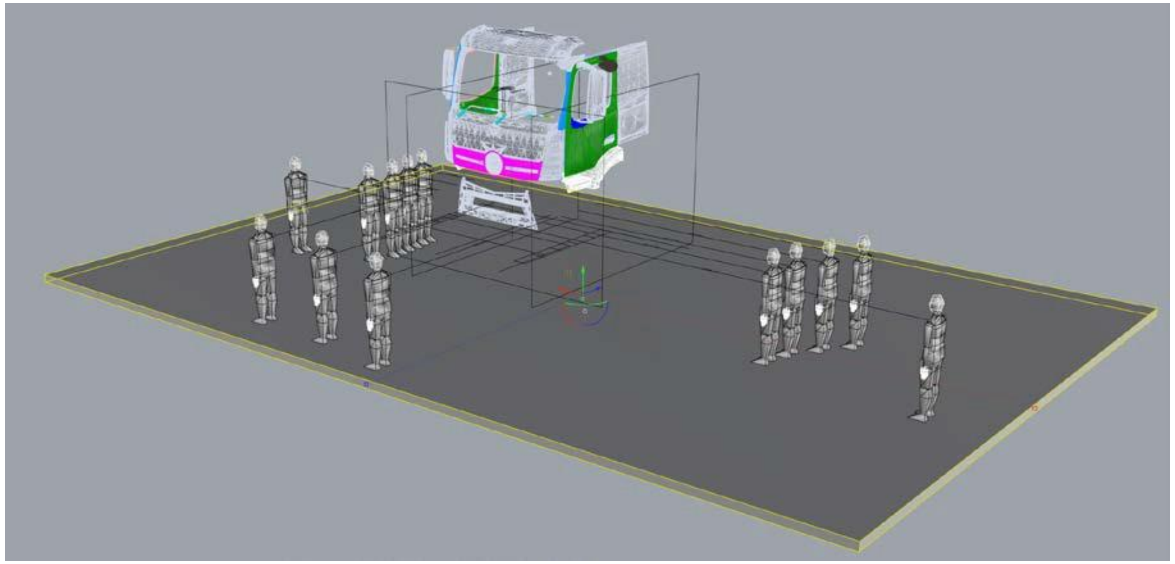


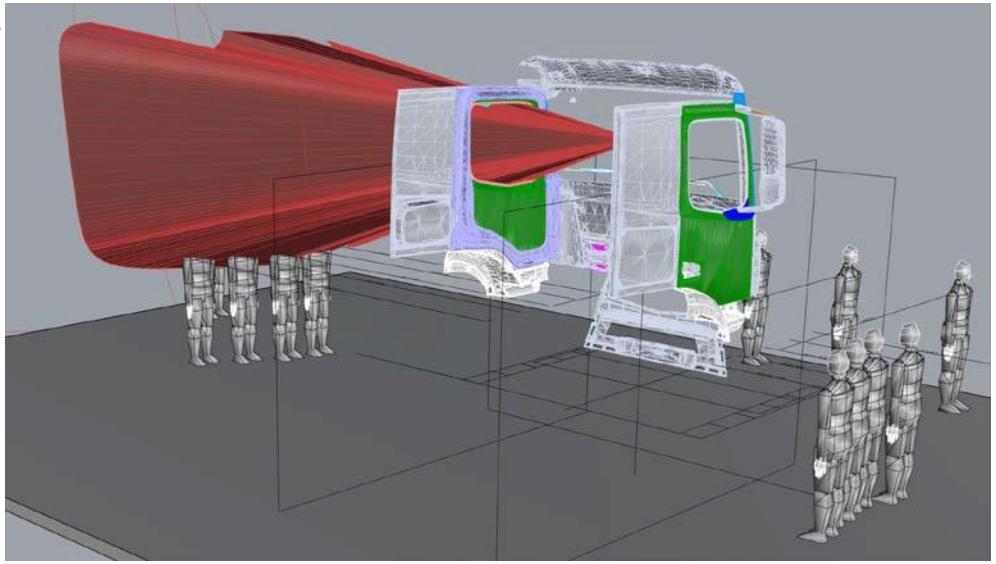
Reminder – the core DVS methodology

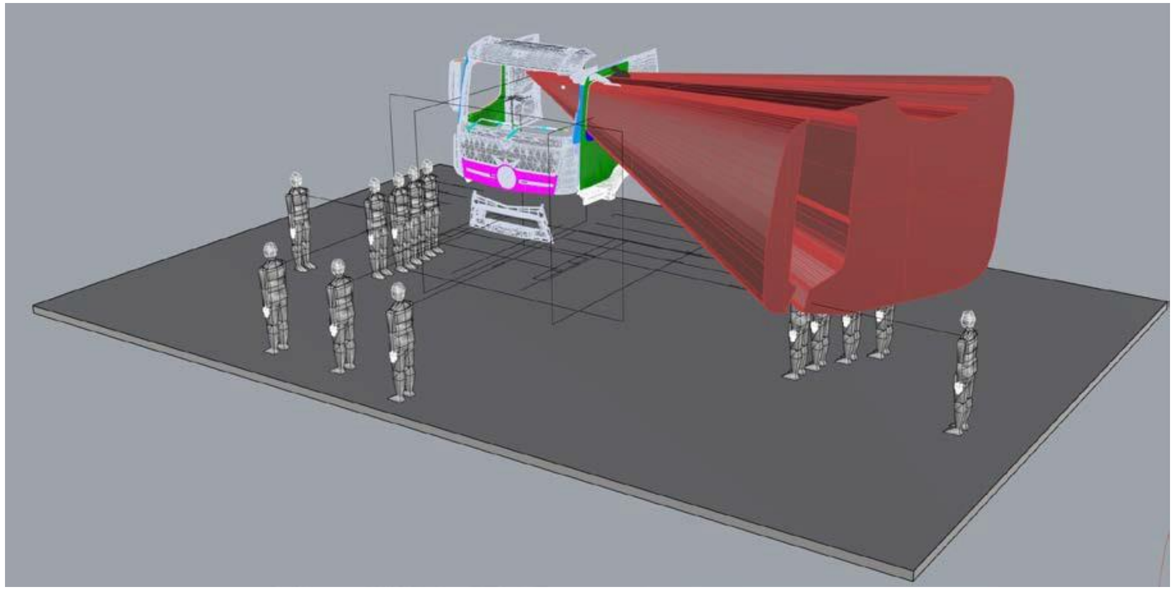
– The 'eye rig' is generated to simulate the view of virtual driver to the front, left and right of the cab using the premise defined by reg 125.



The use of VRU simulations to validate the volumetric results

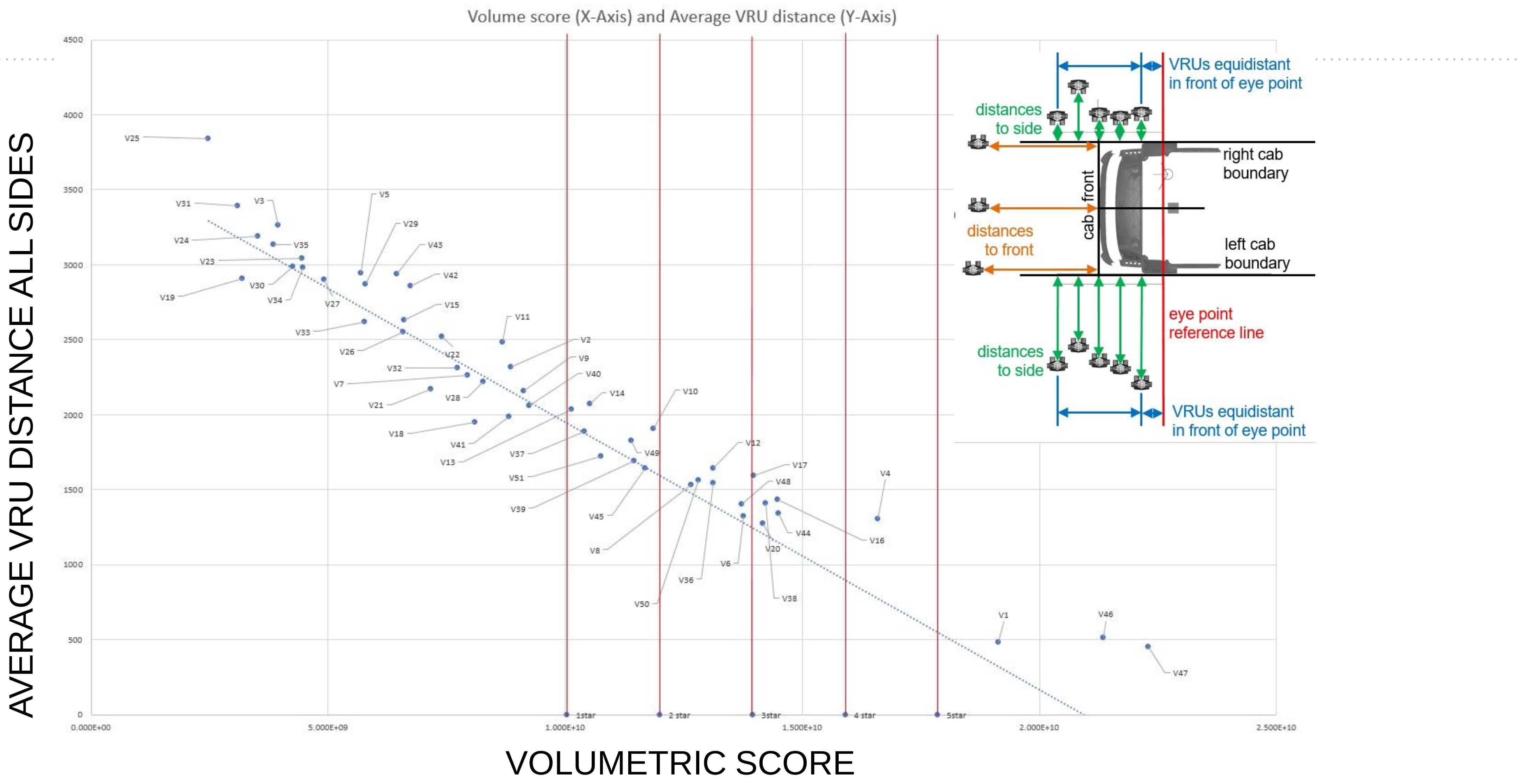






- Top Left – The VRUs are shown around the truck
- Bottom left- the visible volume through the left window is shown
- Top right – The head and shoulders of the VRU intersect with the visible volume at the locations shown and the distances of all VRUs from the side of the truck are measured

The results: Volume plotted against VRU distance



0.97 correlation between volume scores and VRU scores : 0.5 is strong, 1 is perfect

Real world test that is being prototyped

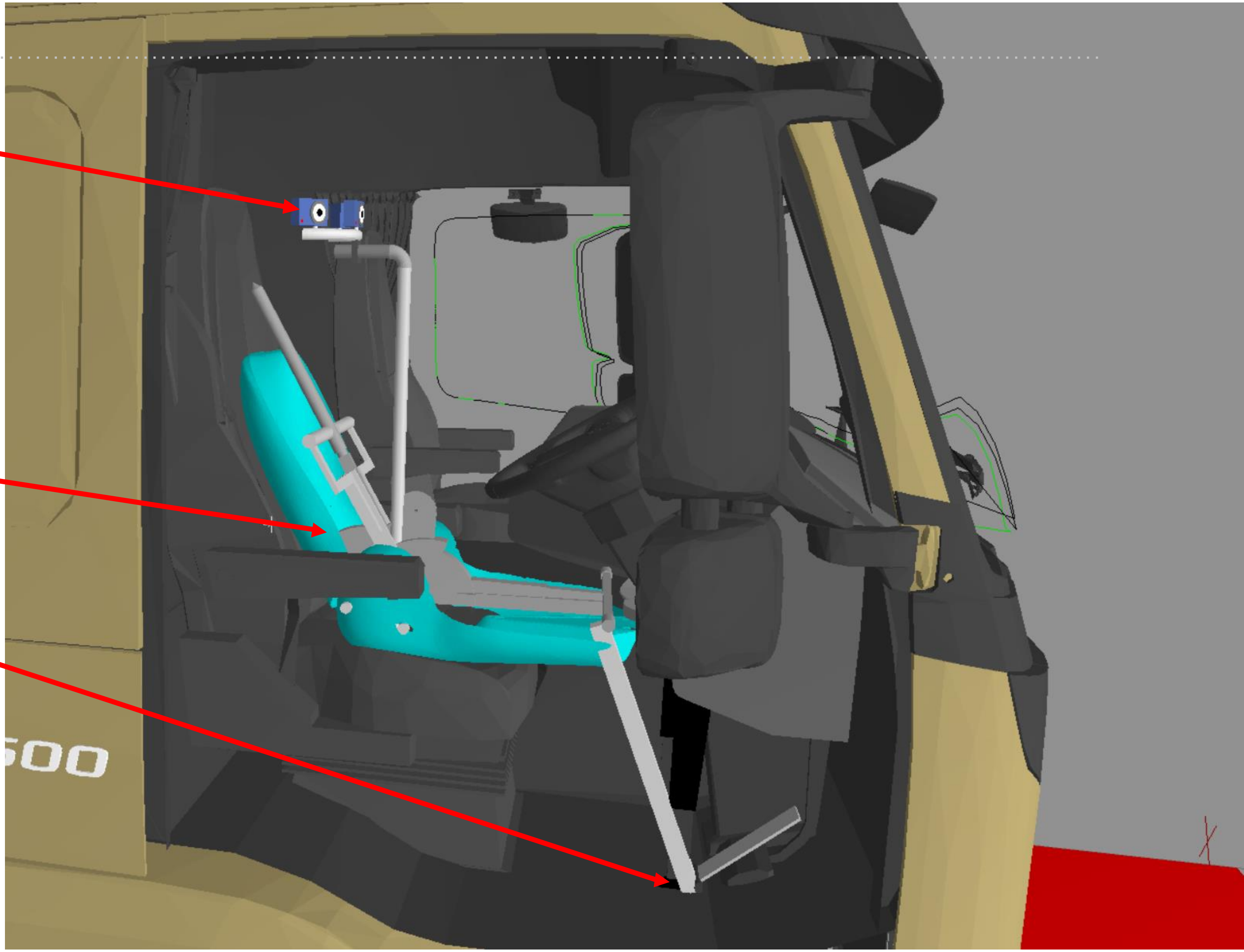
Part 1 – using the seat to support an eye rig that can support three small wireless cameras

Part 2 – The use of computer algorithms to process the camera images to generate a DVS score

Loughborough University

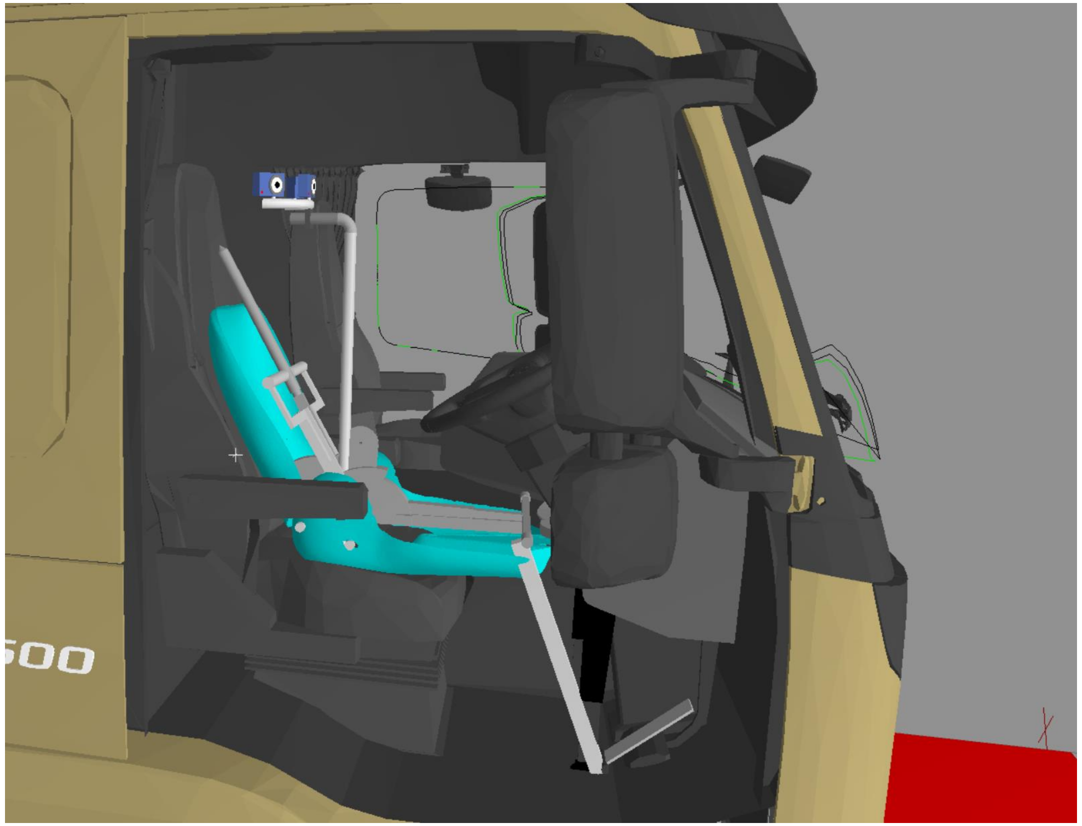
Initial rig proposal – adapting the SAE MANIKIN

- Uses three wireless cameras to allow views to be remotely captured outside of the cab
- Uses a weighted form that is supported by the seat to correctly locate the front camera location
- Uses the AHP calculations in SAE 1516
  - The SGRP height defines the foot angle for interaction with the A pedal
- Eye points match those used in the virtual version.

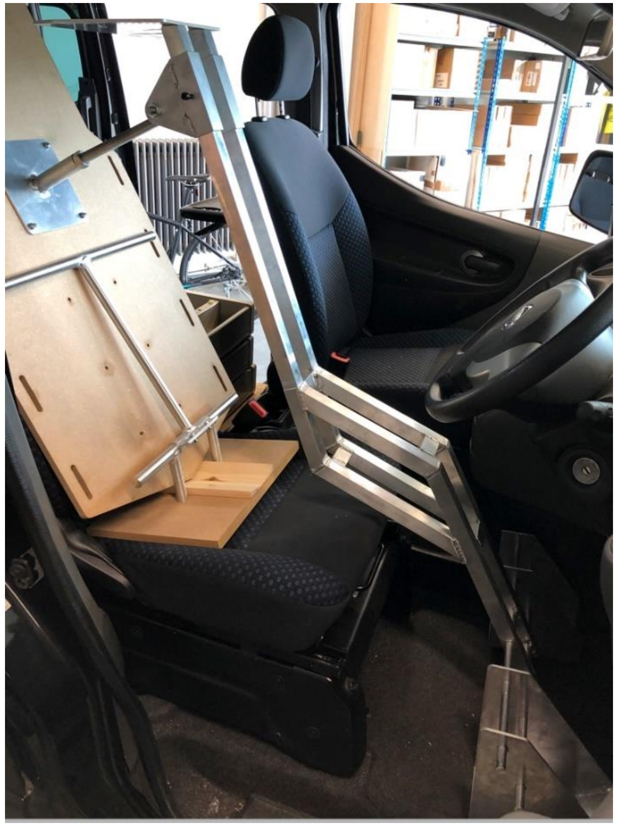


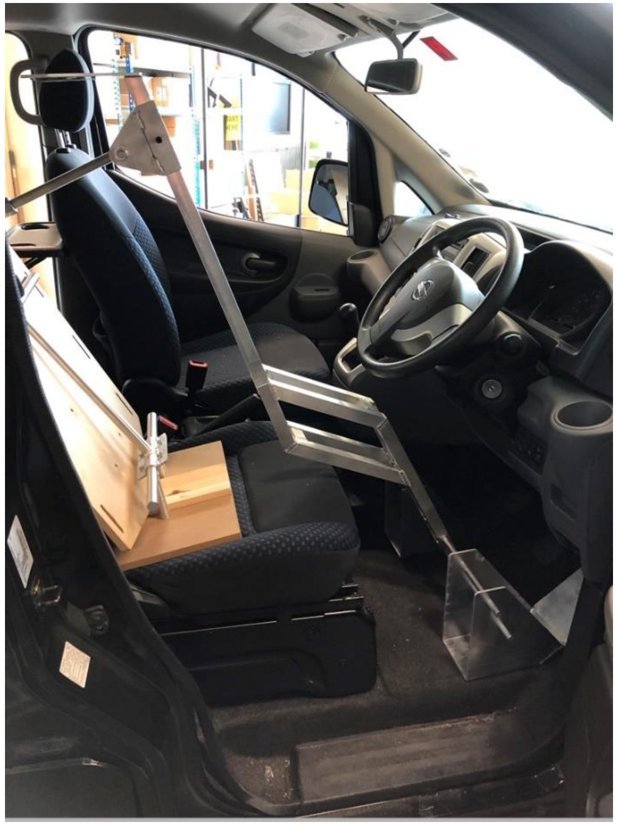
Part 1 – using the seat to support an eye rig that can support three small wireless cameras

Initial rig proposal – adapting the SAE MANIKIN



Revised proposal – new rig





Part 1 – using the seat to support an eye rig that can support three small wireless cameras

- Key features of the rig design

Platform for the three cameras

When platform is horizontal the eye point is replicated as per the CAD version of the test

Adjustment of camera platform angle possible through the window with an adjustment screw

Loaded at the hip point in the same manner as the SAE manikin

Location of the rig associated with the AHP location by placing the rig with the 'foot' resting on the A-pedal

Aluminium – Lightweight to enable easy access to the cab

Initial testing of the rig in a van cab (Nissan NV200)

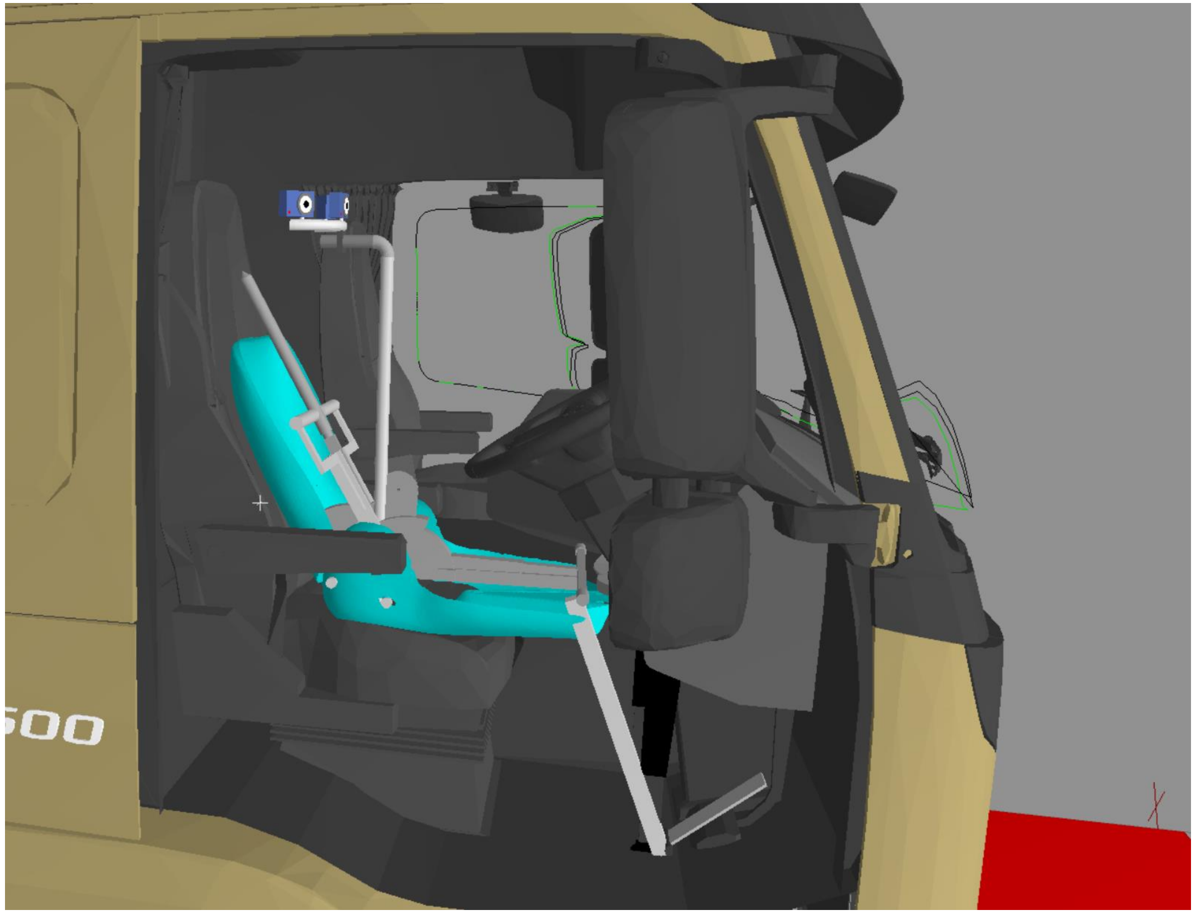
Real world test that is proposed for prototyping

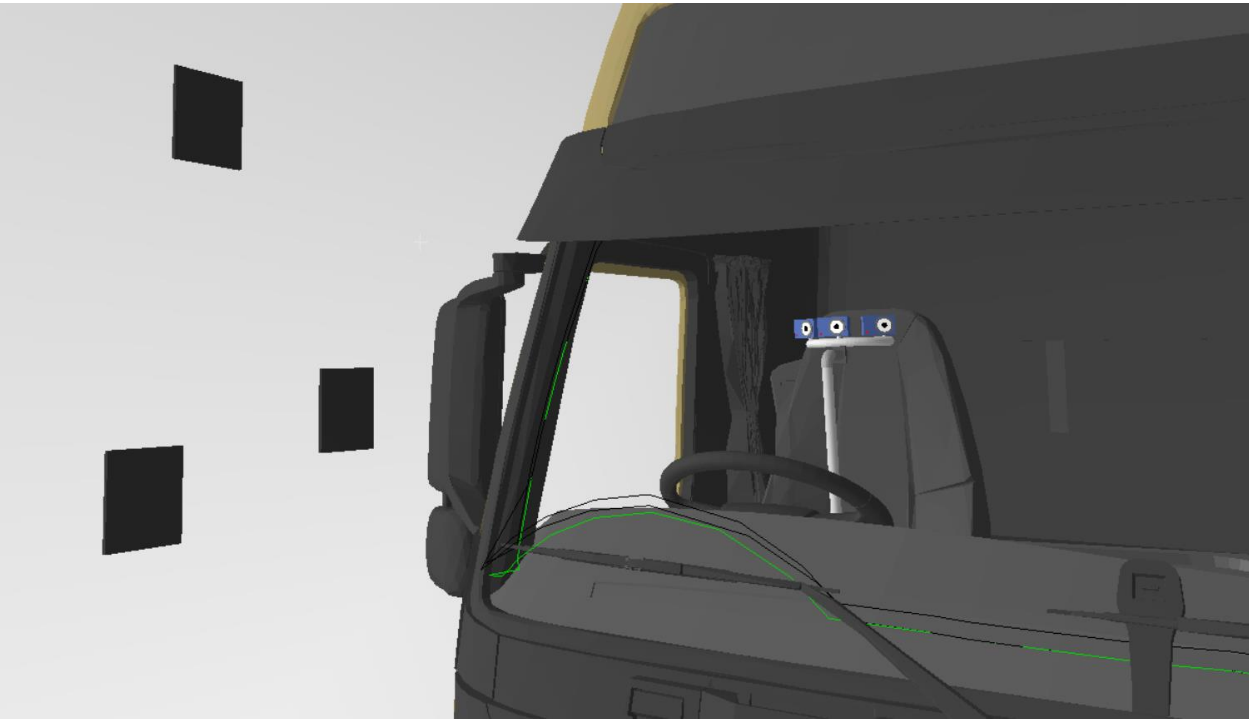
Part 2 – The use of computer algorithms to process the camera images to generate a DVS score

This has been the main effort since the last meeting

Example test method – Stage 1: Investigator sets up the physical rig

1. The investigators set up the eye rig inside the cab, representing the eyepoint in left, forward and side positions. Cameras will be positioned to represent these three eyepoints, and will capture still images of what can be seen (both in terms of cab interior and features external to the cab)

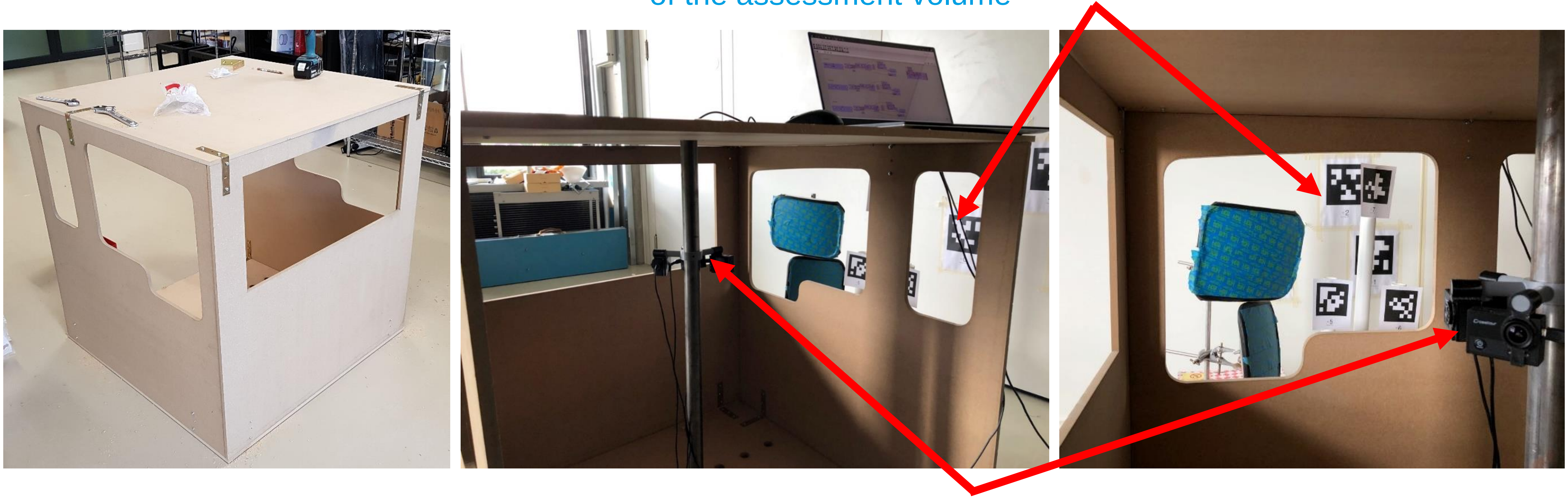




Example test method – Stage 1: Investigator sets up the physical rig

1. We have built a cab rig which allows the testing of the process to be completed in our labs

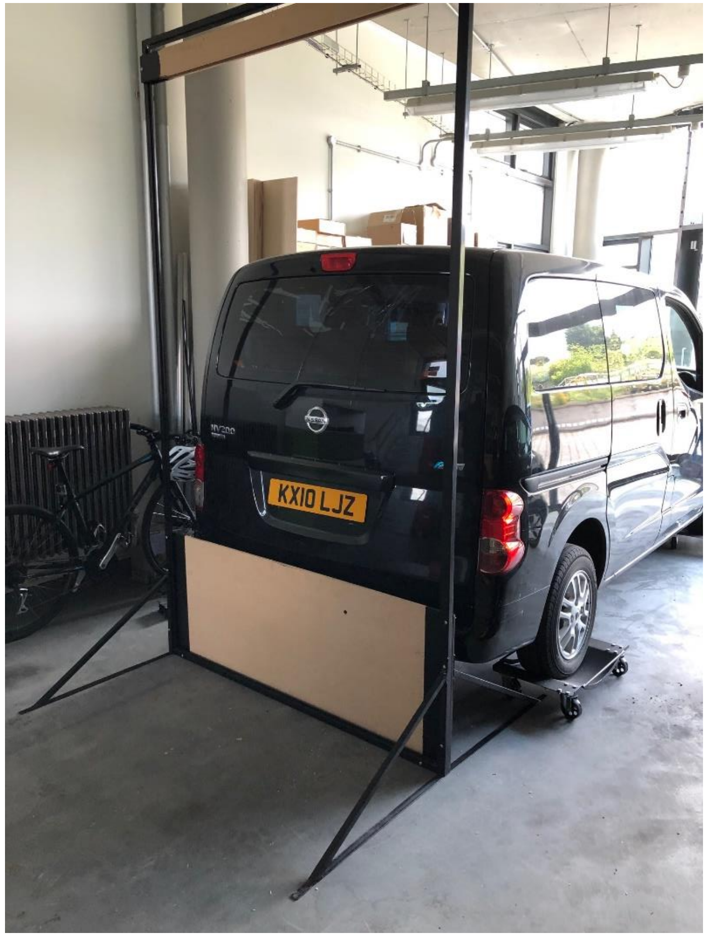
2 sets of QR code type markers to determine the distance from the camera to the wall, and the edge of the assessment volume



Camera rig (3 Go Pro type Cameras) on a 3D printed structure

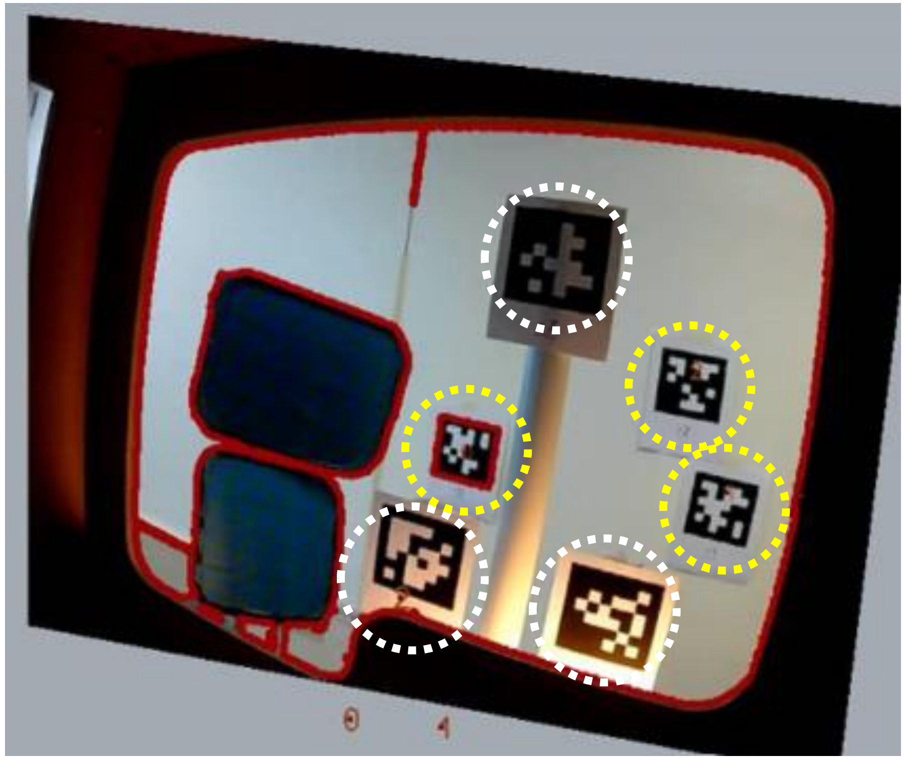
Example test method – Stage 2: A wall is orientated next to the vehicle

2. A moveable assessment wall will be used. On each of these walls, a number of markers (similar to QR codes) will be positioned in a triangular arrangement; two will be positioned with a set distance from the floor, and a third higher up (although the exact location/distance of this third marker relative to the two lower markers is less important). All markers must be visible in each eye point camera.



Example test method – Stage 3: Cameras capture the images for each view (right front and left)

3. The automated script recognises the position of these markers. The physical size of the marker is detected, and this in turn then determines their distance from the camera. Using triangulation, the algorithm seeks to fit a ‘plane’ through these three markers which can then determine the distance but also angle of the wall relative to the camera. The two lower markers can also be used to identify/determine the assessment volume height which will then be used later in the algorithm for volume assessment definition. A further set of three markers now determine the location of the assessment volume next to the truck



Yellow highlighted markers determine the distance to the wall

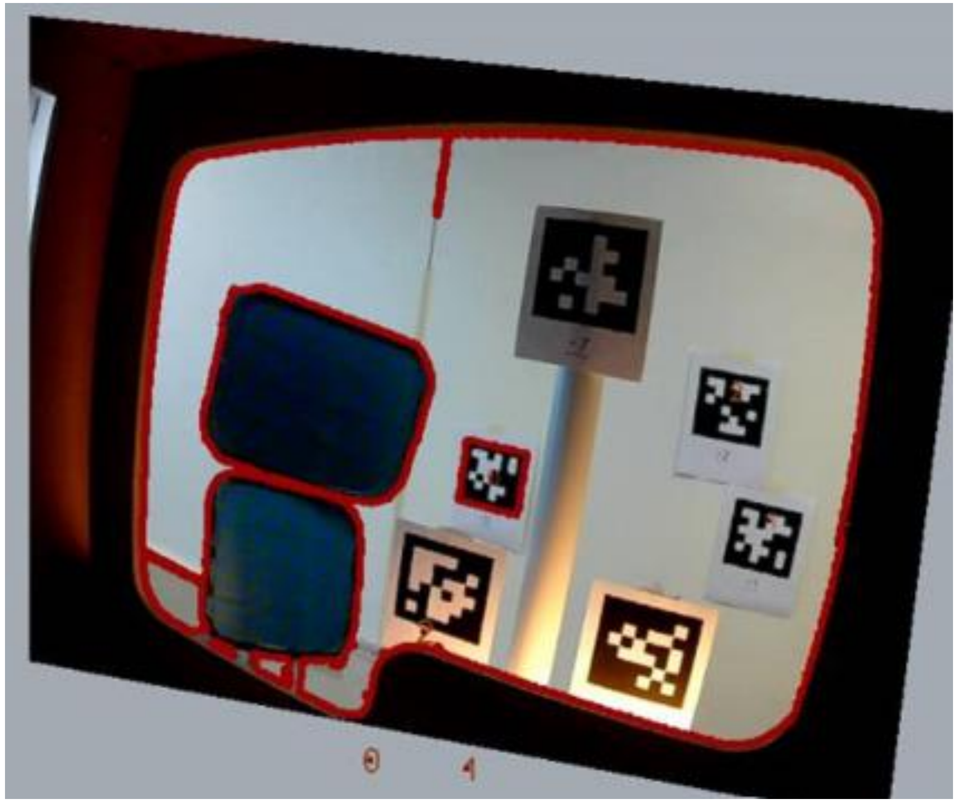
White highlighted markers determine the distance of the inside edge of the assessment volume

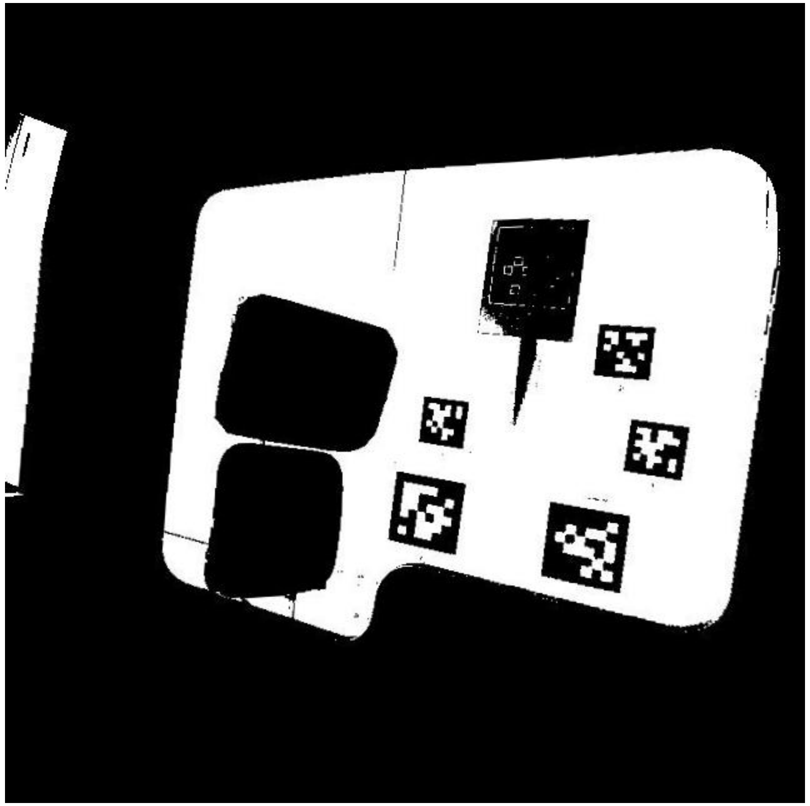
Red line shows the window aperture being automatically generated

Example test method – Stage 4: Removal of distortion due to camera lenses

4. Any camera lens will distort the real world image and so this distortion has to be removed. There are two methods currently being used for

1. Using image processing software and then reimporting the path into the algorithm
2. Using a mathematical process within the algorithm to remove the distortion
3. The images below show the image with distortion, (left) and the distortion removed (right)





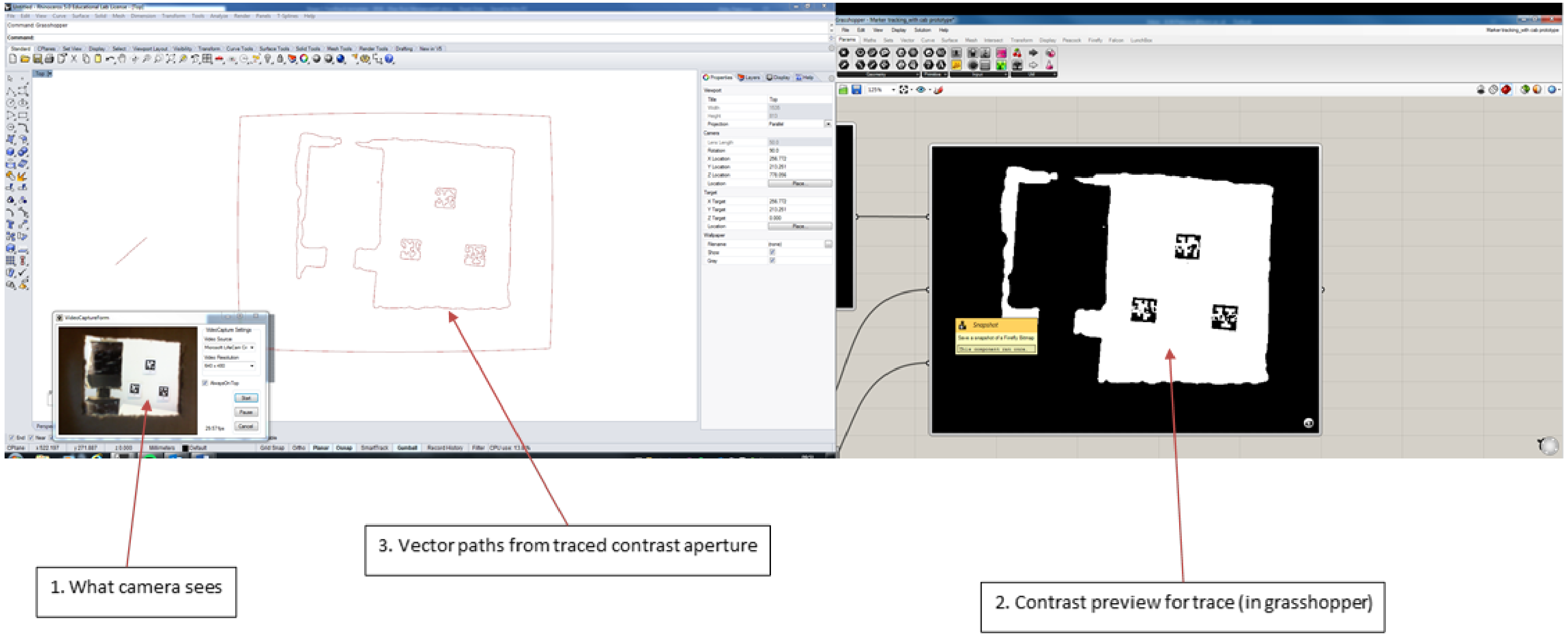
Example test method – Stage 5: Contrast in the image used to derive a window path

5. With the positions of the walls now set up, the creation of apertures can now be determined.

- By illuminating the walls, and keeping all other aspects of the setup dark there is sufficient contrast between the inside of the cab and the wall

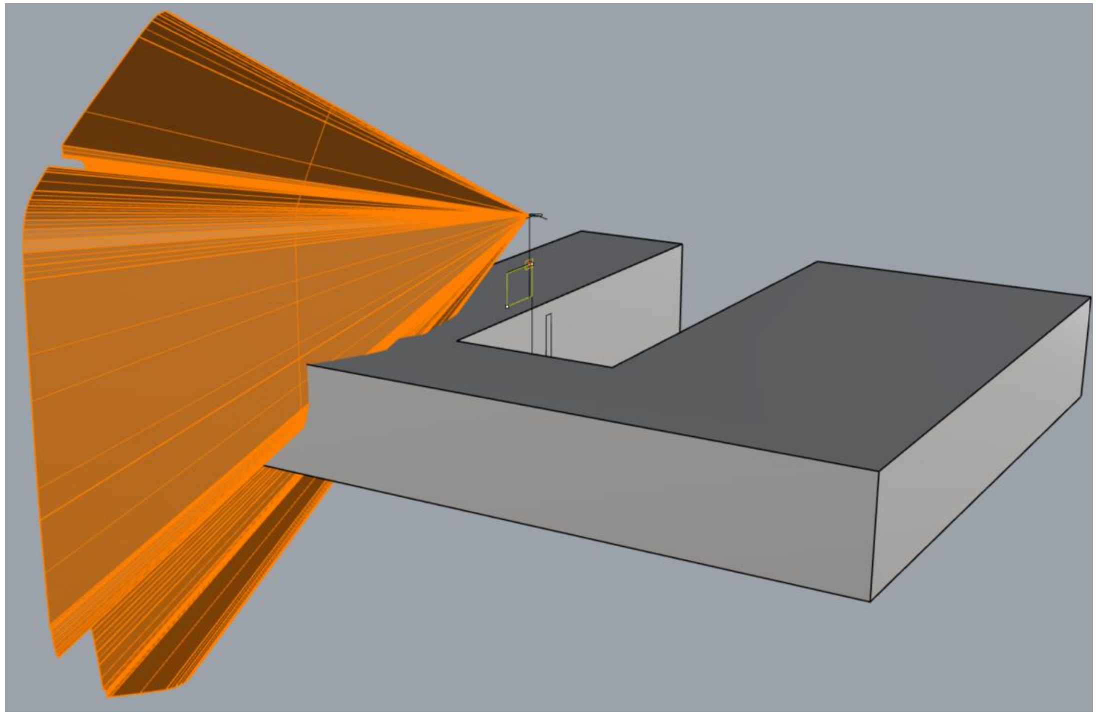
- Using contrast threshold adjustment techniques, it will be possible to determine a clear boundary between light and dark regions of the camera.

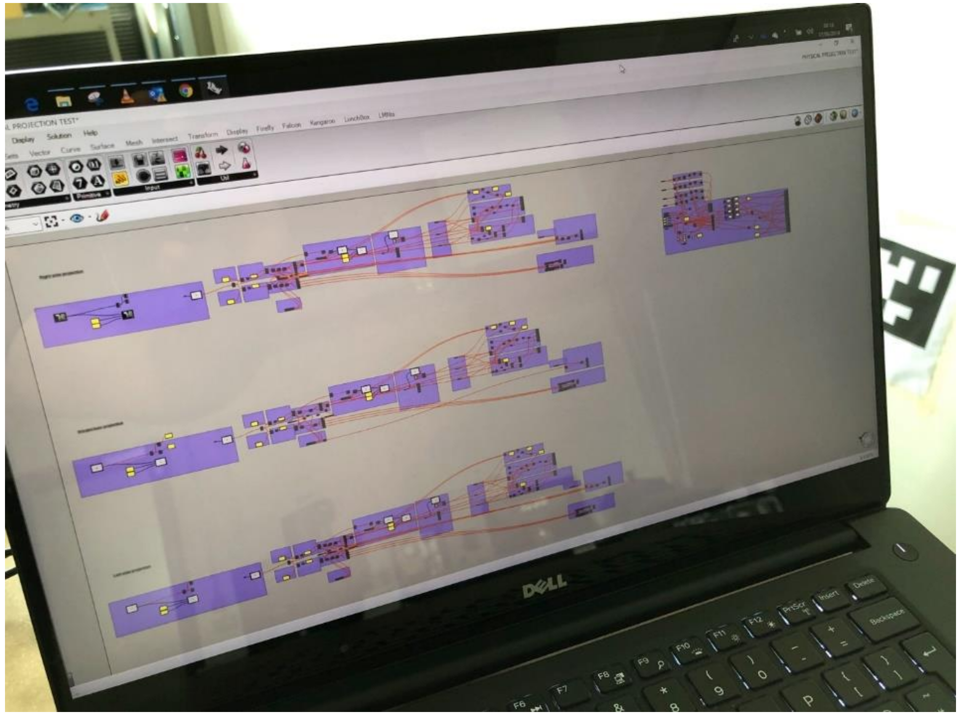
- The script will fit a spline around the areas with highest levels of contrast.



Example test method – Stage 6: The path and other info gathered generate a visible volume

6. With the splines created to determine the apertures, a digital projection from the eyepoint can be set up. This is achieved as the camera position is represented in the script with a point that is known in relation the walls and the sides and front of the cab

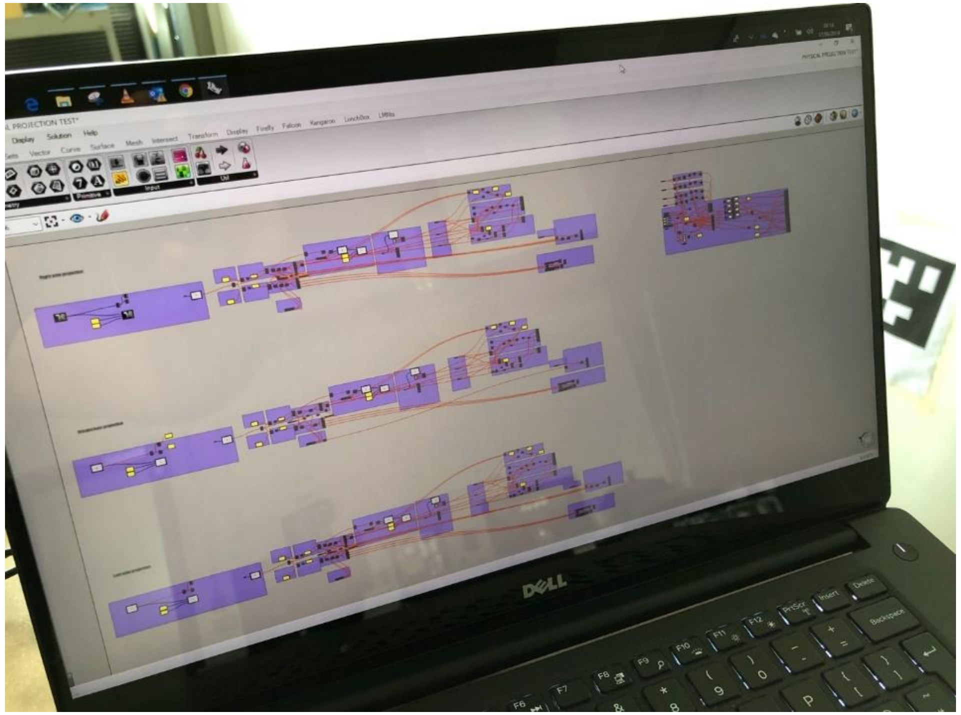




6. The existing Grasshopper algorithm developed by Loughborough University for the Digital DVS can then be used; the projections can be trimmed with the assessment volume, and if necessary, a range of height iterations could then be made with the existing script, but based on physical geometry.

Free to use for all

The process defined uses two plugins which are third party. We have requested and received permission to use these plugins for the DVS work as long as the credit is given to the authors at no cost.



An important benefit of this technique

- The digital DVS technique can quickly calculate the DVS score for hundreds of potential cab heights

- For example, the cab height range for one model of a Daimler truck that we have tested is over 800 millimetres between lowest possible height and maximum possible height, and 800 results can be produced in three hours.

- By using real world data to feed into the same technique that defines the digital DVS, the power of the digital DVS to calculate results for multiple cab heights can be leveraged

- This means that it is does not matter what the cab height is for the real world test vehicle, we can calculate all possible heights from one measured vehicle from height range data provided by manufacturers

		Volumes				
Cab floor height above ground plane	Increment	Right	Front	Left	Total volume	Rating
1900	160	3775121128.800	142731258.380	1033963538.400	4951815925.600	Zero star
1899	161	3777692892.600	143956580.350	1037371798.500	4959021271.500	Zero star
1898	162	3780263390.800	145191507.790	1040784888.700	4966239787.300	Zero star
1897	163	3782832622.700	146436117.550	1044202797.200	4973471537.500	Zero star
1896	164	3785400588.000	147690455.840	1047625537.900	4980716581.700	Zero star
1895	165	3787967286.100	148954555.690	1051053098.800	4987974940.600	Zero star
1894	166	3790532716.600	150228445.380	1054485476.800	4995246638.800	Zero star
1893	167	3793096879.000	151512152.830	1057922668.700	5002531700.500	Zero star
1892	168	3795659772.700	152805701.610	1061364659.100	5009830133.400	Zero star
1891	169	3798221397.300	154109140.010	1064811468.800	5017142006.100	Zero star
1890	170	3800781752.300	155422508.470	1068263082.500	5024467343.300	Zero star
1889	171	3803340837.400	156745873.860	1071719497.100	5031806208.400	Zero star
1888	172	3805898651.800	158079329.560	1075180709.100	5039158690.500	Zero star
1887	173	3808455195.200	159422999.820	1078646715.500	5046524910.500	Zero star
1886	174	3811010466.900	160777020.590	1082117504.300	5053904991.800	Zero star
1885	175	3813564467.200	162141442.180	1085593089.400	5061298998.800	Zero star
1884	176	3816117195.900	163516269.550	1089073458.900	5068706924.400	Zero star
1883	177	3818668652.600	164901537.370	1092558609.800	5076128799.800	Zero star
1882	178	3821218837.600	166297301.180	1096048538.600	5083564677.400	Zero star
1881	179	3823767750.400	167703548.880	1099543242.200	5091014541.500	Zero star
1880	180	3826315391.000	169120321.170	1103042716.300	5098478428.500	Zero star
1879	181	3828861759.900	170547630.550	1106546959.400	5105956349.900	Zero star
1878	182	3831406855.700	171985475.840	1110055967.800	5113448299.300	Zero star
1877	183	3833950678.900	173433914.360	1113569738.300	5120954331.600	Zero star
1876	184	3836493229.300	174892985.970	1117088267.800	5128474483.100	Zero star
1875	185	3839034506.700	176362562.290	1120611545.000	5136008614.000	Zero star
1874	186	3841574511.000	177842498.020	1124139582.400	5143556591.400	Zero star
1873	187	3844113242.300	179332694.770	1127672371.000	5151118308.100	Zero star
1872	188	3846650700.100	180833065.050	1131209906.400	5158693671.600	Zero star
1871	189	3849186884.500	182343549.730	1134752185.700	5166282619.900	Zero star
1870	190	3851721795.300	183864104.850	1138299205.800	5173885106.000	Zero star
1869	191	3854255432.400	185394677.960	1141850963.800	5181501074.200	Zero star
1868	192	3856787795.600	186935198.940	1145407456.500	5189130451.000	Zero star
1867	193	3859318884.800	188485603.250	1148968680.900	5196773169.000	Zero star
1866	194	3861848699.700	190045805.280	1152534634.000	5204429139.000	Zero star
1865	195	3864377240.600	191615702.530	1156105314.900	5212098258.000	Zero star
1864	196	3866904511.700	193195191.600	1159680715.900	5219780419.200	Zero star
1863	197	3869430504.100	194784163.610	1163260835.800	5227475503.500	Zero star

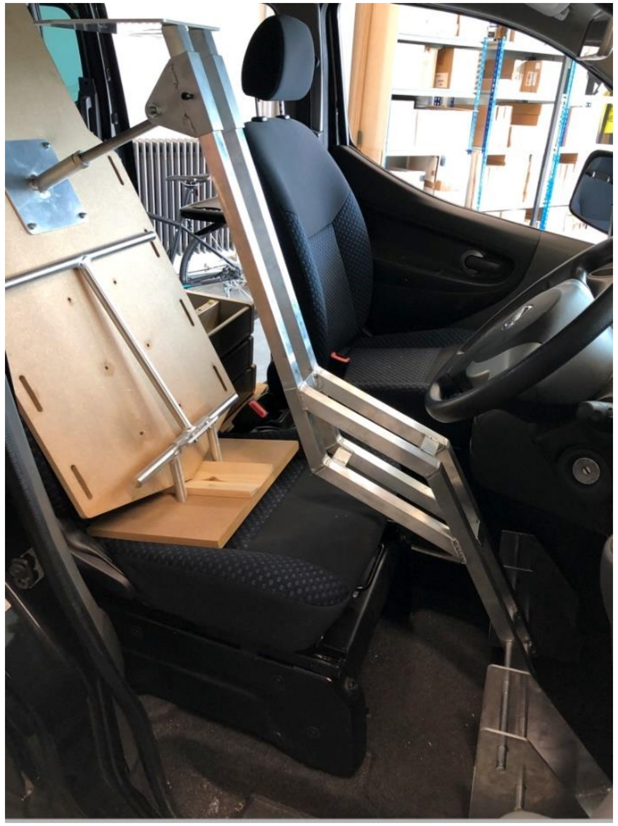
Next steps

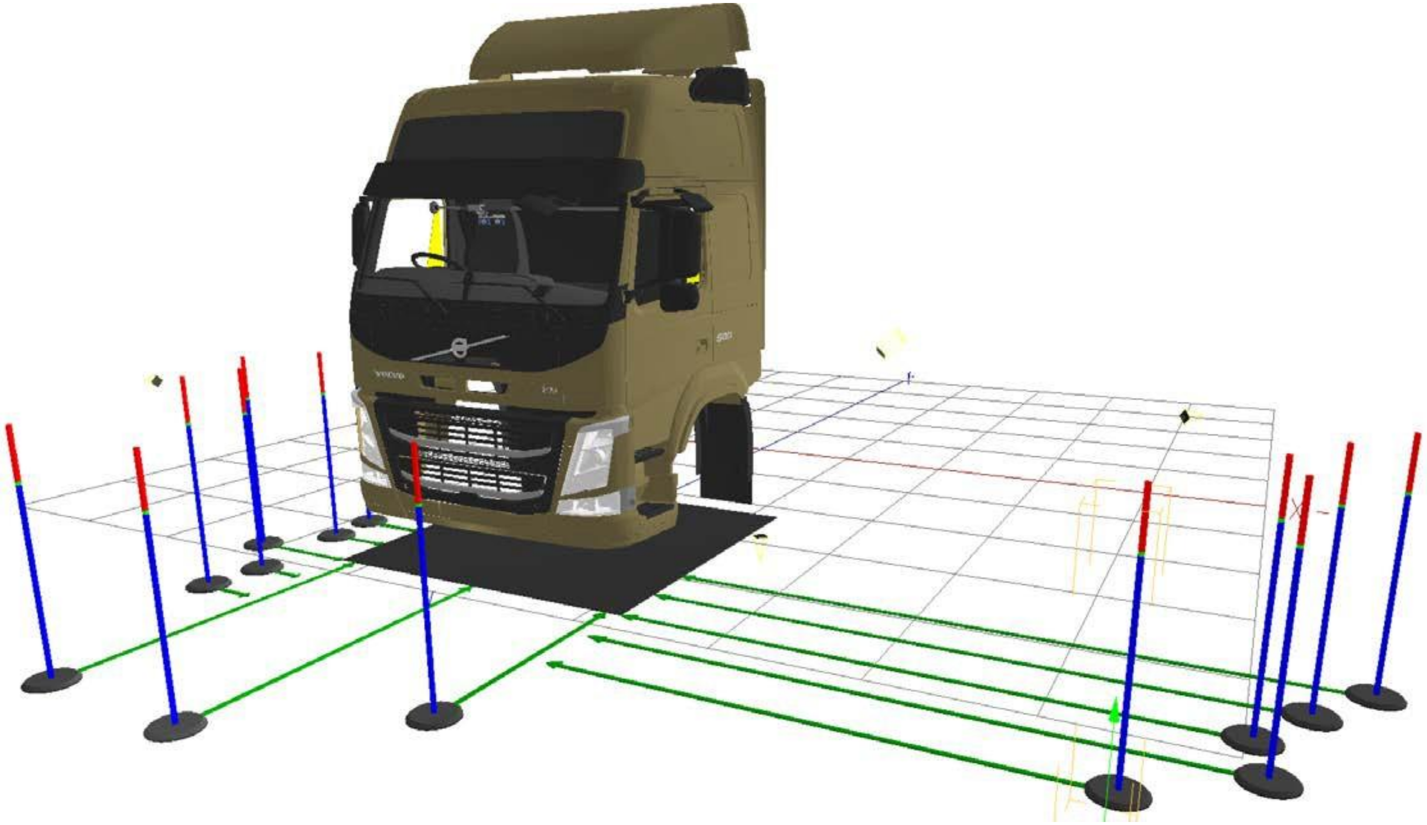
- To validate the results from the physical test against the digital (June 2019) in a lab based experiment
- To then test the rig in a truck cab (July 2019)
- To demonstrate the test method to end users
  - The testing of a vehicle in the real world, when compared to CAD data testing, could result in differences in the volumetric score
  - The size of these differences will be determined in part by the manner in which the variables discussed above are controlled in terms of rig placement and fluid levels in the vehicle, for example
  - It is highly unlikely that the physical test will provide the exact same results as the virtual test.
  - If the 1 star boundary is adopted by the EU as a minimum requirement, it may be that a real word test vehicle must reach a 1.5, or 2 star performance to be allowed to operate
  - The size of this tolerance will be determined by testing of the technique with a sample of vehicles

Next steps

– We are still considering the potential for a more basic system which would use the same camera rig, but use more traditional visual markers

– As discussed in the last meeting, this technique looses many of the efficiency advantages of the approach currently being explored.





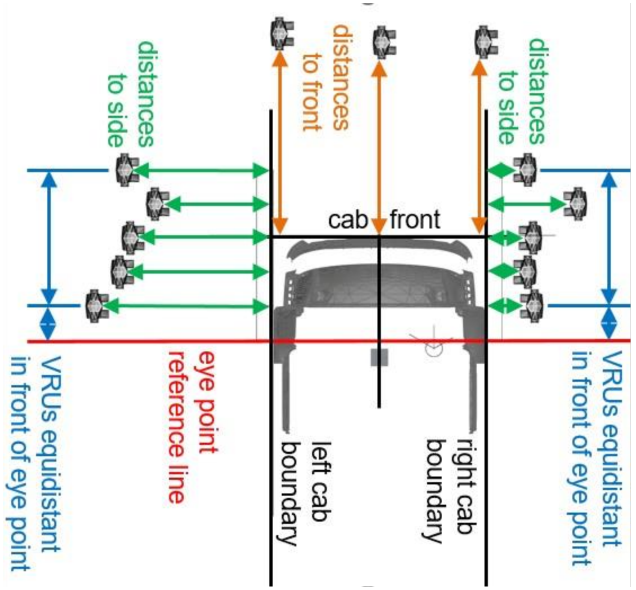
LDS recommendations for DVS limits to Category N3 and N2 vehicles

What do the star rating mean in real terms?

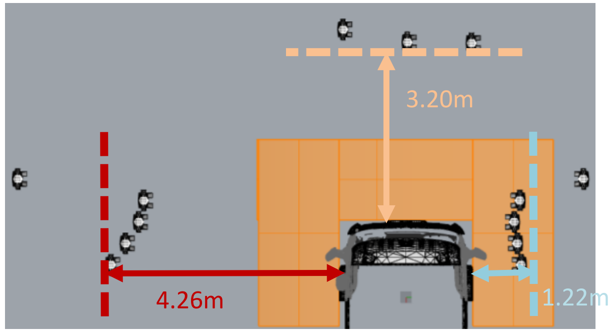
- A 1 star rating means that that average VRU distance for an array of 5 VRU simulations can be seen by the driver (head and shoulders) at a distance less than 4.5m, to the front at a distance of 2m (3 VRUs) and to the right at a distance of 0.6m (5 VRUs)

- This basically means that the VRUs should be within the area covered by the mirrors. The VRU chosen was a 5th%ile Italian Female on the premise that over 99% of Europeans are taller

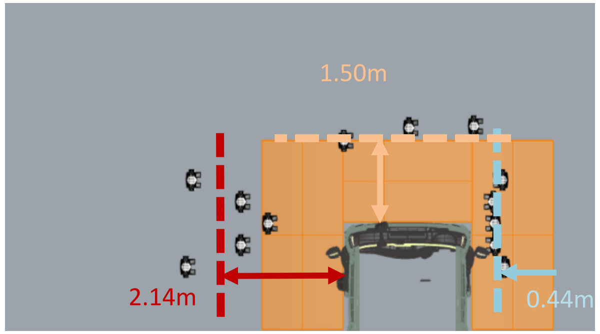
- If a vehicle if zero star it fails this test and so VRUs can be hidden from both direct vision and indirect vision
  - Therefore a Zero star vehicle has blind spots



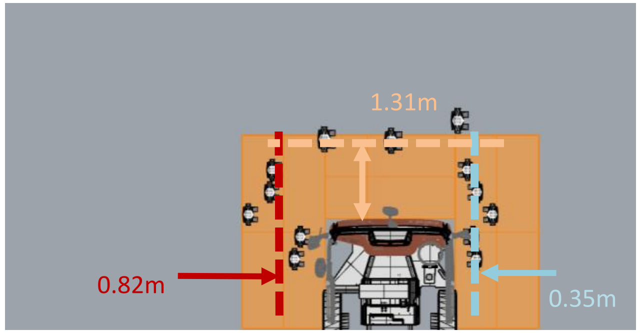
Zero * Poor
Mercedes 2.3m cab (H)



3* Good
Volvo FE LEC



5* Excellent
Mercedes Econic

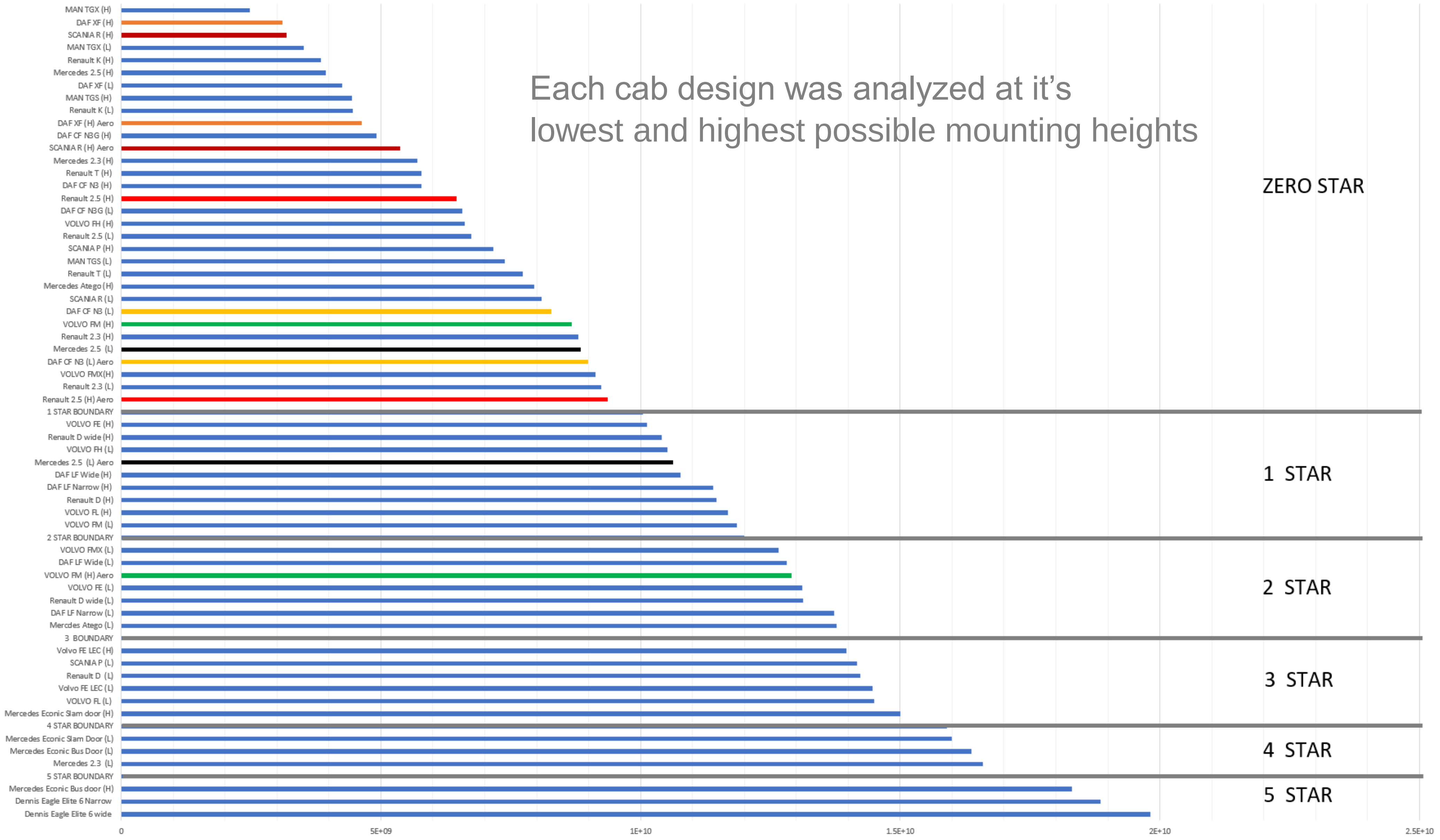


Images show average distances VRUs can be seen to each side of the cab

How does the sample perform?

Show the volumetric and star rating scores for each cab design at its highest and lowest possible mounting heights

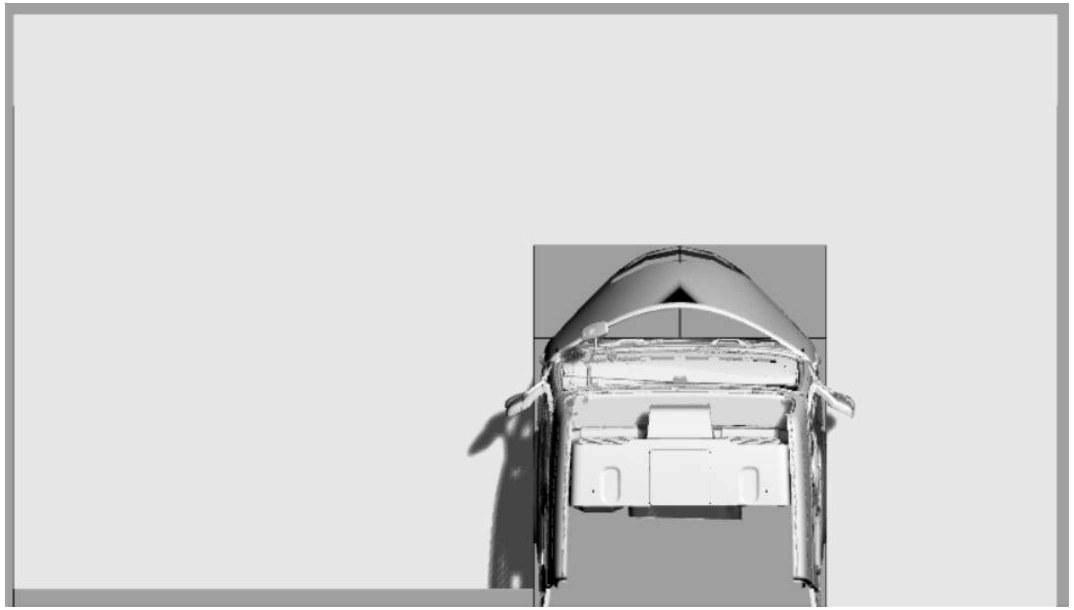
The coloured bars show the potential improvement of zero star vehilces by adding an Aerodynamic front

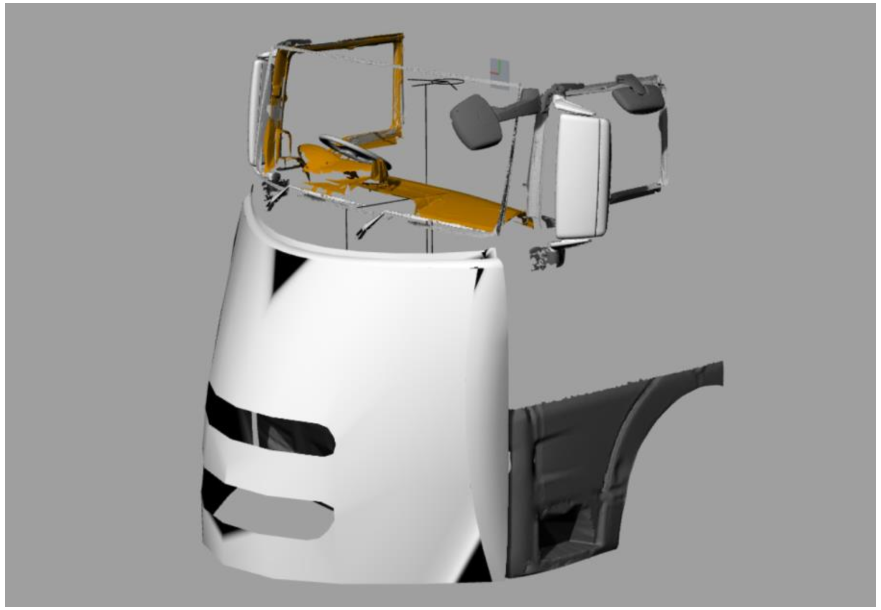


Analysis of the benefits of Aerodynamic front ends to improve DVS scores

How can the star ratings be improved

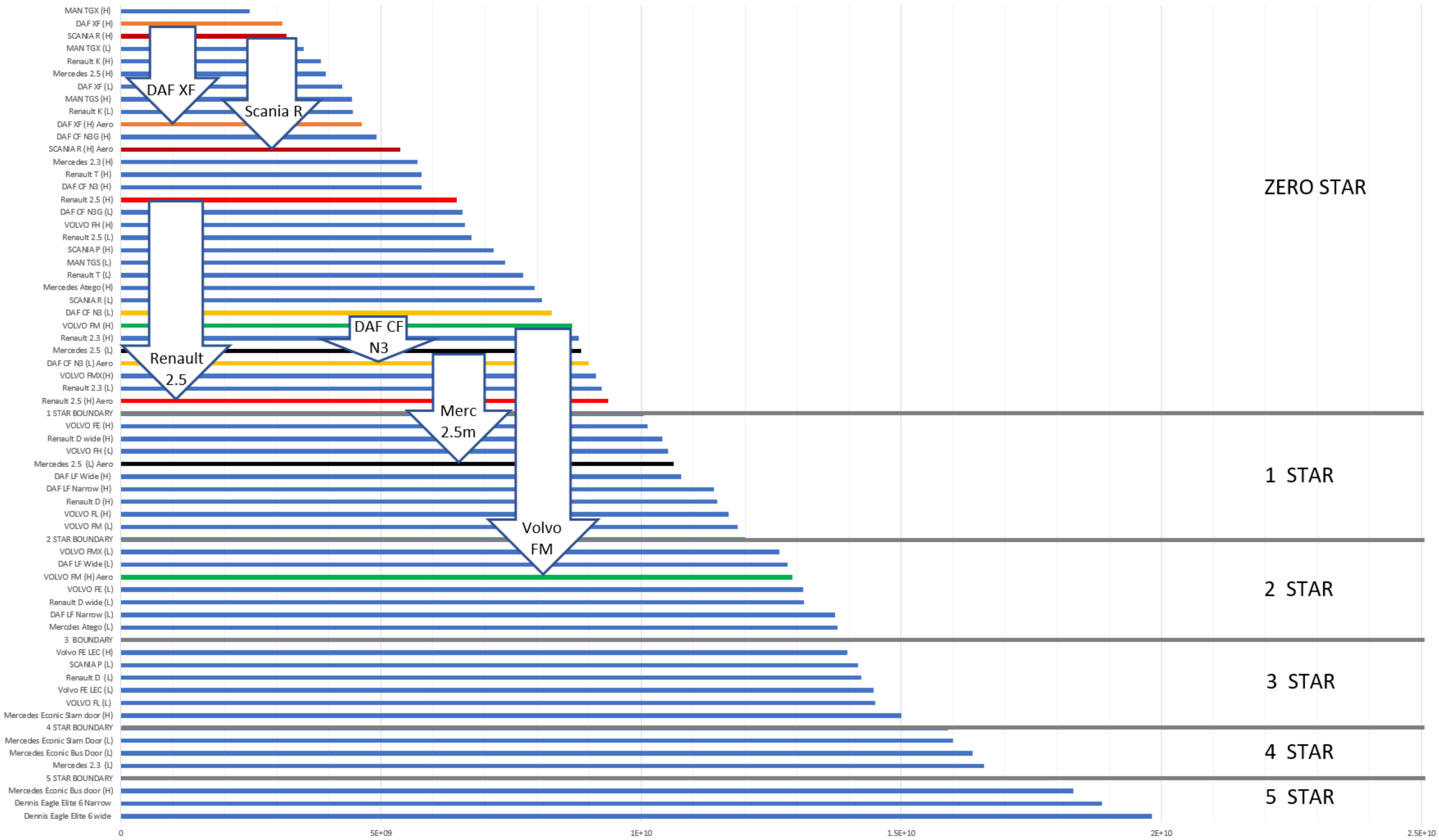
- The results indicate that the design of some vehicles needs to improve significantly to enable even the 1 star threshold to be met
- There are examples of vehicles with high cabs which still perform well in the DVS due to their superior design with respect to DV
- However the potential of addition of Aerodynamic front ends to truck cab is an opportunity to improve DVS scores
- In order to explore the benefit 6 zero star have been assessed with the addition of a **800mm Aerodynamic feature***
  - DAF XF
  - DAF CF
  - Mercedes 2.5m cab width
  - Volvo FM
  - SCANIA R (2015)
  - Renault C 2.5





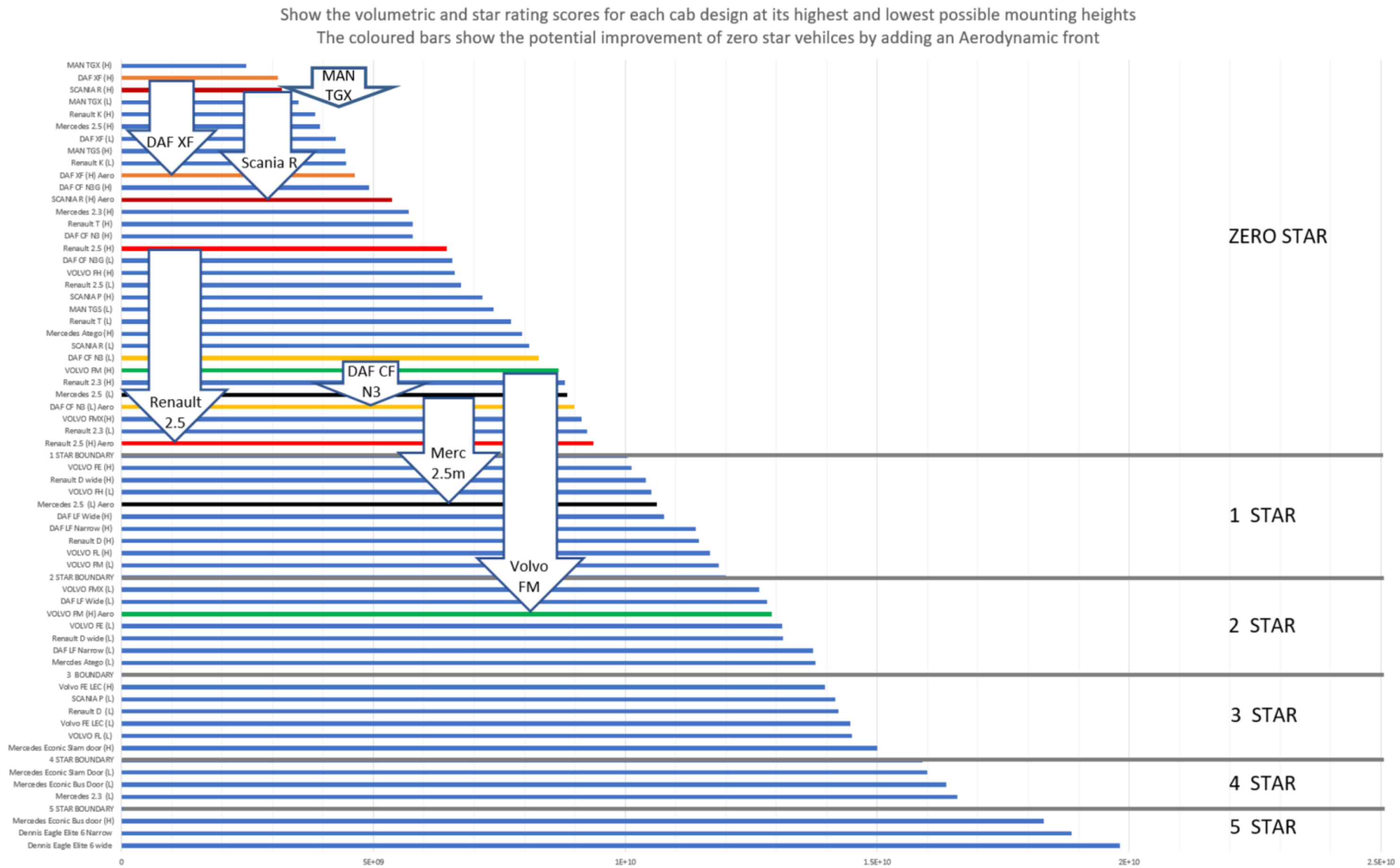
*Please Note. This analysis did not use manufacturers data. The assessment volume was simply modified to reflect an additional 800mm to the front of the vehicle

Show the volumetric and star rating scores for each cab design at its highest and lowest possible mounting heights
The coloured bars show the potential improvement of zero star vehilces by adding an Aerodynamic front



How can the star ratings be improved

- Of the 7 vehicles tested 2 achieved an improvement from a Zero star rating to a 1 or 2 star rating
  - Mercedes 2.5m cab width and Volvo FM
- Two vehicles were close to achieving a 1 star rating
  - DAF CF and Renault C 2.5
- Three vehicles would require considerable improvements to achieve 1 star



LDS recommendations for DVS limits to Category N3 and N2 vehicles

LDS recommendation

- Defining a TfL DVS rating limit for Category N2 and N3 should in our view be based upon the evidence of the LDS analysis of truck design performed in the definition of the DVS

- It is clear that the highest Volvo FM can achieve a 2 star rating with an Aerodynamic front end.

- **Therefore the recommendation for Category N3 is TfL DVS 2 star**

- It is clear that multiple vehicle cabs which can be Category N2 can achieve TfL DVS 3 star or better e.g. Mercedes 2.3m cab width can achieve 4 star

- **Therefore the recommendation for Category N2 is TfL DVS 4.5 star**

Mercedes 2.3m cab width can achieve 4 star at minimum cab height

Project information

Thank you for your attention, are there any questions?

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