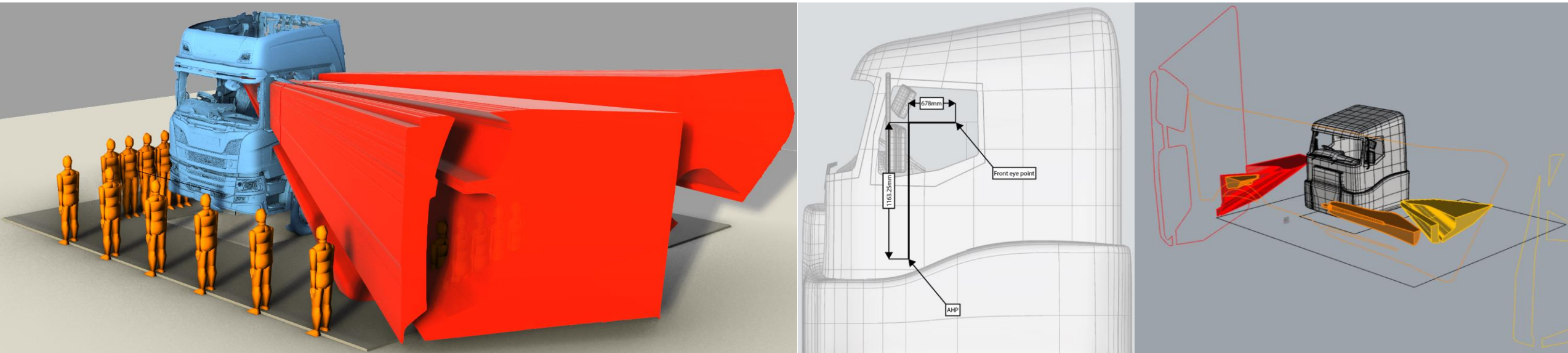


The potential application of the TfL Direct Vision Standard in UNECE regulation – The LDS and TfL position

Loughborough University Design School (LDS): Design Ergonomics Research Group
Research Sponsored by Transport for London

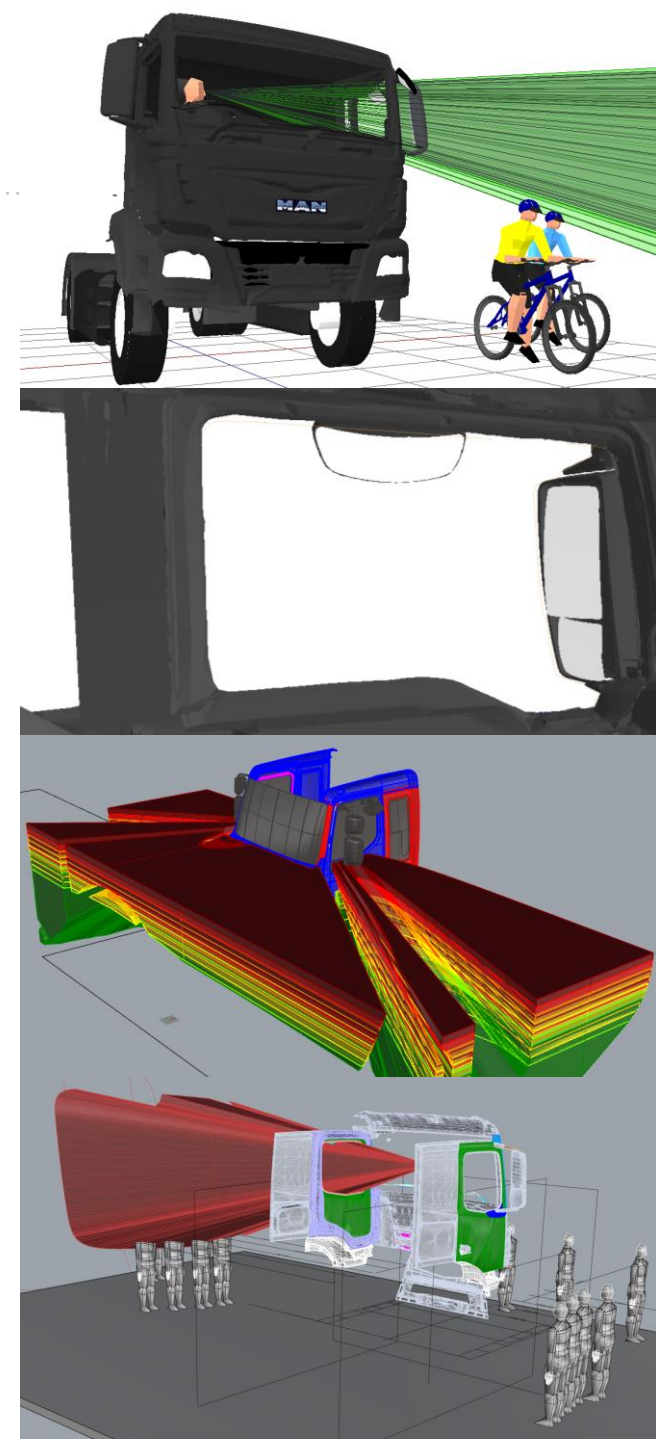
Dr. Steve Summerskill – Senior Lecturer in Industrial design and ergonomics

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



Contents

- Main points to be covered at the Osaka meeting
 - Our position on the application of the TfL DVS at the European level
 - Our response to the ACEA VRU DVS proposal
 - The reduction of the visibility requirements to the head only
 - Further work on the physical test to compliment the digital DVS
 - Response to ACEA/OICA points in this meeting
 - Summary



UNECE VRU Proxy meetings – our position

Our position has been consistent throughout the UNECE VRU Proxy meetings that have been attended by TfL and LDS members

1. The TfL Volumetric assessment is an accurate method that all manufacturers are currently applying, with results being validated with the LDS version of the test. Manufacturers are using the test now
2. It assesses direct vision to the **'Area of Greatest Risk'** which has been defined by an accident data analysis and testing has shown that the area of greatest risk is currently only visible through indirect vision in many trucks.
3. It is our position that assuming that a driver can effectively use **six mirrors** and a minimum of **three windows** to maintain situational awareness is in many scenarios likely to be not possible, which is again borne out by the accident data which showed the causation factor **"Blind spot"** or **"did not look"** as being the most common in accidents between VRUs and trucks. (See previous meeting presentations for details).

UNECE VRU Proxy meetings – our position

Our position has been consistent throughout the UNECE VRU Proxy meetings that have been attended by TfL and LDS members

4. The work of Richard Wilkie (Leeds University) highlighted the issues with indirect vision in comparison to direct vision which included the following findings;
 1. The perception from pedestrians, cyclists and drivers, that **making eye contact** with a VRU/Driver is important, therefore the driver should be able to see the head of the VRU
 2. That reaction time for indirect vision is 0.7seconds higher when compared to direct vision (truck would travel 4.7m at 15 MPH in that time)
 3. <http://content.tfl.gov.uk/road-safety-benefits-of-direct-vs-indirect-vision-in-hgv-cabs-technical.pdf>
5. The combination of the accident data analysis and the work of Richard Wilkie highlights that direct vision is an important factor in reducing accidents between VRUs and trucks, and the **EU parliament has voted in agreement with this position**
6. We have therefore made the **assumption that the head is the minimum requirement** for identification based upon interactions with Psychologists in the context of recognising a human

UNECE VRU Proxy meetings – our position

EU legal text requirement

Vehicles of categories M2, M3, N2 and N3 shall be designed and constructed 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 of and to the side of the driver**, while taking into account the specificities of different categories of vehicles.

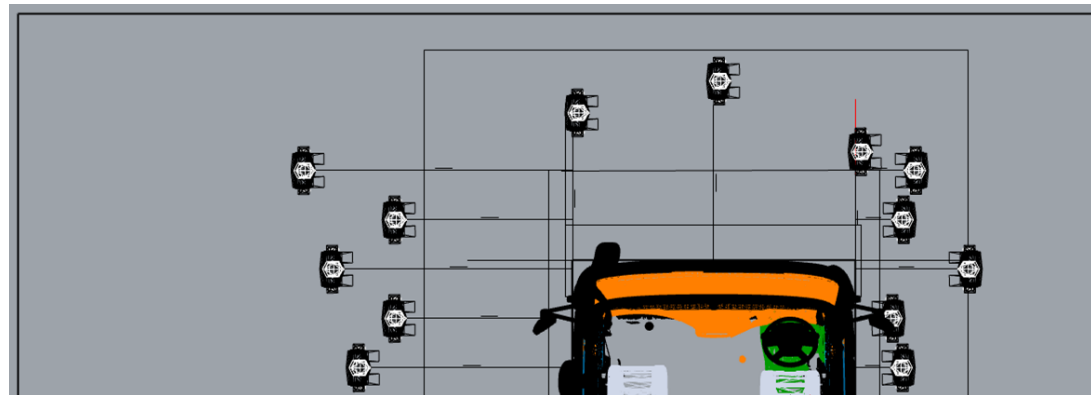
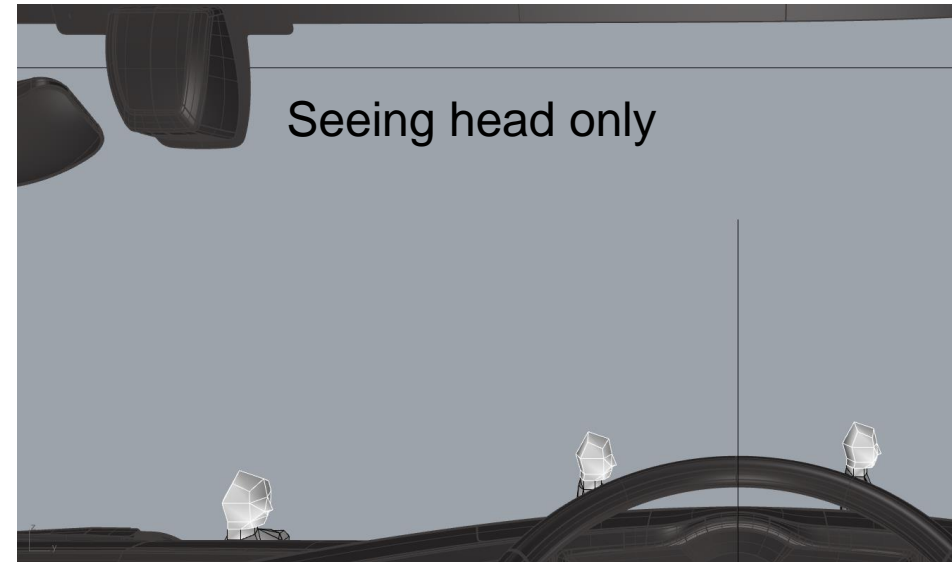
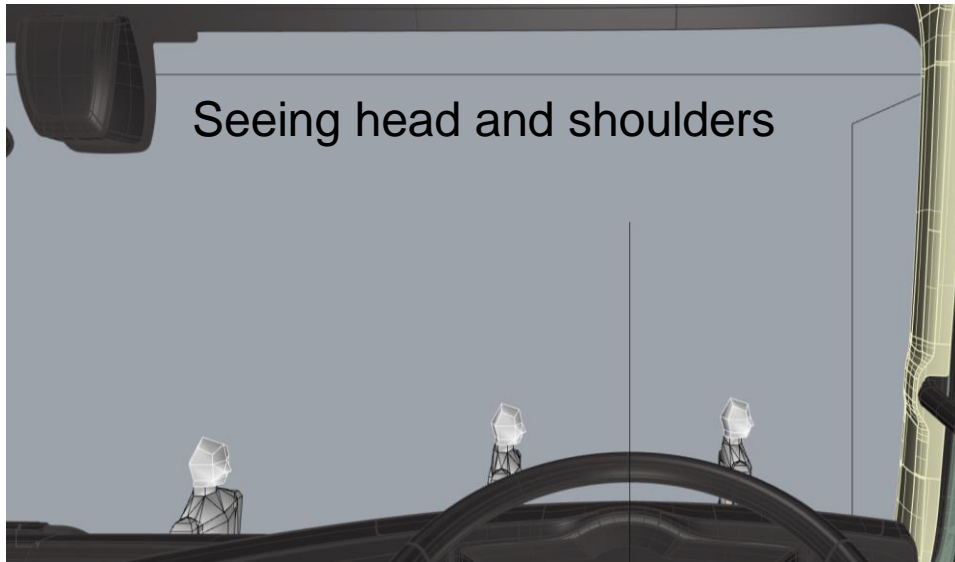
Our response to the ACEA VRU DVS proposal on the 16th of January 2020

- Adopting a VRU simulation with a stature of 1600mm is not valid because it automatically excludes anyone shorter than this, which would be difficult to justify to the lay person i.e.
 - 28% of UK female adults
 - 44% of French female adults
 - 38% of German female adults
 - 45% of Italian females adults
- Using an assessment method which only assesses performance at the edge of the mirror coverage area is poor in that this does not improve vision inside the **“area of greatest risk”** that is defined by the TfL project accident data analysis.
- The TfL approach defines a **scale of performance** in terms of star ratings that measure the ability to see the “area of greatest risk” and allows a progressive standard to be defined with improved performance limits over time, it is questionable that this is possible with the ACEA method
- It is not acceptable in our view to allow **any part** of the VRU simulation to be seen to allow detection. There is no scientific data available to support this assumption. The work of Richard Wilkie supports our definition of the requirement to see the head.

Reducing the minimum part of the human that must be visible

Only used to establish the minimum safety requirement (minimum star rating)

- As agreed at the ACEA meeting in January we have explored the reduction of the size of the visible portion of the VRU rigs to define the minimum acceptable limit



Reducing the minimum part of the human that must be visible

Only used to establish the minimum safety requirement (minimum star rating)

- This has been done for all vehicles within a star boundary of the previous 1 star boundary and includes a sample of 27 vehicles
- We have then used the same process as described in the TfL DVS definition project report to identify the vehicle which just passes the test to all sides. See slides below.
- This vehicle has the potential to become an option for the new performance limit
- This new limit has a volumetric score which is **ALMOST EXACTLY 1 DVS** star boundary below the old 1 star rating

Visible volume requirements for each star boundary in the TfL DVS (mm^3) therefore 1 boundary width is **1954525605 mm^3**

1 star	10041212265.90
2 star	11995737871.28
3 star	13950263476.66
4 star	15904789082.04
5 star	17859314687.42

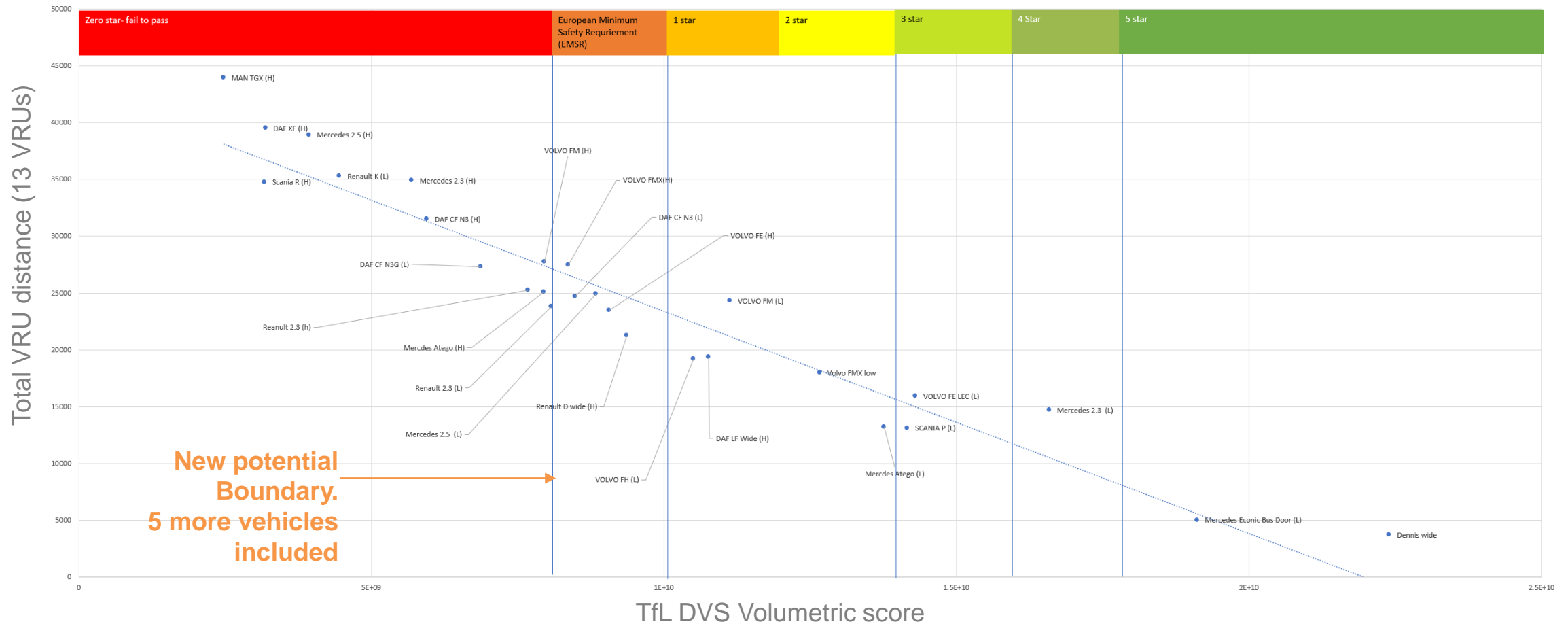
Volumetric score for the new vehicle defined by HEAD only visibility of the VRU is 8080080371 mm^3 which is **1961131894 mm^3** below the original 1star TfL DVS boundary.

This is 100.33% of the DVS star boundary value. **This is a moment of serendipity!**

Therefore, we propose that the EMSR is added to the options considered for the minimum requirement as an extra boundary.

Reducing the minimum part of the human that must be visible

Only used to establish the minimum safety requirement (minimum star rating)



- Sample = 27 vehicles
- The new test with Head only correlates well with the volumetric performance for each vehicle with a correlation coefficient of 0.96 where a score of 1 is perfect
- The new test includes 5 vehicles which were previously excluded (if this limit is selected)

Reducing the minimum part of the human that must be visible

Only used to establish the minimum safety requirement (minimum star rating)

- It is therefore our proposal that a new potential boundary for the minimum performance be set at the EMSR level and added to the discussion about the acceptable minimum requirement
- That it should be possible to determine if a vehicle can meet the acceptable minimum requirement defined here using **either** the **TfL DVS digital Volumetric result**, or the **Physical version of the test** that we have defined
- The following slides will show how we have further tested the Physical method with virtual means which has reduced the amount of measures that should be taken to achieve a result

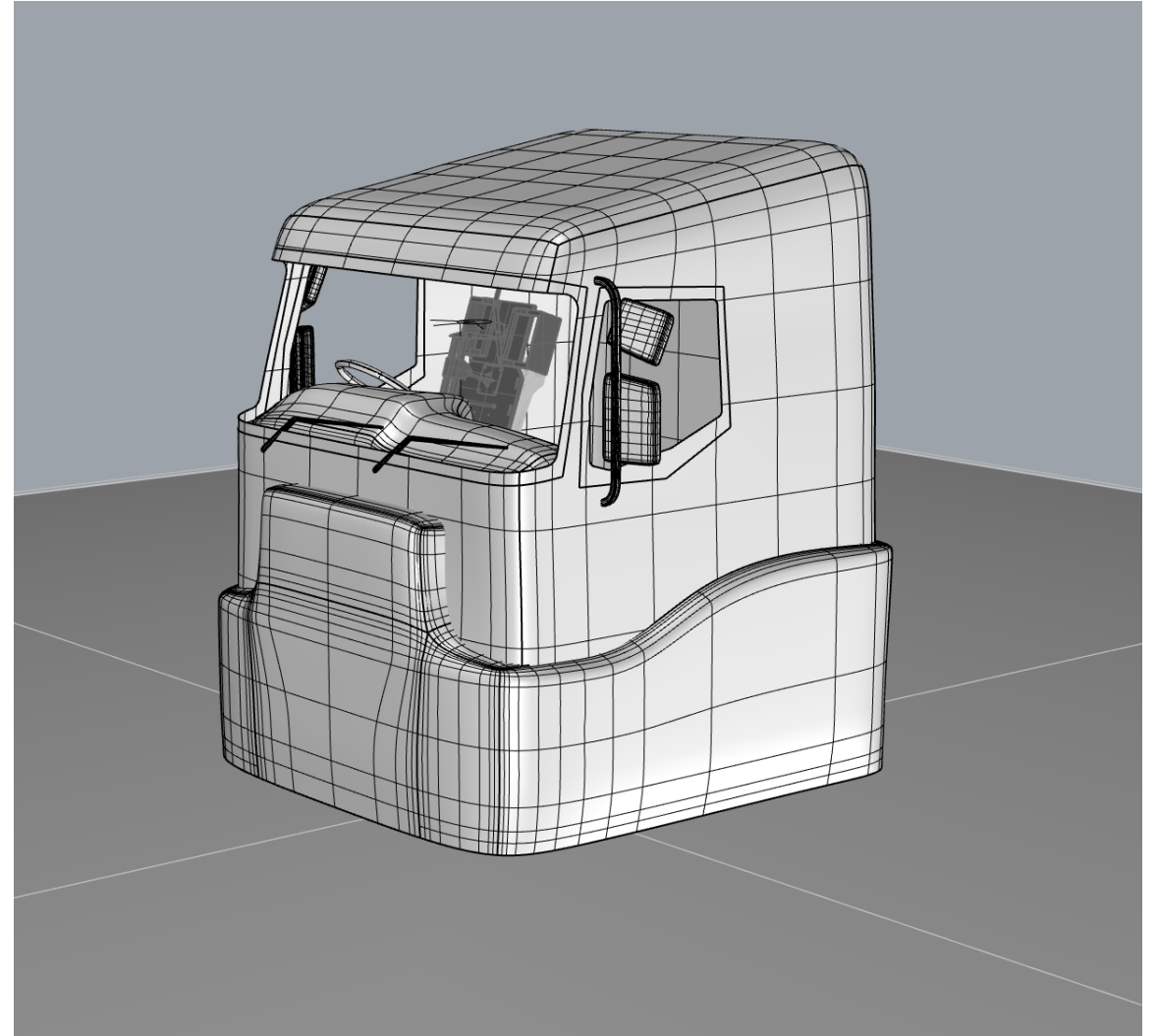
Further work on the physical test to compliment the digital DVS

- Before we start, there has been **a key misunderstanding** of the aims of the Physical DVS test in the ACEA/OICA position
- The aim of the visual target ‘stick’ used in the DVS Physical test is not to recreate the VRU test discussed above
- The aim is to define a test which allows a measurement which relates to the volumetric approach. The aim of the ‘Stick’ is not to represent a human, but to provide a height at which a **SECTION** of the visible volume is measured
- More detail on this below

More detail on the proposed physical test method – Dr Russell Marshall

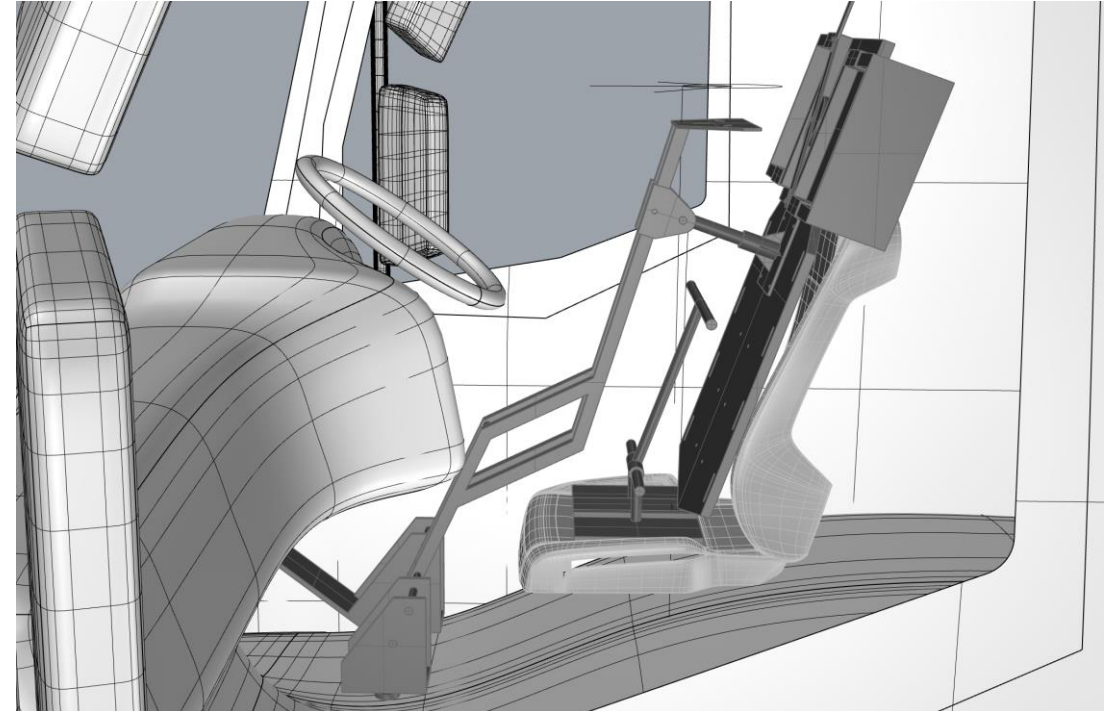
Initial Setup

- Vehicle setup in running order
- Parked on level ground
- Appropriate space around vehicle: 2m to front and driver's side, 4.5m to passenger side

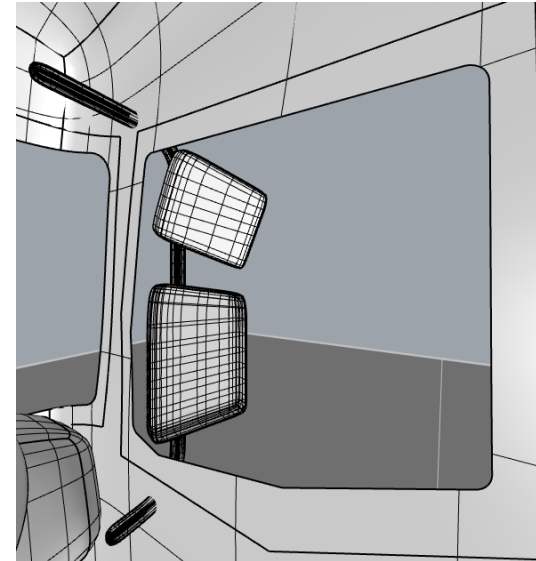
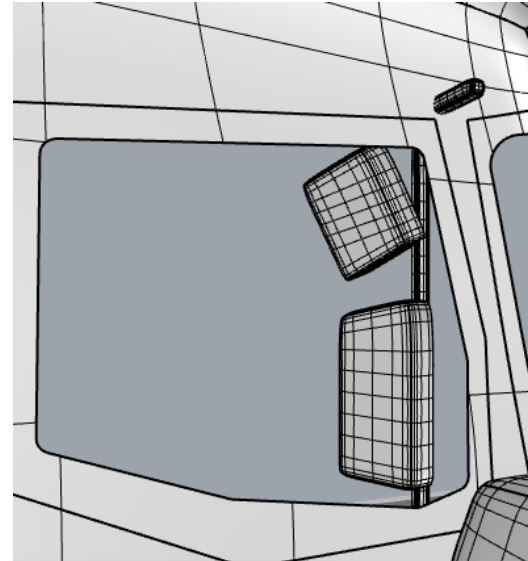
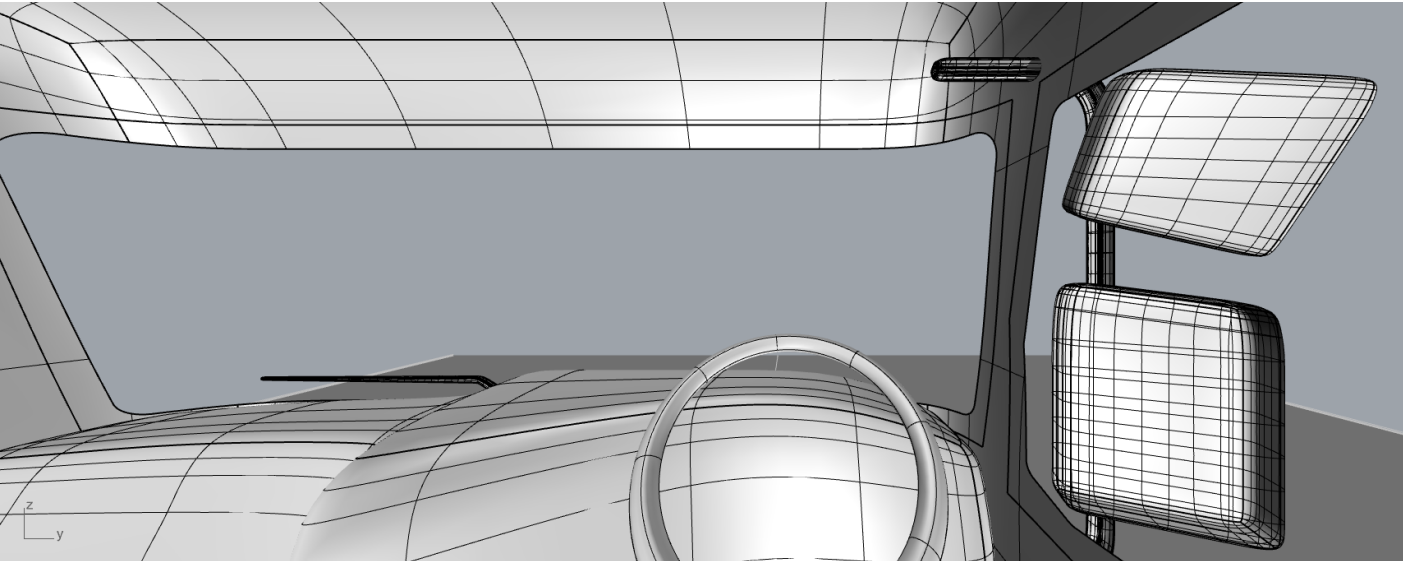


Installation of Physical Eye Rig (PER)

- PER installed into seat and seat adjusted to level PER
- Camera rig installed onto PER
- Three cameras mounted at three eye points
- Wi-fi enabled cameras provide remote view

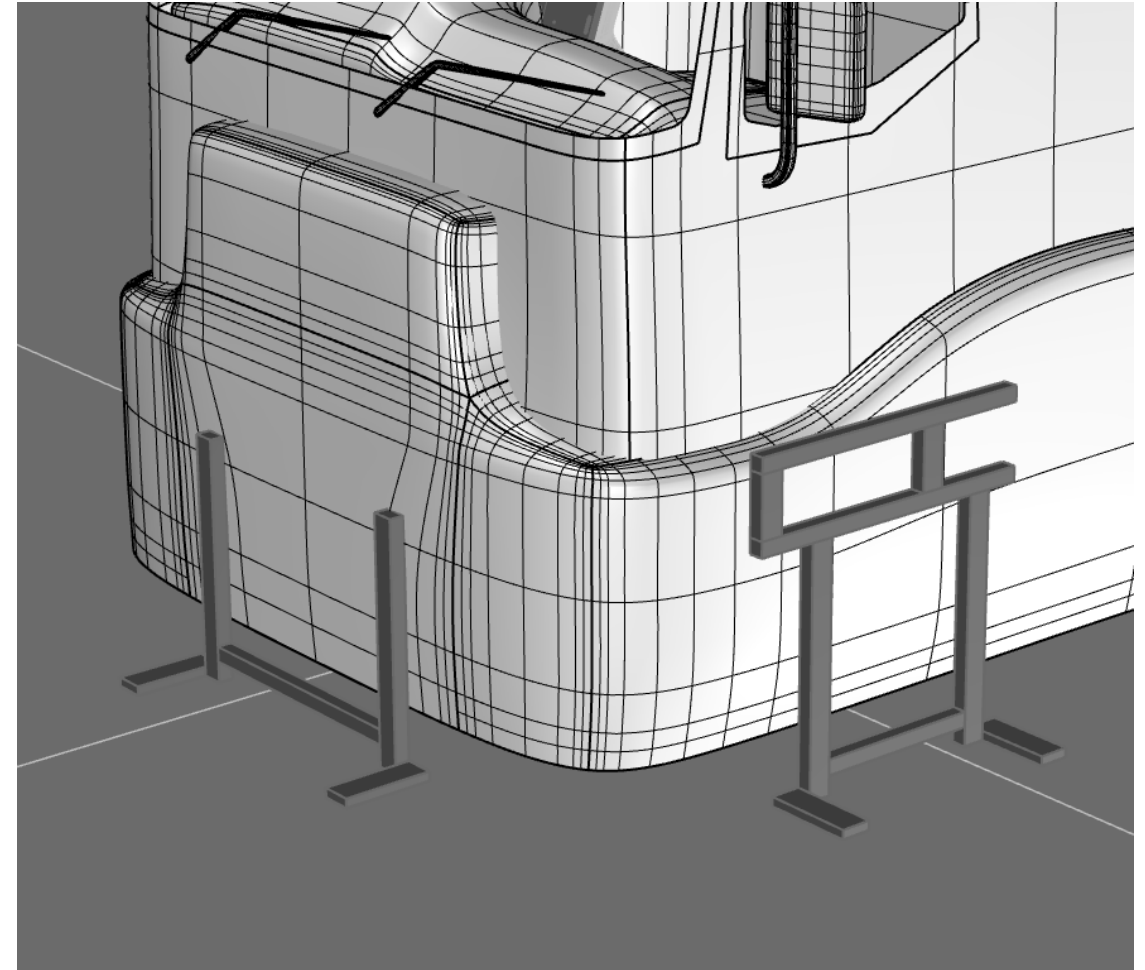


Installation of Physical Eye Rig (PER)



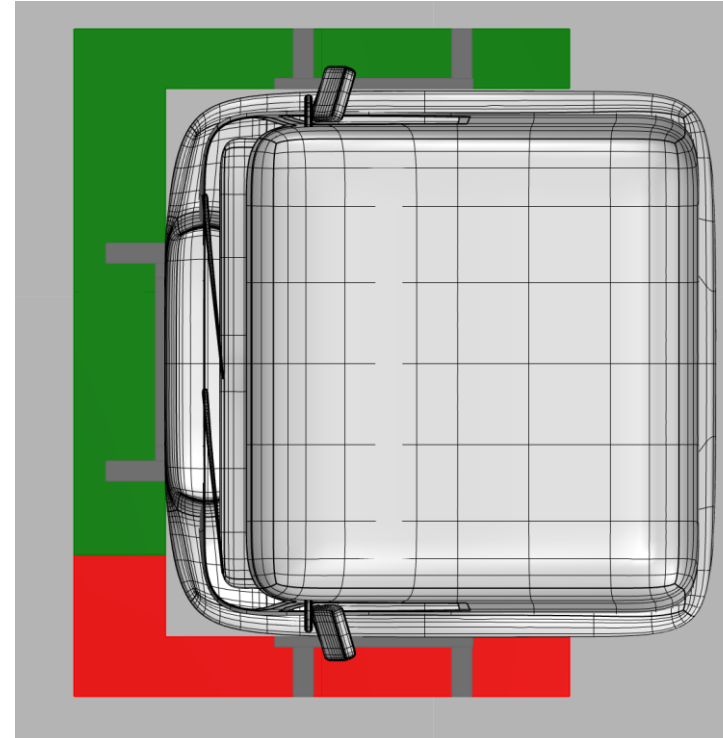
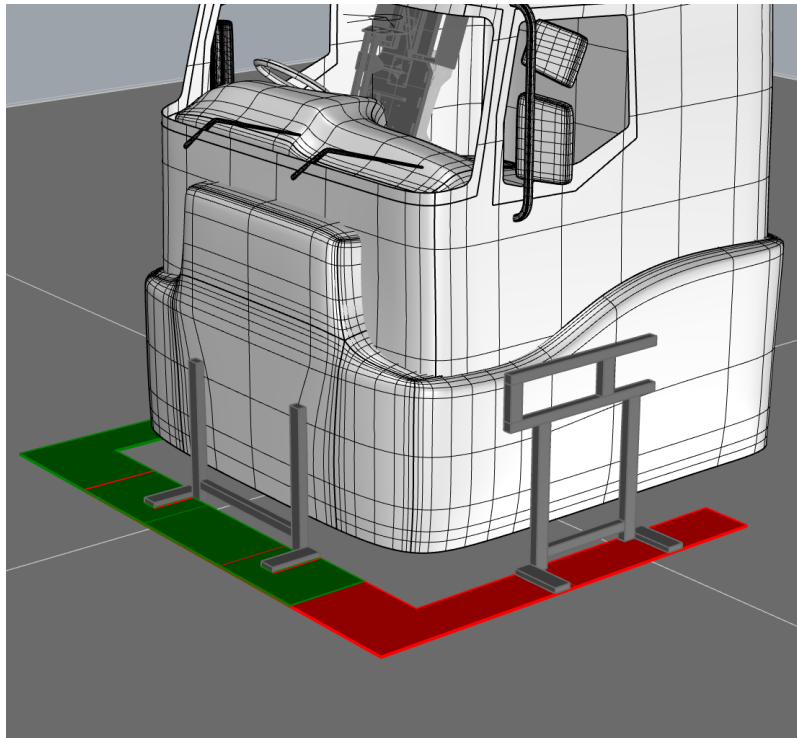
Vehicle Extents Rigs (VER)

- Specifically designed rigs used to determine front, left and right limits of the vehicle



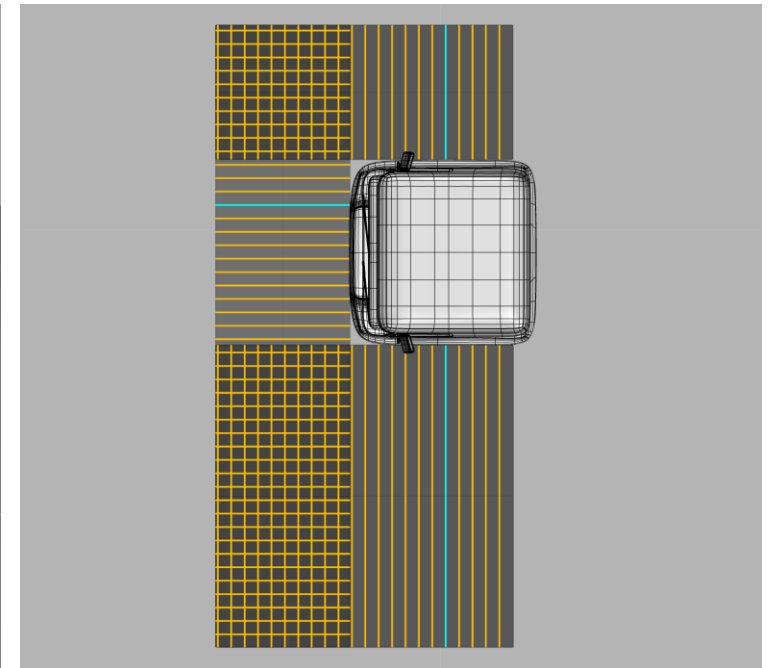
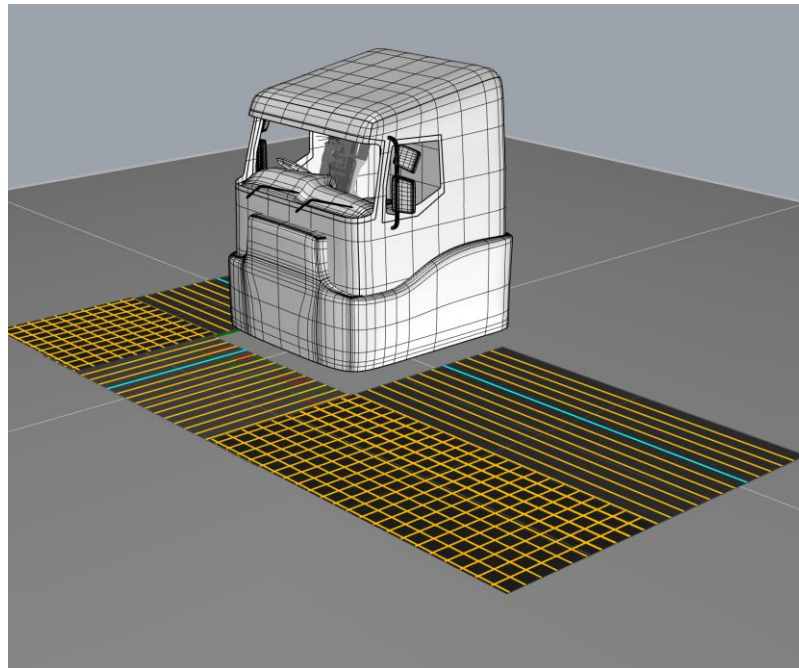
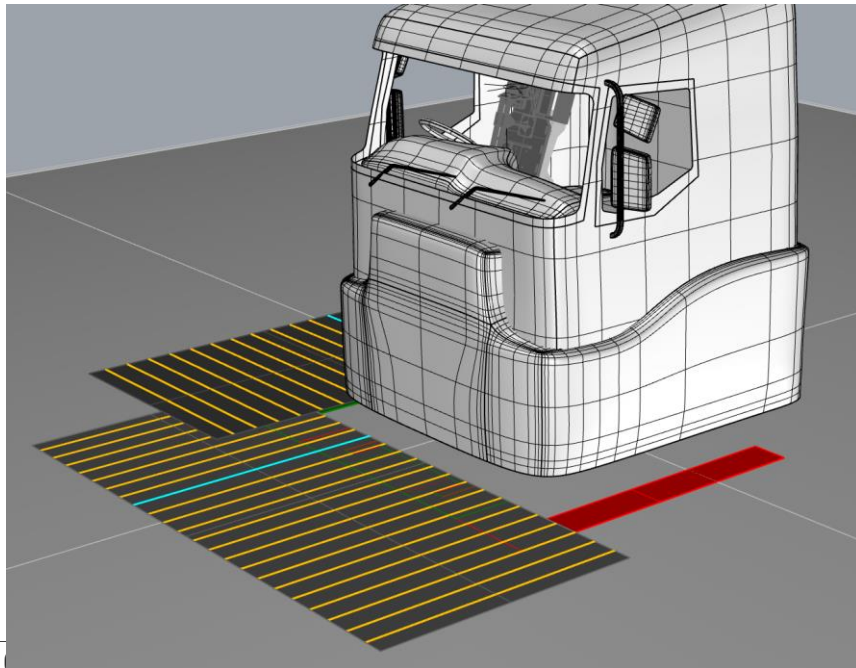
Vehicle Extents Mats (VEM)

- VEMs aligned to VERs and used to create correctly aligned and square exclusion zone for the vehicle
- Also provides a template for the Assessment Area Mats



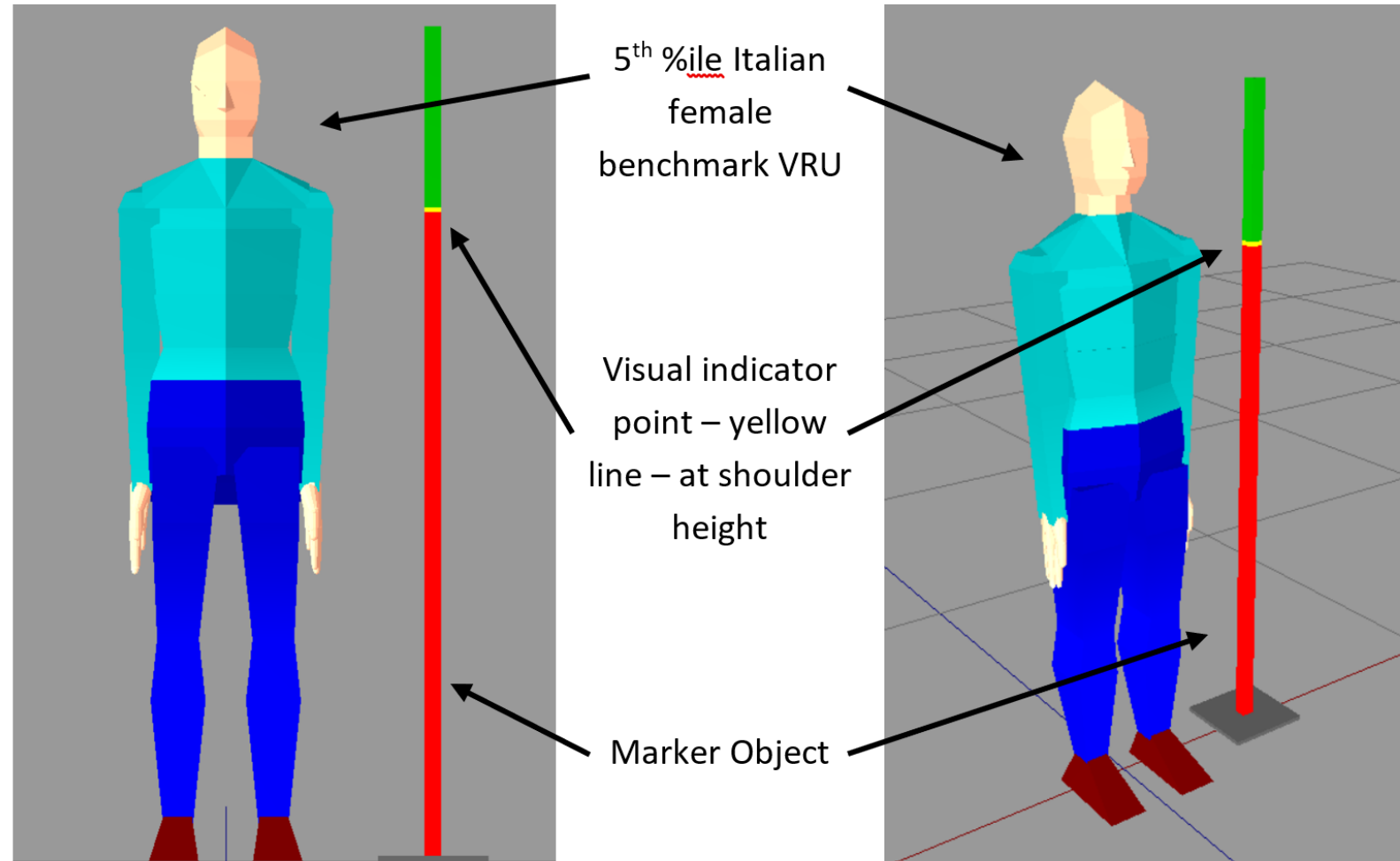
Assessment Area Mats (AAM)

- Assessment area mats installed and aligned to VEMs
- Each AAM marked with assessment lines at 200mm (possibly 300mm) spacing – this will be evaluated at the upcoming testing



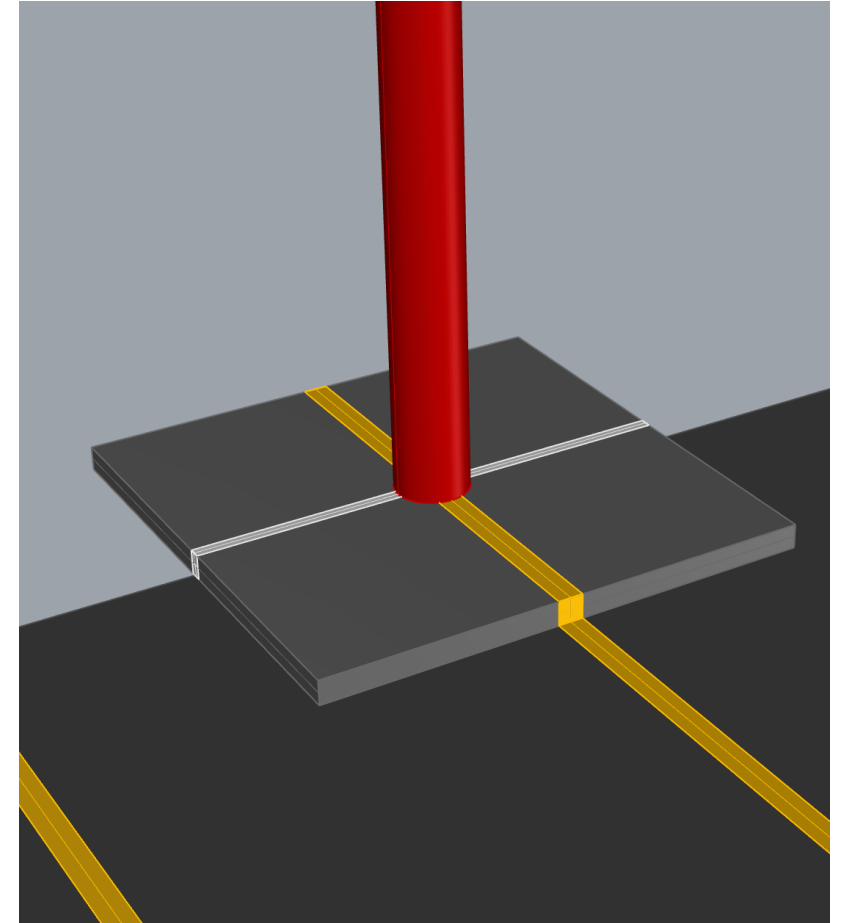
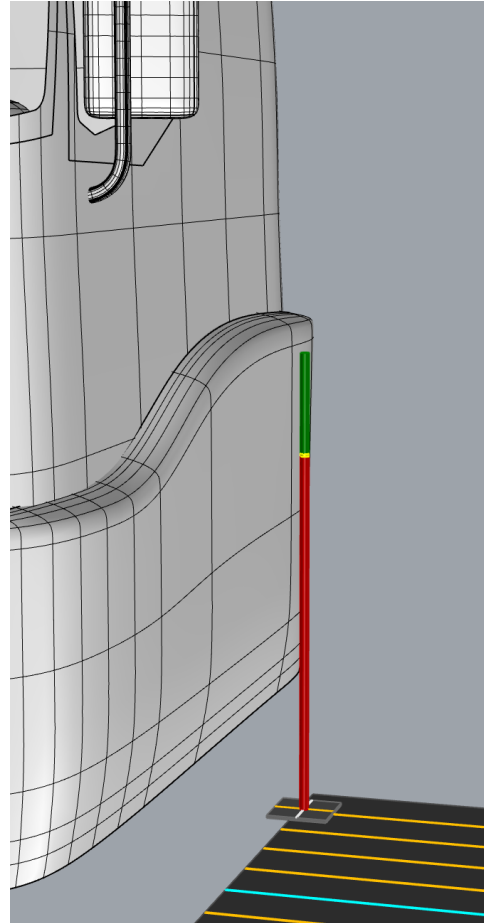
Marker Object (MO)

- Marker object designed to indicate the target height: e.g. shoulder (or head) of 5th %ile Italian female

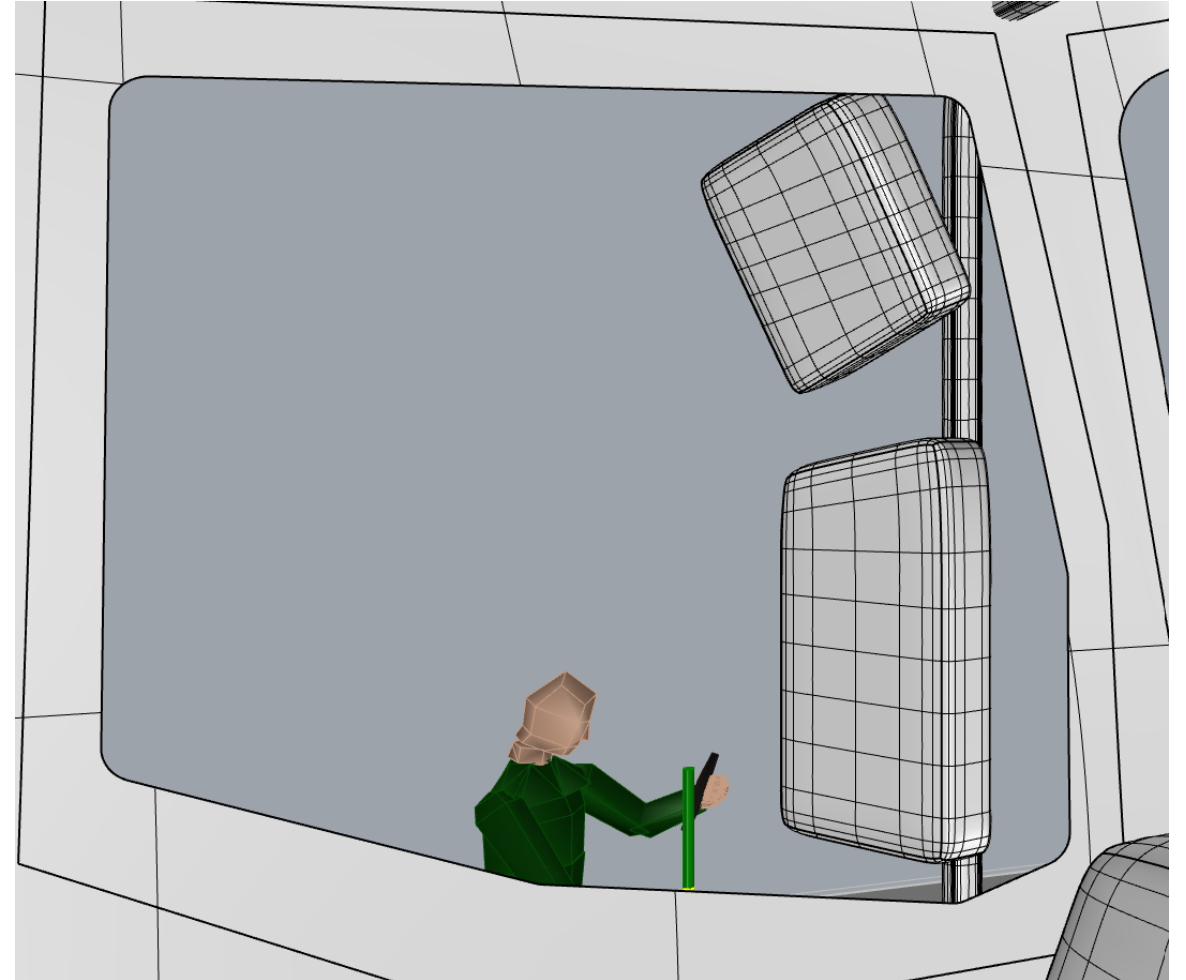
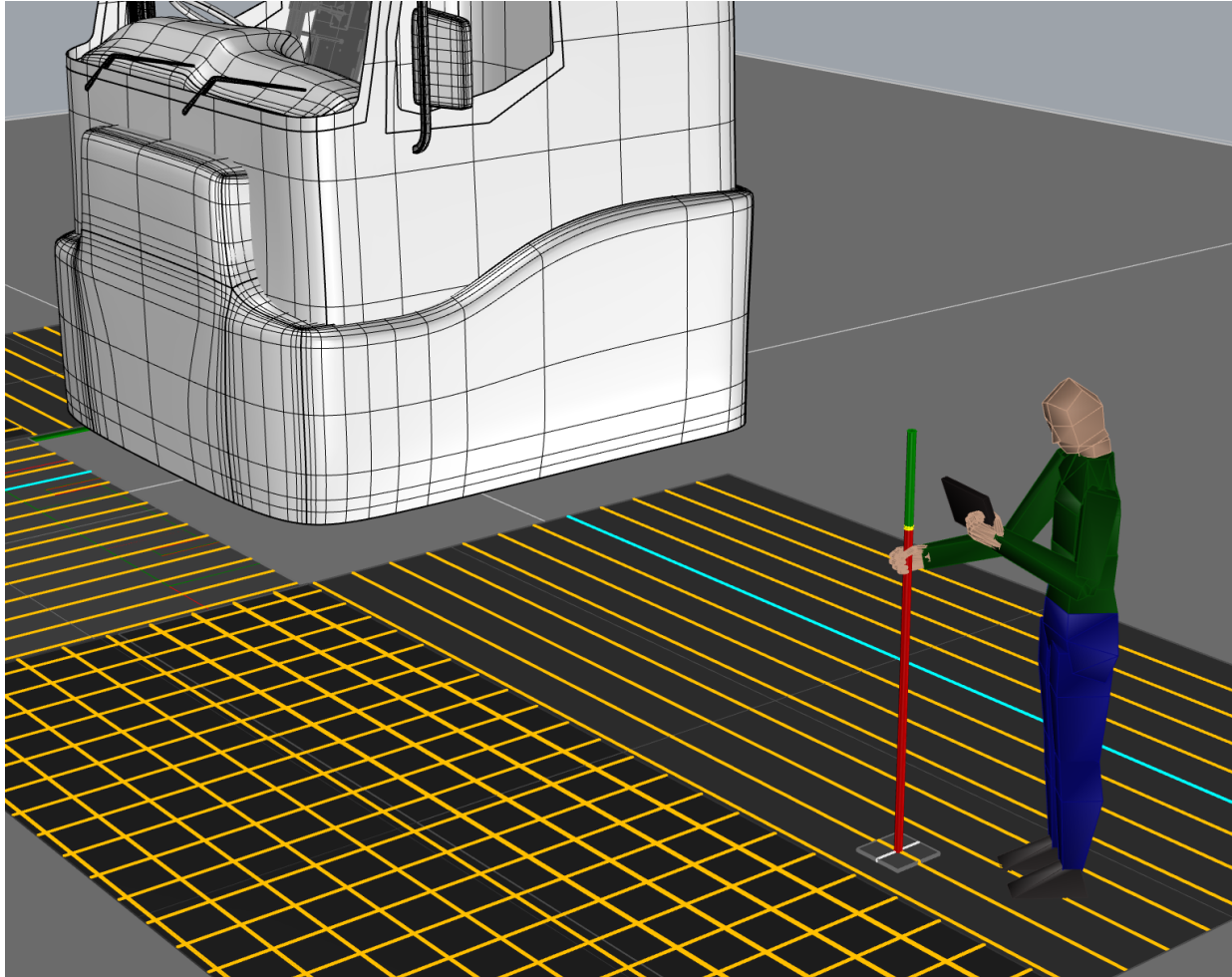


Evaluation Procedure

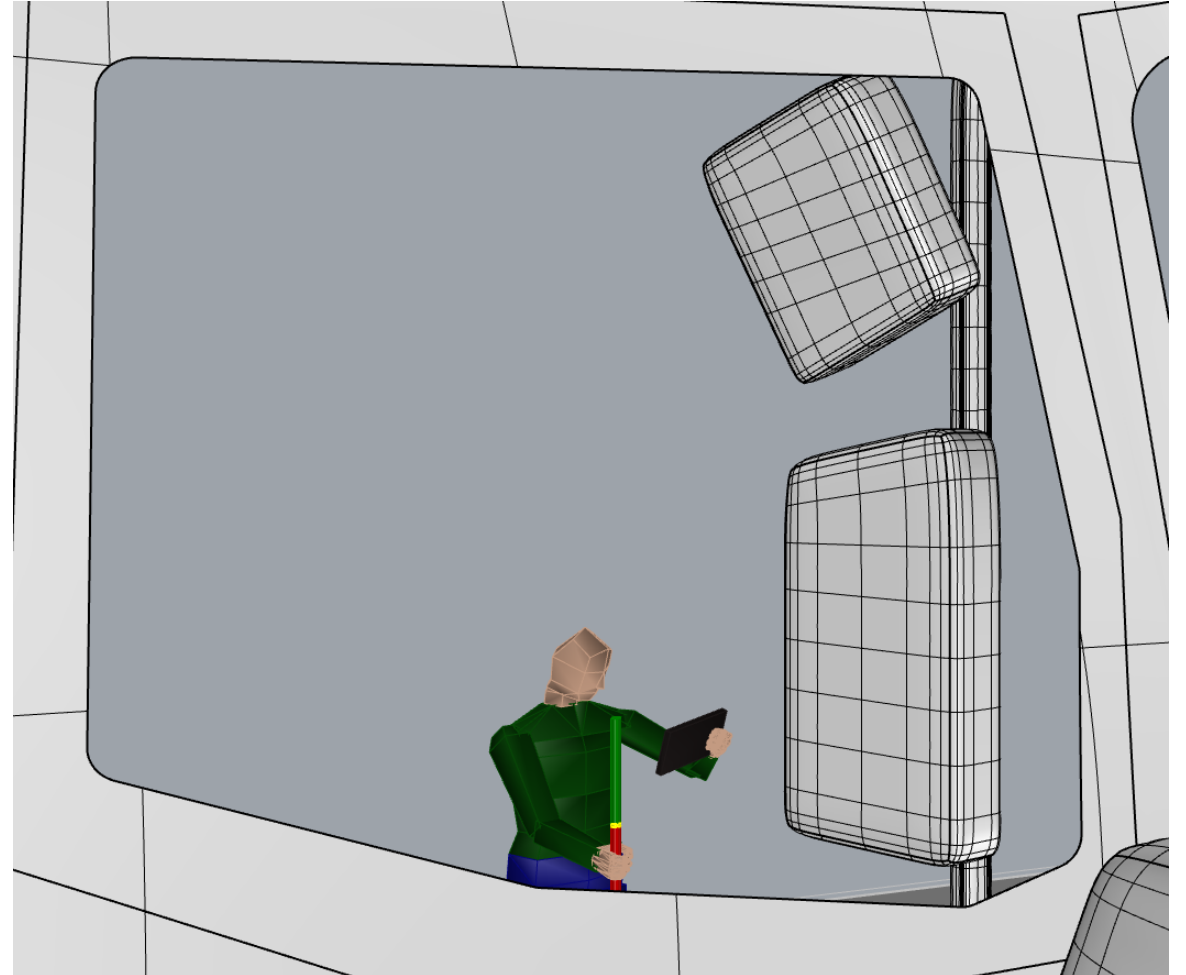
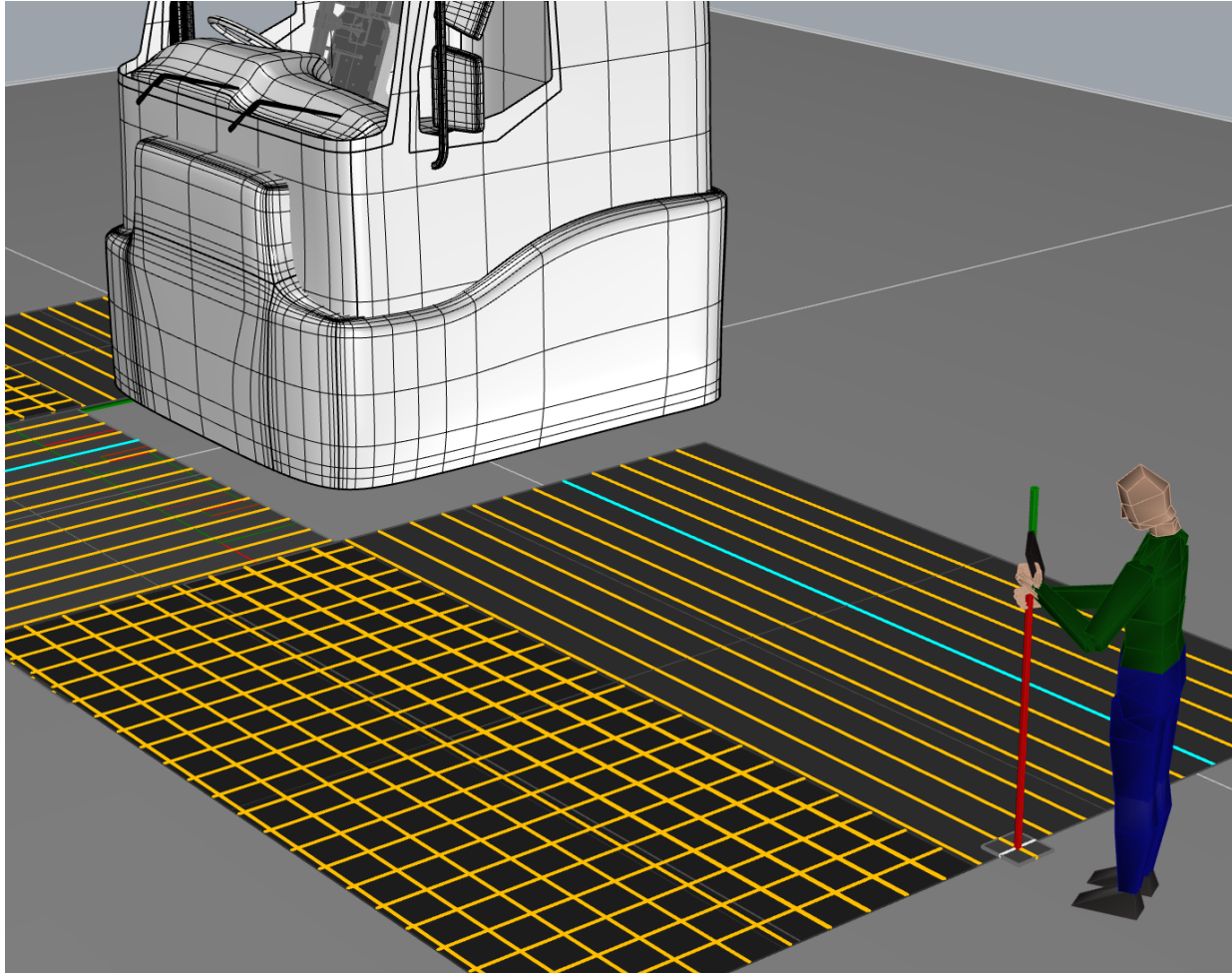
- MO is placed on each line on the AAMs and aligned to the markers
- The MO is then moved along each line and the visibility of the yellow band recorded



Evaluation Procedure

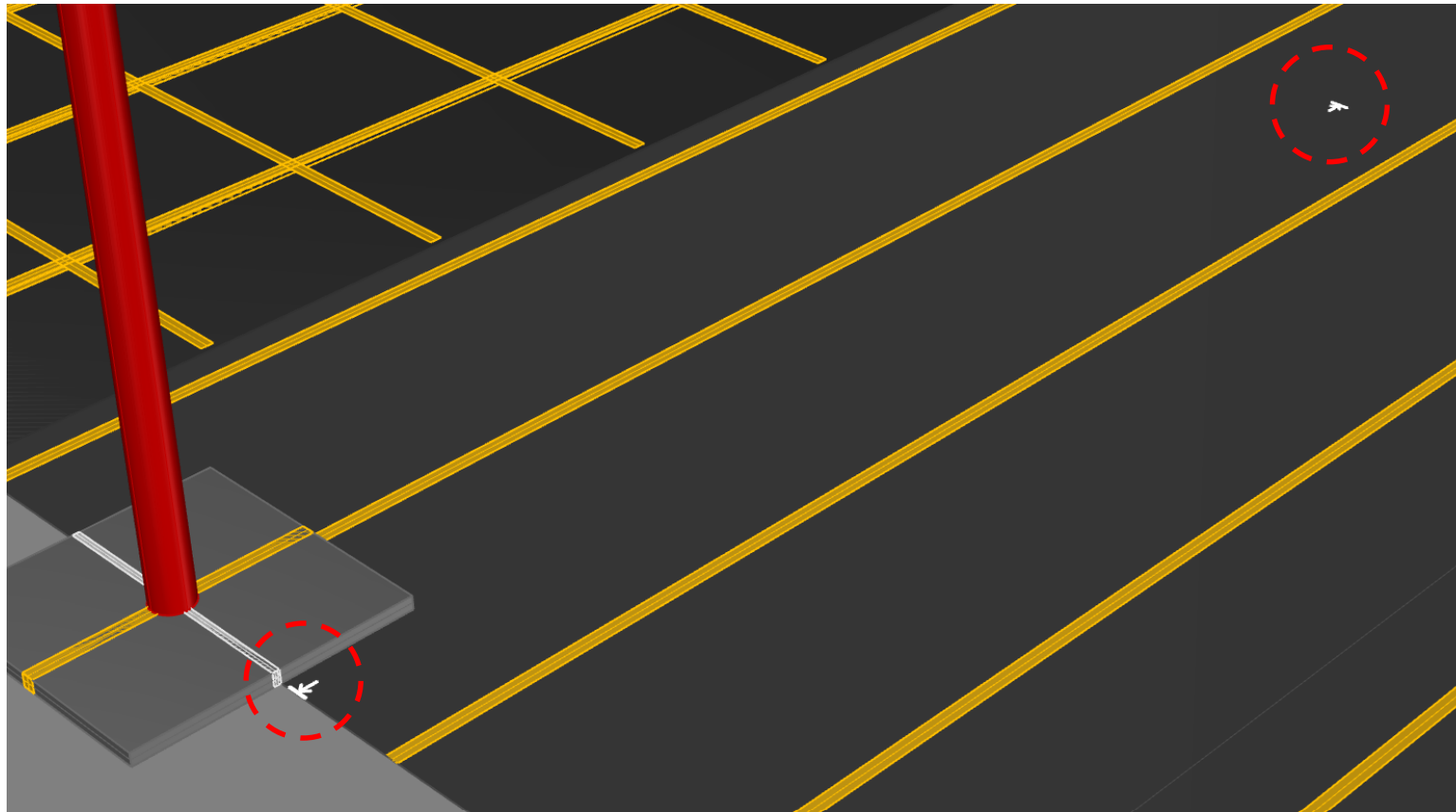


Evaluation Procedure



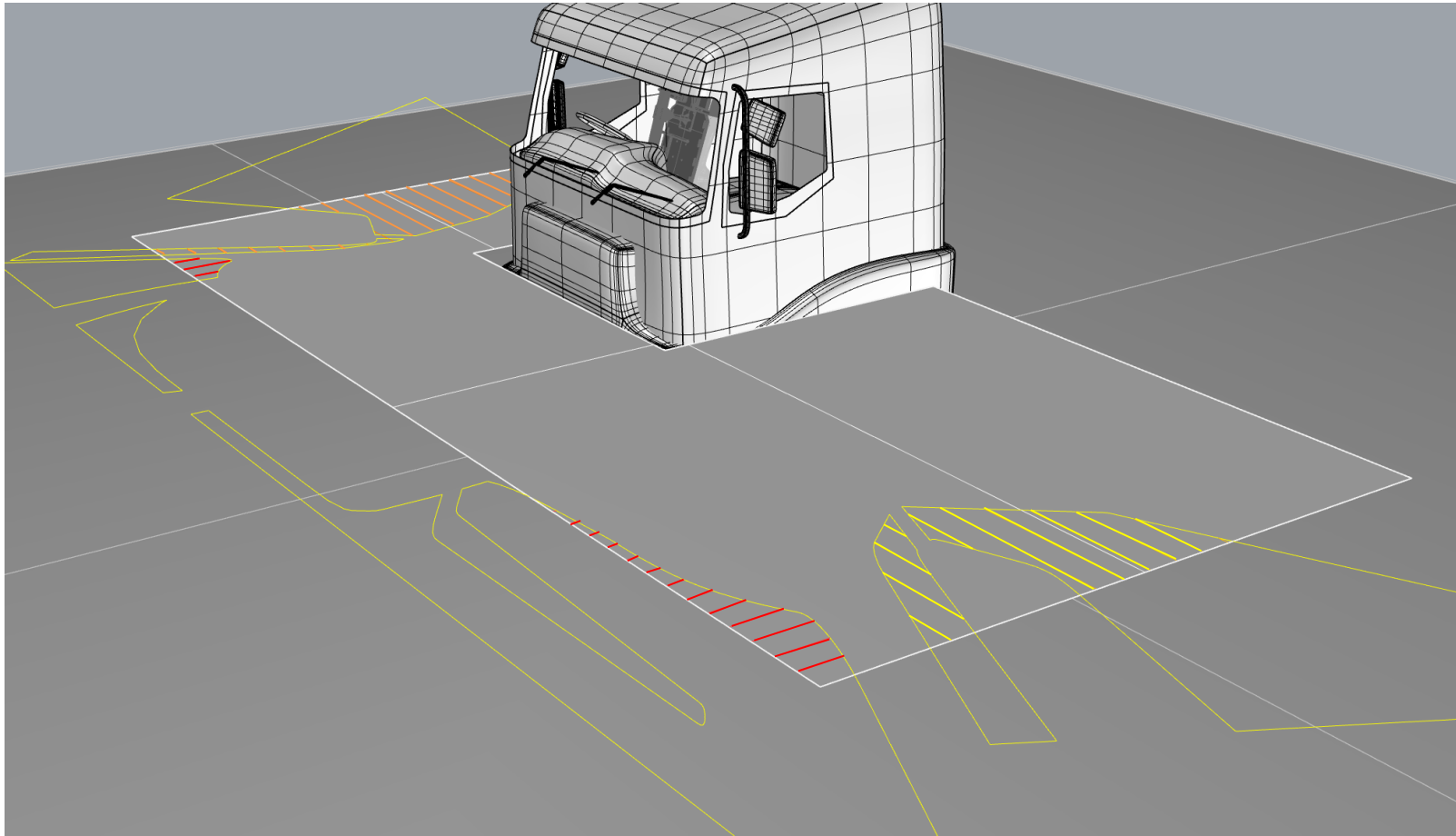
Evaluation Procedure

- Visible sections of each line marked on the mat



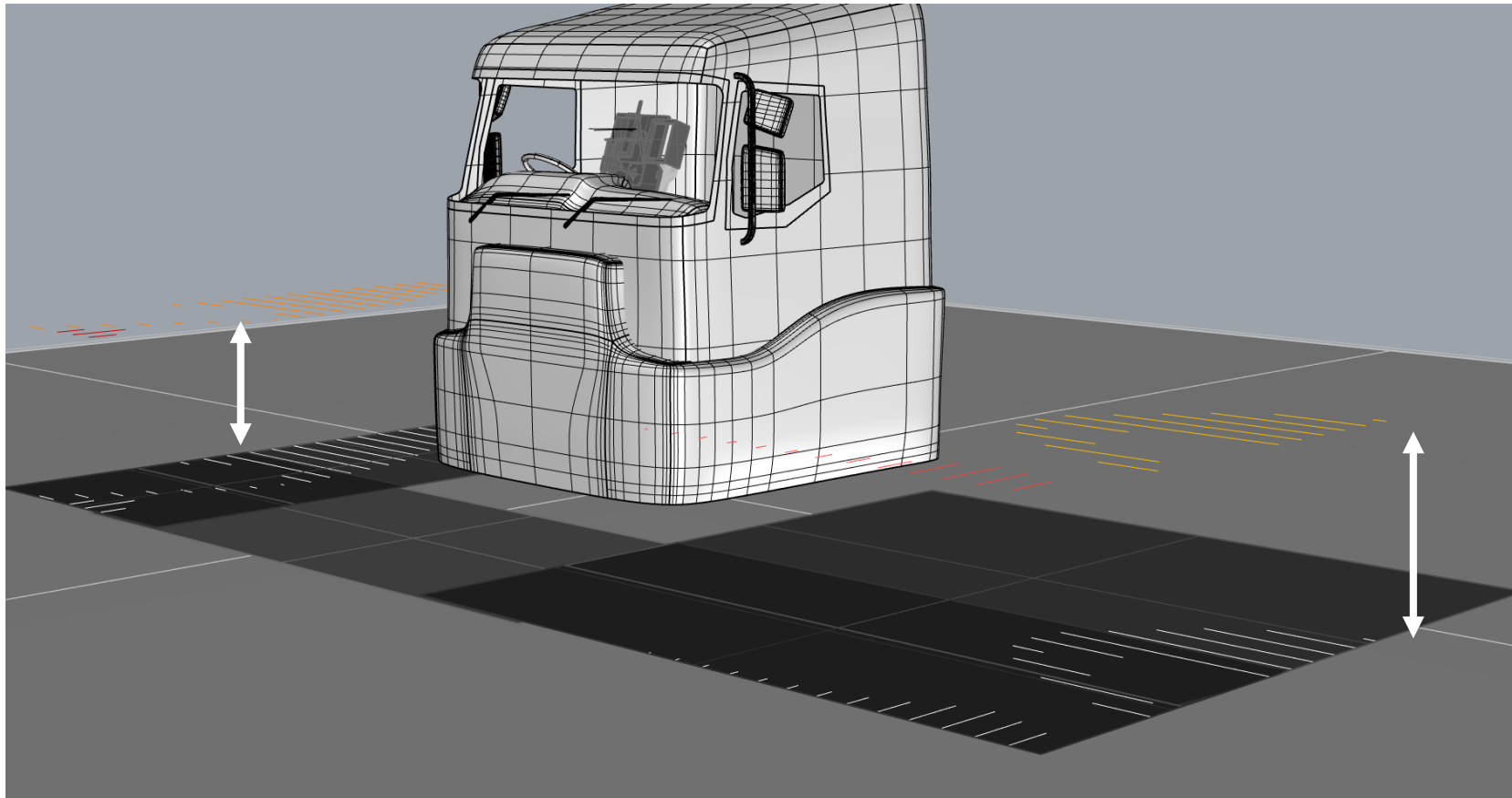
Evaluation Procedure

- This produces a series of lines representing a projection of the visible area on a plane at the assessment height



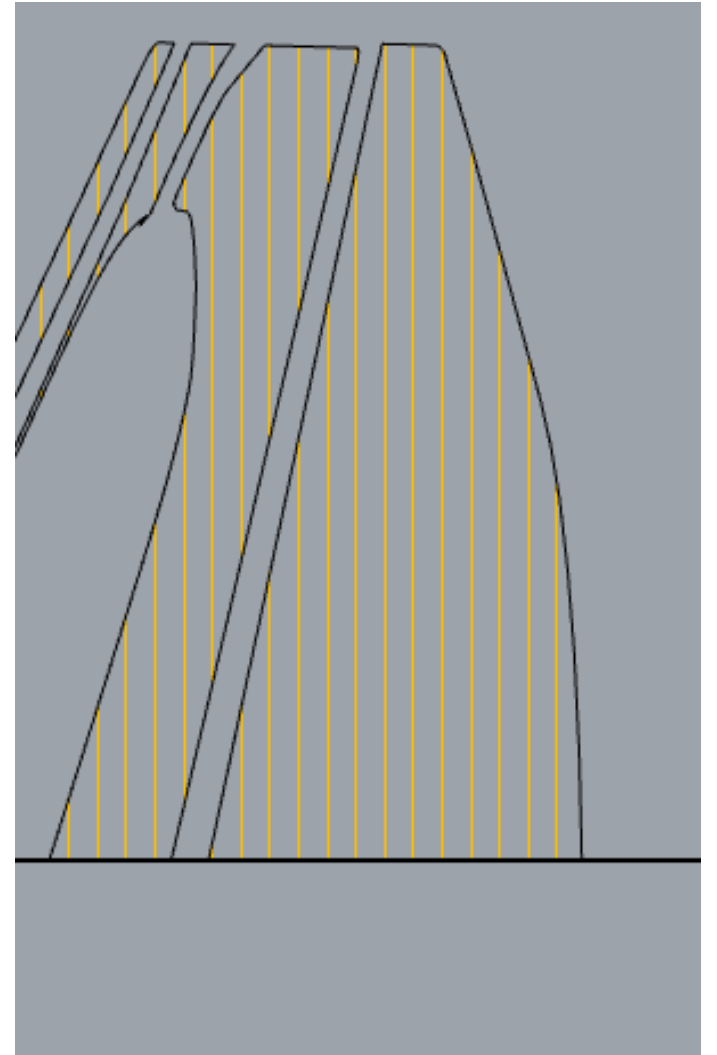
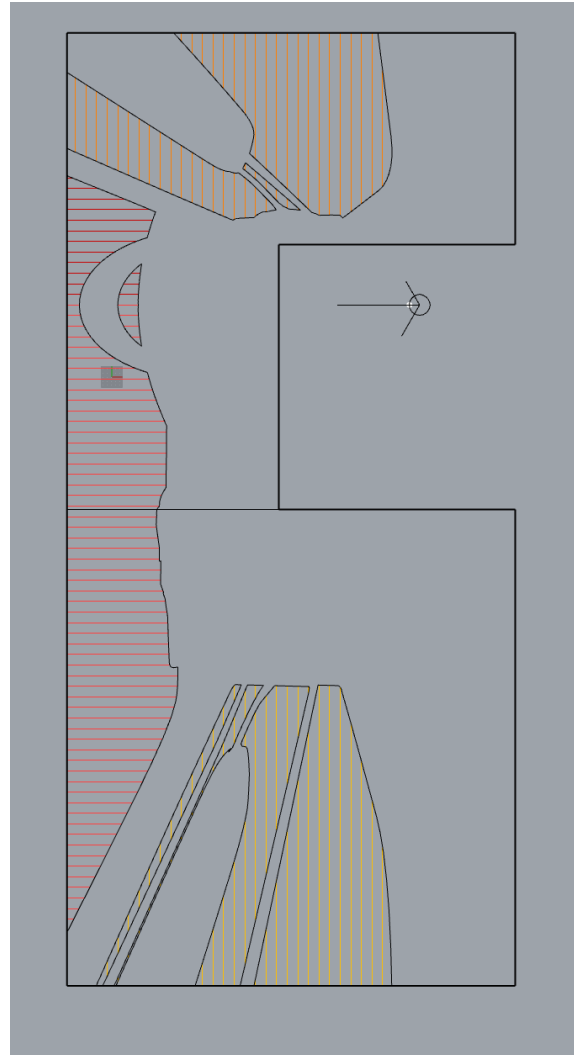
Evaluation Procedure

- The lines on that elevated plane, recorded on the ground on the AAMs
- All visible line segments lengths summed
- This provides the result equivalent to the volumes of the TfL volumes



Evaluation Procedure

- Some vehicles will produce multiple visible segments in and around mirror bodies
- These can be totalled in the same manner



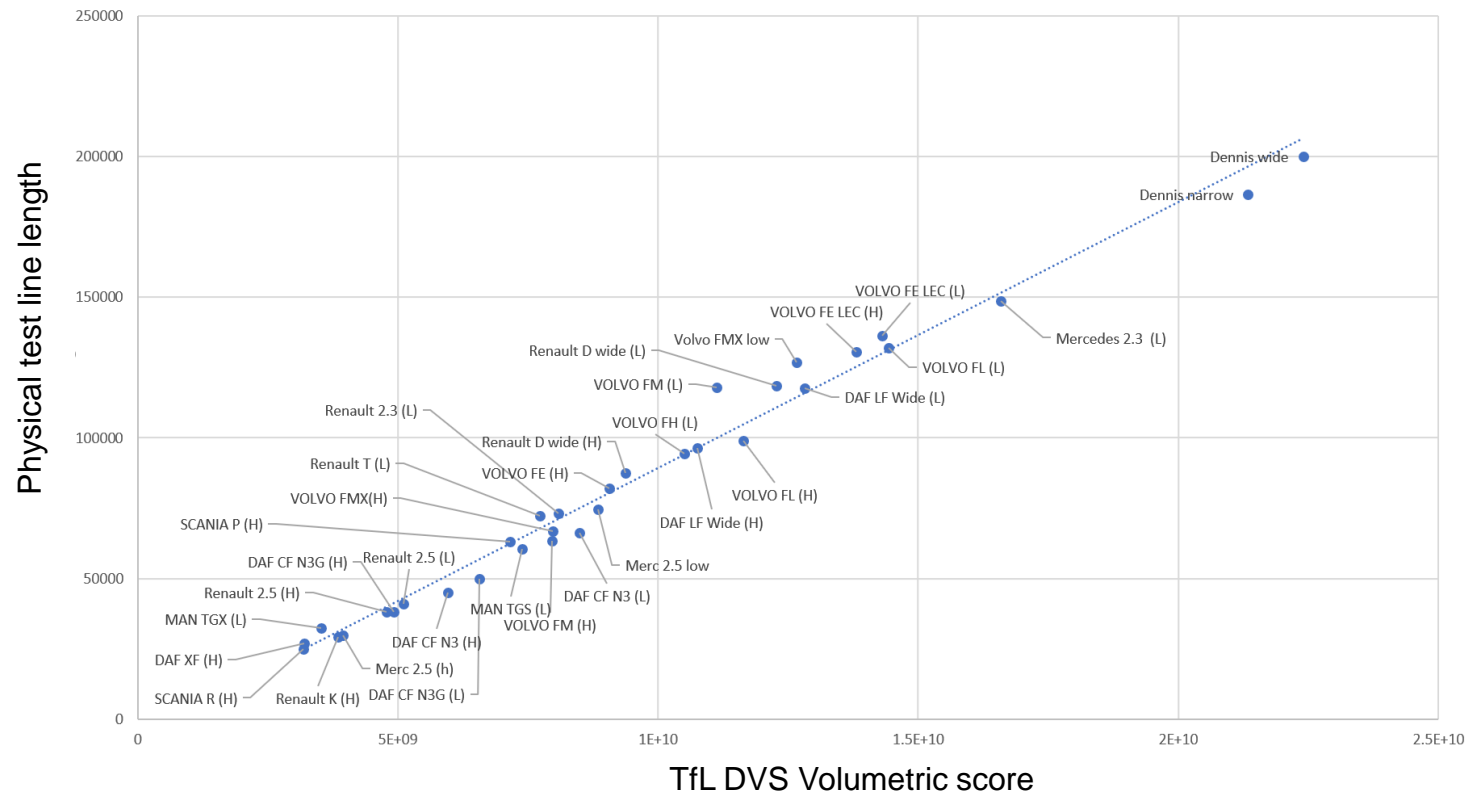
Evaluation Procedure

- Lower door windows will be accounted for using a second adjustable visible band on the MO
- If the lower door window is lower than the assessment plane then:
 - The second band is adjusted to the lower edge of the lower door window and then the same procedure is carried out
- Lower door window visible segments added to the main window segments

Virtual testing of the physical test method

Further work on the physical test to compliment the digital DVS

- As discussed above the use of the physical test **defines a section** of the portion of the assessment volume visible to the driver and we would therefore expect there to be a high correlation between the volumetric approach and the physical testing approach
- Our simulations have shown that the correlation is **almost perfect** with a correlation coefficient of 0.992
- This result is for measured lines taken every 100mm as per the content above

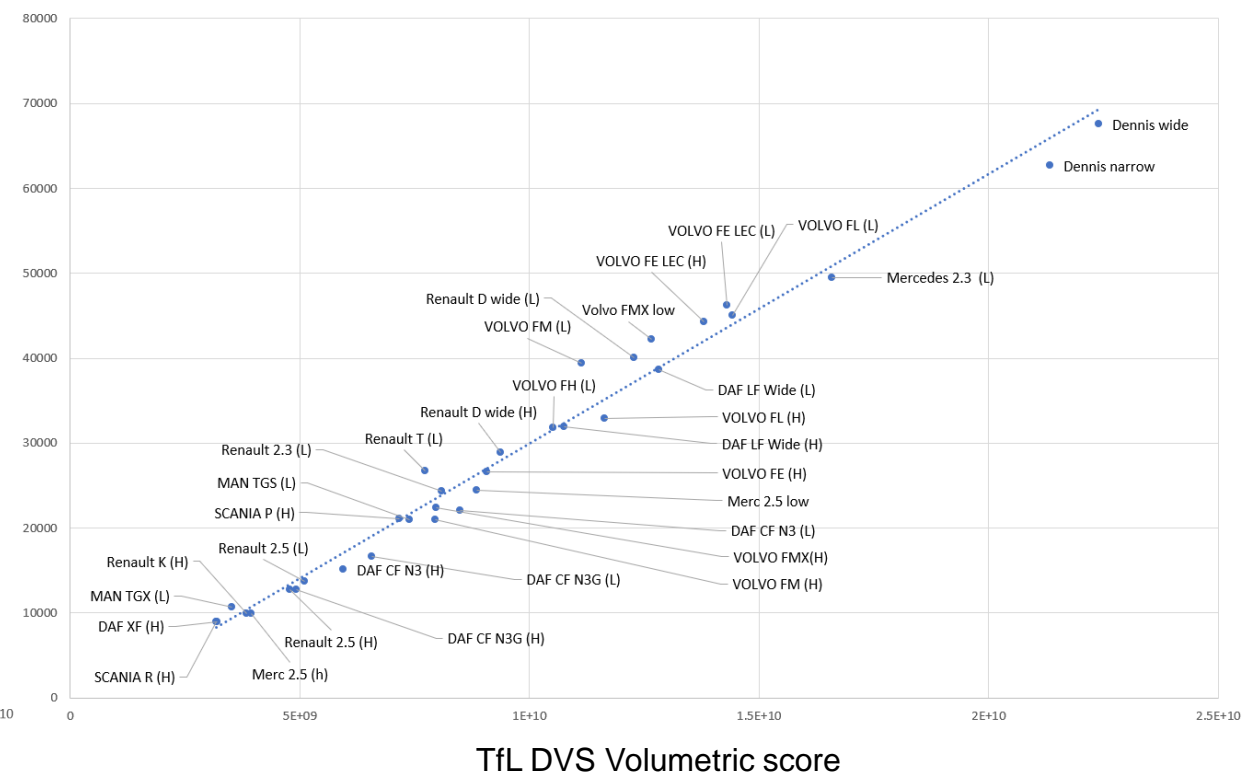
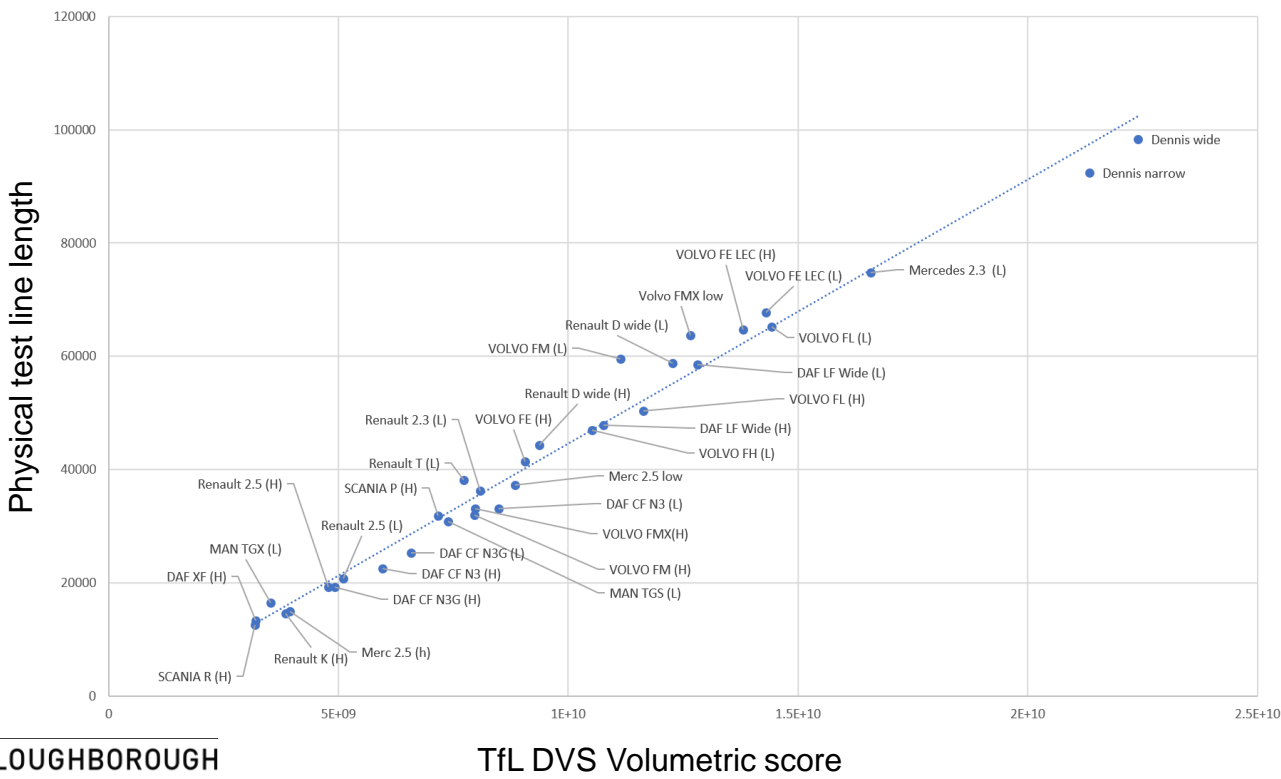


Further work on the physical test to compliment the digital DVS

- With this result secured we have increased the distance between the measured lines to 200mm and 300mm to simplify the test in the real world and then **recalculated the correlation coefficient**.
- Therefore, during March, we will perform the physical testing pilot at the **Millbrook proving ground** in the UK using measures taken every 200mm, and every 300mm
- TfL are funding this work

Lines taken every 200mm – Correlation Coefficient = 0.9905

Lines taken every 300mm – Correlation Coefficient = 0.9905



Our response to the ACEA VRU presentation at this meeting

Our response to the ACEA VRU presentation at this meeting

- ACEA/OICA statement “**Average distance of ~2400 mm corresponds to ~7 m³ DVS volume which means that blind spot is eliminated at 7 m³ DVS volume or more**”
- When we look at the three vehicles which “**Just Pass**” the test of VRU visibility at 2m to the front, 4.5m to the left and 0.6m to the right the result is as follows
 - Front = DAF LF Narrow High is at the limit to the front but good to left and right = DAF has a eye point more rewards than most in the cab affecting forward vision, but, narrow cab makes it easier to see left and right
 - Left (Right in Europe) = Mercedes 2.3 High **fails to the right and front** but is the boundary vehicle to the left
 - Right (Left in Europe) = Renault 2.3 Low = Boundary right, **fails to the front**, passes to the left
- This shows that there is **NO EXISTING VEHICLE** which can actually achieve an average distance of 2400mm and the ACEA/OICA suggestion is an oversimplification of the issue, it is in effect saying that it is **OK to take the results from the three examples above** and ignore that the vehicles fail in some directions.
- The design variability in design variables such as the eye point location in the vehicle cab in X & Y and the width of cab, in the three examples above, mean that results can't be combined from multiple vehicles
- So, it is our view that we should use existing vehicle design to set the safety limit as it can be demonstrated that the result is achievable with an existing design

Our response to the ACEA VRU presentation at this meeting

Yes but accidents occur outside of cities including blind spot sideswipe accidents on highways

This is a misunderstanding of the new physical test method, see slides above

We do not agree with this argument, see slides above on testing to each side

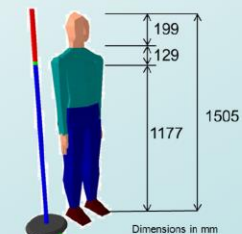
This is an over simplification of the issue. The sample that we test includes only the **absolute maximum** and **minimum cab mounting heights** for 26 cab designs leading to 52 different conditions, there are vehicles in between these two extremes which will pass the test

Understanding the London Direct Vision Standard Approach



- Scope of Transport for London is trucks that are driving in the City of London (Greater London)
- Definition of 1 star on DVS scale:
 - 1 star rating means an average distance of VRUs to be seen by the driver (head and shoulders) at a distance of 4.5m to near-side, 2m to the front and 0.6m to the off-side. The VRU chosen was a 5th %ile Italian female covering 99% of Europeans (Loughborough Design School, VRU-Proxi-10-07)*
- Height of 5th %ile Italian female 1177 mm up to shoulders by using a stick, VRU width not respected
- Determinant for 1 star level was existing vehicle (Volvo FE) meeting requirement at least on all sides, this 1 star vehicle fulfils visibility exactly on one side but performs better on the other two sides
 - ⇒ **This means 1 star on current DVS scale goes beyond the aim of eliminating the blind spot**
- 28 of 51 current in EU available vehicle models would be banned, therefore TfL allowed safety systems as alternative

Stature of 5th %ile Italian female



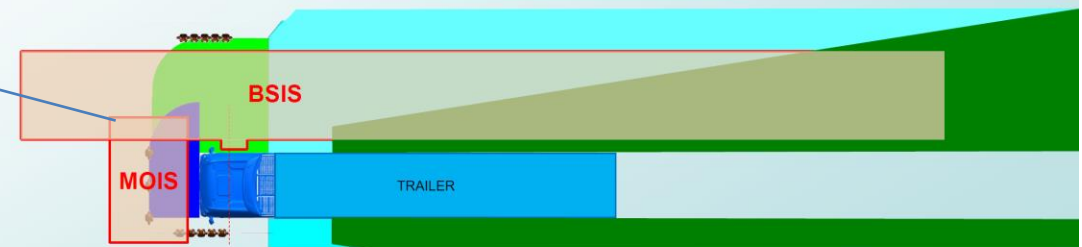
Our response to the ACEA VRU presentation at this meeting



Considerations for UN Direct Vision Regulation

- Scope of UN Regulation is Type Approval for all trucks and buses driving on all roads (not in city only)
- At least in EU all trucks will have safety systems as from 2024 (MOIS & BSIS)
- Direct vision regulation will be the 3rd regulation addressing the close proximity area at the near side and off-side of the truck

MONITORING AREAS BSIS + MOIS (EU >2024)



BSIS = Blind Spot Information System (ECE R151)
 MOIS = Moving-Of Information System (ECE R xx)
 ECE R46 = Colored areas (in theory not blind spots)

These systems will provide auditory warnings

There is obvious potential for these systems to be overloaded and to provide multiple warnings in urban environments, with many human factors issues

The driver still needs to be able to identify where the VRU is once a warning is received



Our response to the ACEA VRU presentation at this meeting

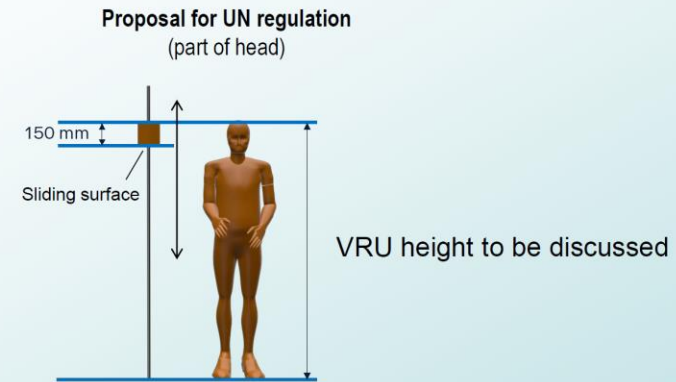
It is our understanding that detailed test methodologies are to be presented at this meeting, and then tested before the meeting in Sweden. This method is speculative and has no supporting evidence presented?

The research in this area discusses SALIENCE, i.e. the noticeability of the visual object, we do not agree that seeing part of the VRUs clothing will provide a consistent recognition for drivers

There is no evidence to suggest that this is possible or useful

It is not our responsibility to prove or disprove that this test will work and this is not part of our contract with TfL. We need to discuss this

VRU Height and Visibility



- VRUs and driver's head will move in real-life traffic
 - Lean stick is not representing width of VRU body
 - Any body part of VRU 150 x 150 mm to be considered for determining Direct Vision level
 - 150 x 150 mm also considered in regulation for Reversing Motion
 - Loughborough Design School is asked to investigate the effect of this proposal on the direct vision evaluation (DVS)
- } any body part of VRU (150 mm width) will be noticed by the driver

Our response to the ACEA VRU presentation at this meeting

The EU text discusses improving direct vision, not just removing blind spots

EU legal text requirement

Vehicles of categories M2, M3, N2 and N3 shall be designed and constructed **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 of and to the side of the driver, while taking into account the specificities of different categories of vehicles.

Eliminating the Blind Spot to the Greatest Possible Extent

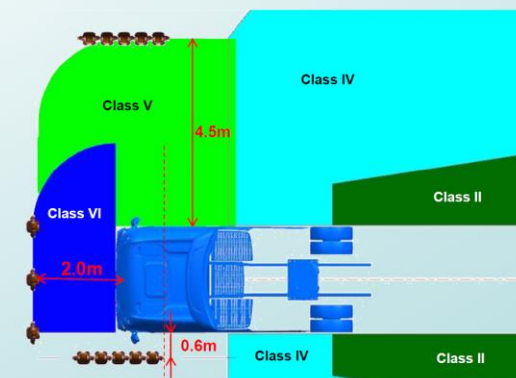


The blind spot is eliminated when the VRUs are visible while standing exactly on outer border of R46 indirect vision FoVs and 0.6 m at driver side:

- 5 VRUs at 4.5 m to the near-side
- 5 VRUs at 0.6 m to the off-side
- 3 VRUs at 2.0 m to the front

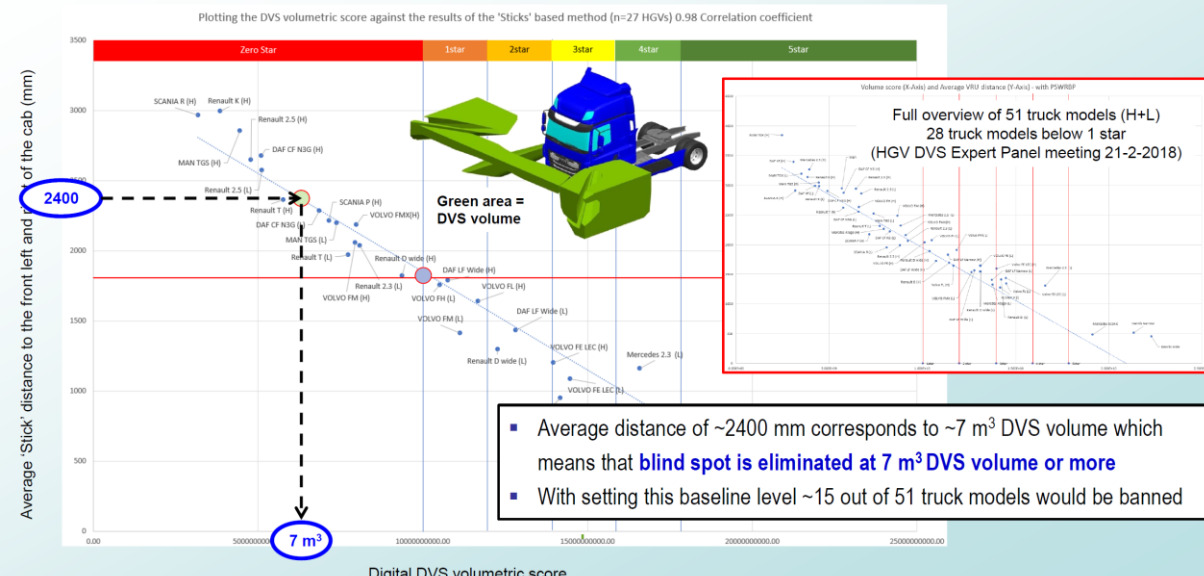
This means that blind spot will be exactly eliminated at an average VRU-distance of **~2400 mm**

This corresponds to an equivalent direct vision performance of **more than 1 star** on current DVS scale based on 5th %ile Italian female (head and shoulder)

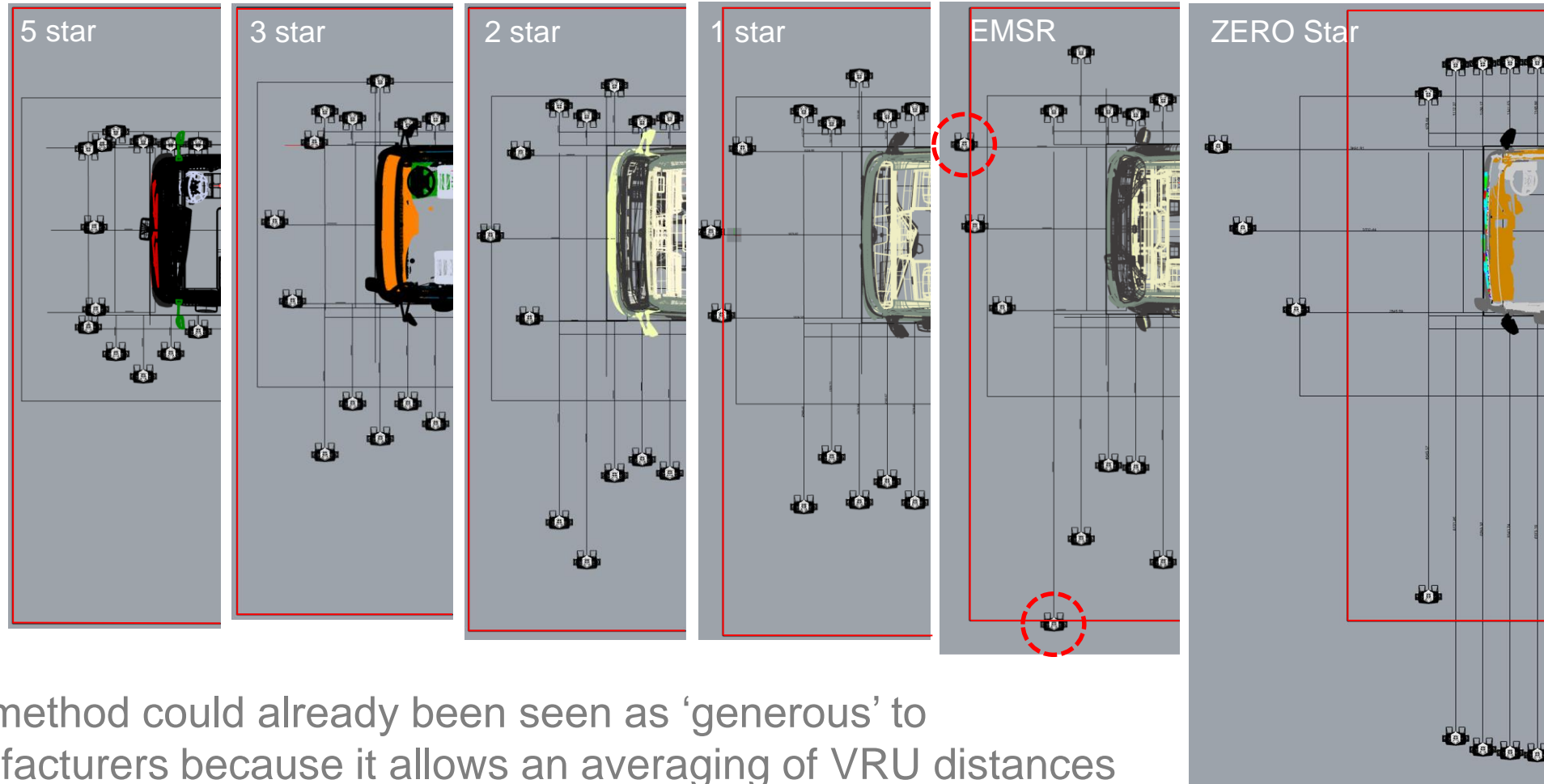


We do not agree, see evidence above

Eliminating the Blind Spot to the Greatest Possible Extent



Example VRU distances for vehicles in the star boundary categories (New version, Head only visible)



- This method could already been seen as ‘generous’ to manufacturers because it allows an averaging of VRU distances

Summary

- The LDS/TfL position has been consistent for all of the UNECE VRU proxy meetings. The Digital DVS is the most accurate and effective method for testing the direct vision capabilities of existing designs and new designs, and defines a simple to understand minimum safety requirement.
- The new physical test has a draft protocol and we are ready to perform physical testing pilot studies before the next meeting. It is equally accurate as the digital approach based upon virtual testing
- That minimum safety requirement simply states that no truck should be allowed in an urban environment which allows VRUs to be hidden from both direct vision and indirect vision capabilities of truck drivers enabled by the cab designs
- Nearly half of the sample that we tested in the TfL DVS project were not able to meet that simple requirement. However, the real aim of the TfL DVS was to support direct vision of the “area of greatest risk” defined by our accident data analysis
- Only vehicles which achieve a TfL DVS star rating score of 2 star or better are genuinely allowing more direct vision of the area of greatest risk, and therefore improving the ability of the driver to directly see the people in close proximity to the truck

This meets the EU text i.e.

Vehicles of categories M2, M3, N2 and N3 shall be designed and constructed 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 of and to the side of the driver**, while taking into account the specificities of different categories of vehicles.