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The potential application of the TfL Direct Vision Standard in UNECE regulation – Reporting results of tasks assigned in the 13th meeting

Loughborough University Design School (LDS): Design Ergonomics Research Group

Research Sponsored by Transport for London

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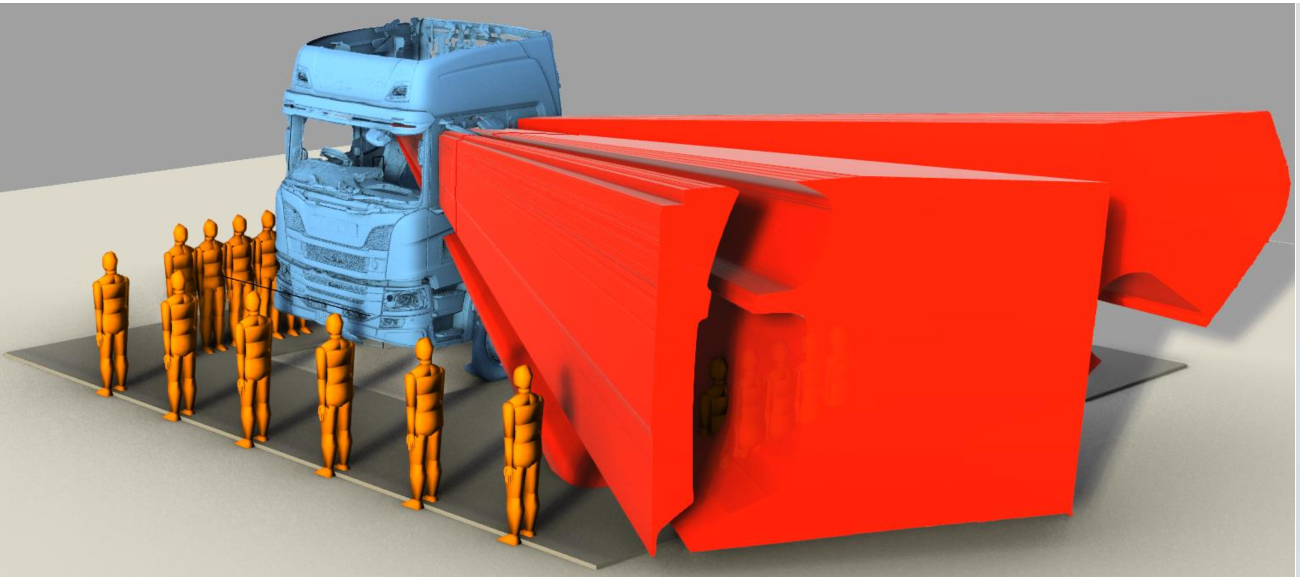

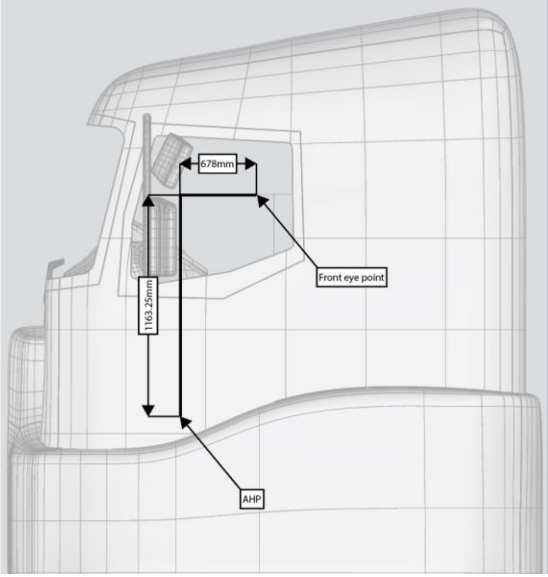

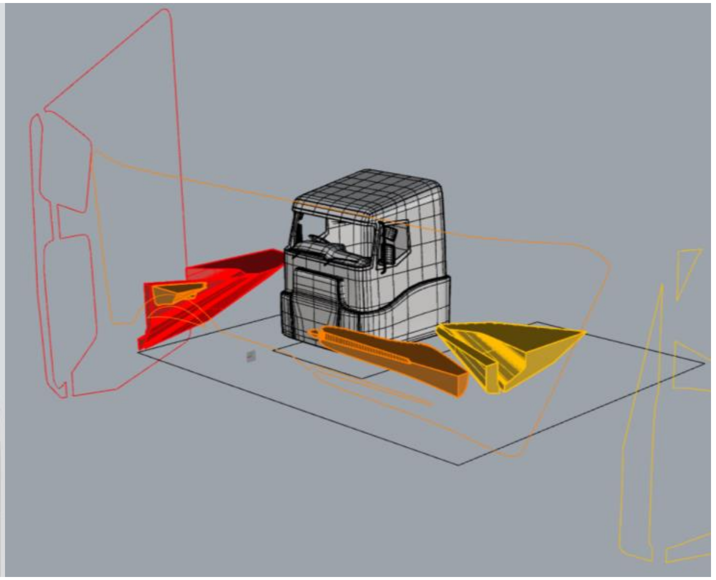

VRU-Proxi-14-08

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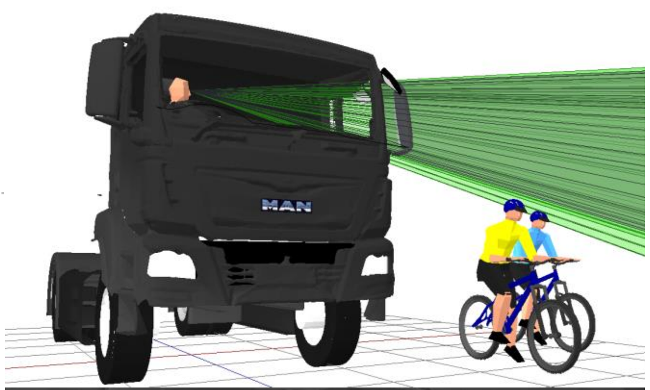
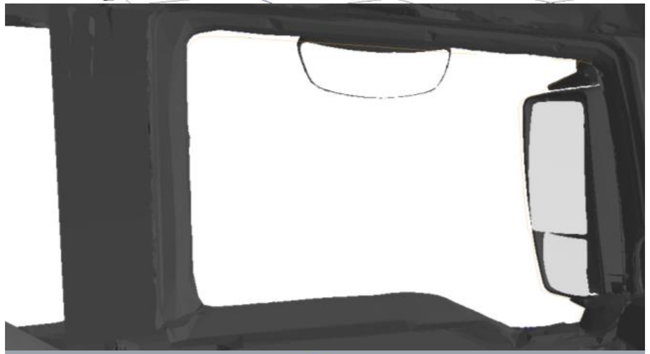
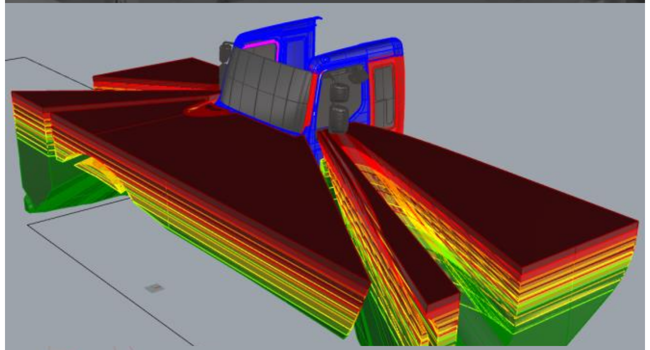
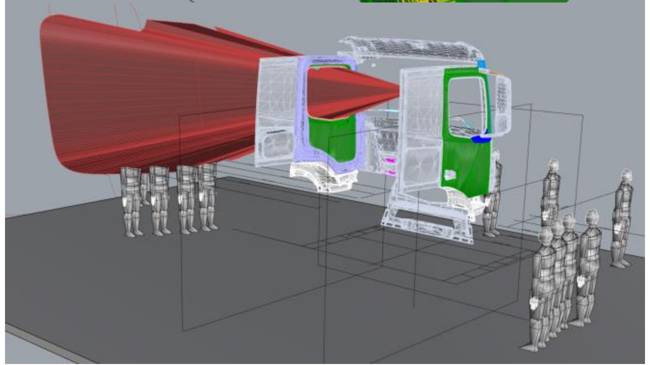








Review of tasks assigned at the 13th meeting

Key tasks

1. Complete the data set for the revised VRU simulations where the head being visible is the new limit. (40 vehicles now in the dataset)

2. Complete the data set for simulation of the LDS Physical test method. (50 vehicles now in the sample)

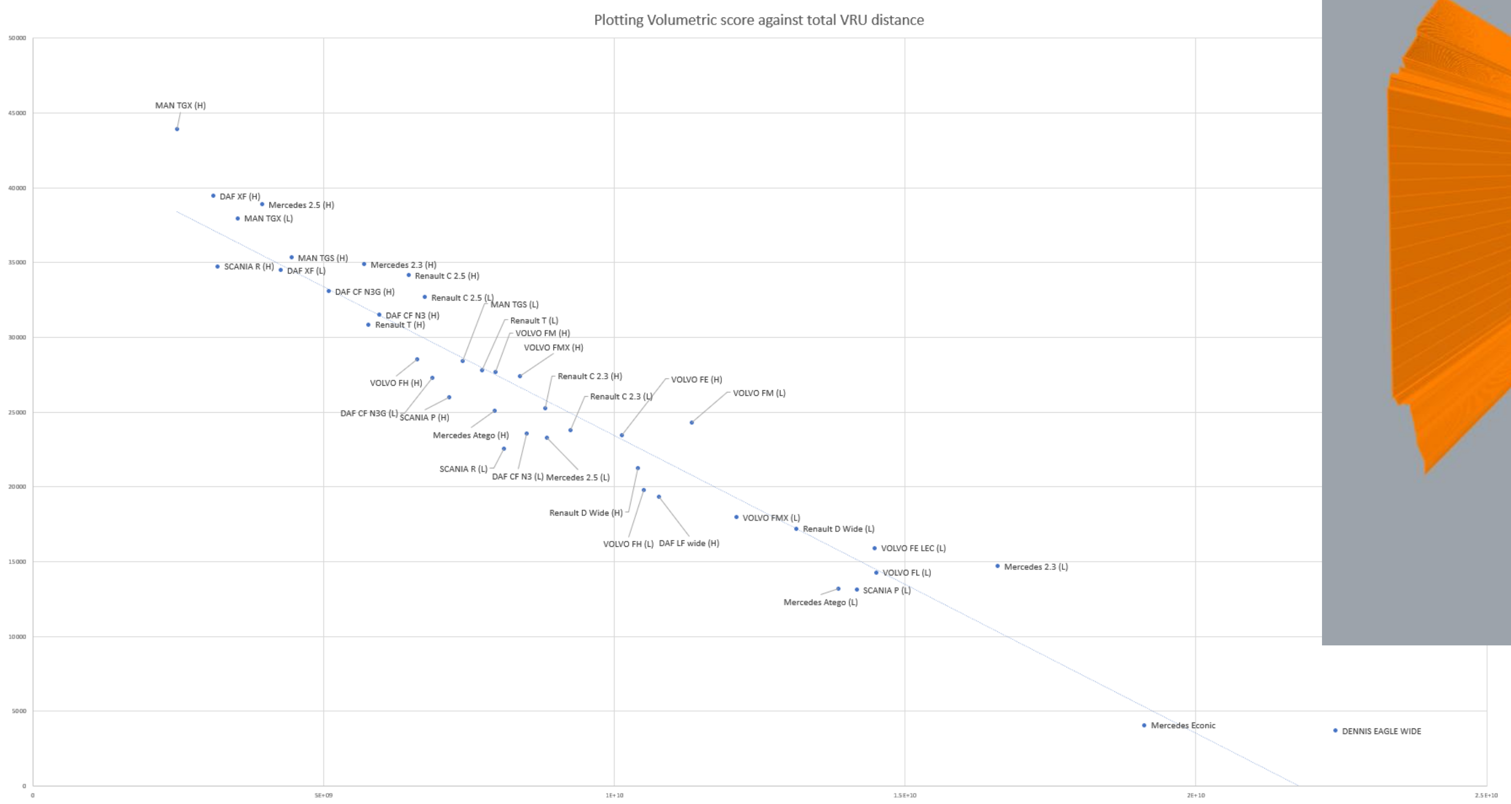
3. Explore the possibilities and results of two potential approaches for utilising the LDS volumetric approach
    1. Utilise an approach where vision to the Front & Passenger side must separately meet a minimum requirement as defined by the volume for an average distance of the VRU simulations, where the distance is defined as the limits of the Class V and VI mirror zone for the passenger and front. For the driver's side a value has been selected for demonstration.
    2. Utilise an approach where the volume to the Front, Driver's side and Passenger side can be combined to give an overall volumetric score but those volumes are defined by a reduced distance of the VRU simulations (see UK Contracting Party proposal from the 13th meeting).

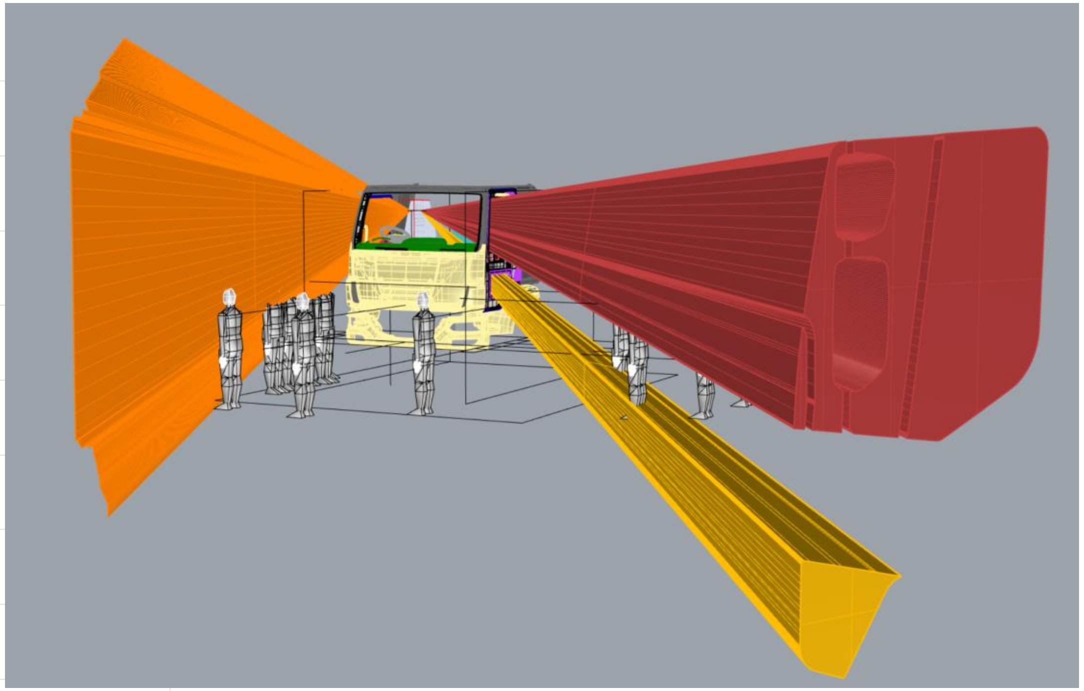
        Note: The updated results from Task 1 completed this task, and the key question of limits that can be acceptable to all remains.The updated graph will be made available at the meeting with the same equations that allow the results different options to be seen.

4. Explore the effect of removing mirrors and windscreen wipers.

Task 1. Add to the data set for the revised VRU simulations for head and neck only

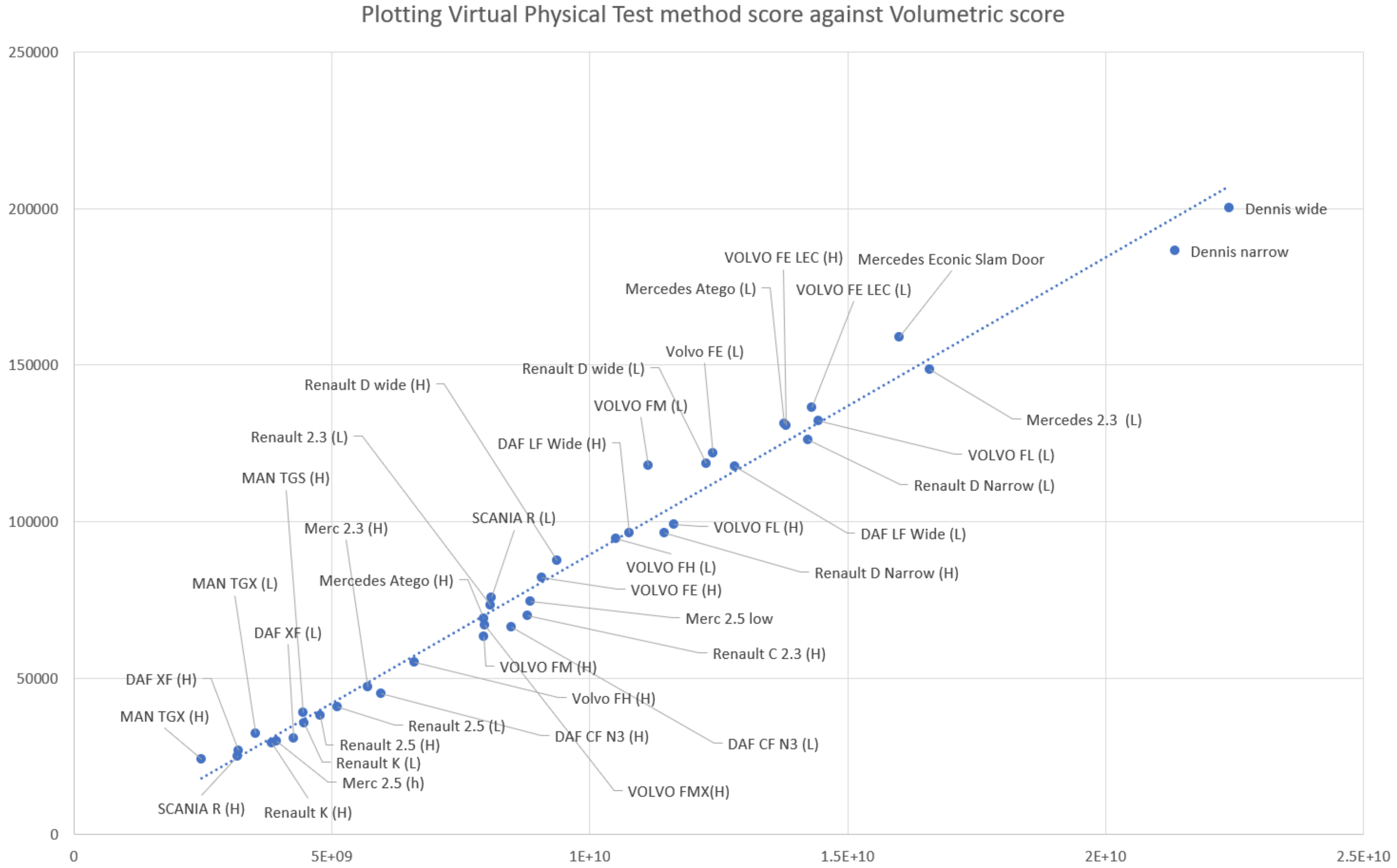
40 vehicles now in the sample. Pearson's Correlation coefficient = 0.964 between volume and VRU distance. Therefore using VRU simulations where the head is visible as opposed to head and shoulders is proposed for determining the minimum volumetric limits for the UNECE version of the DVS.

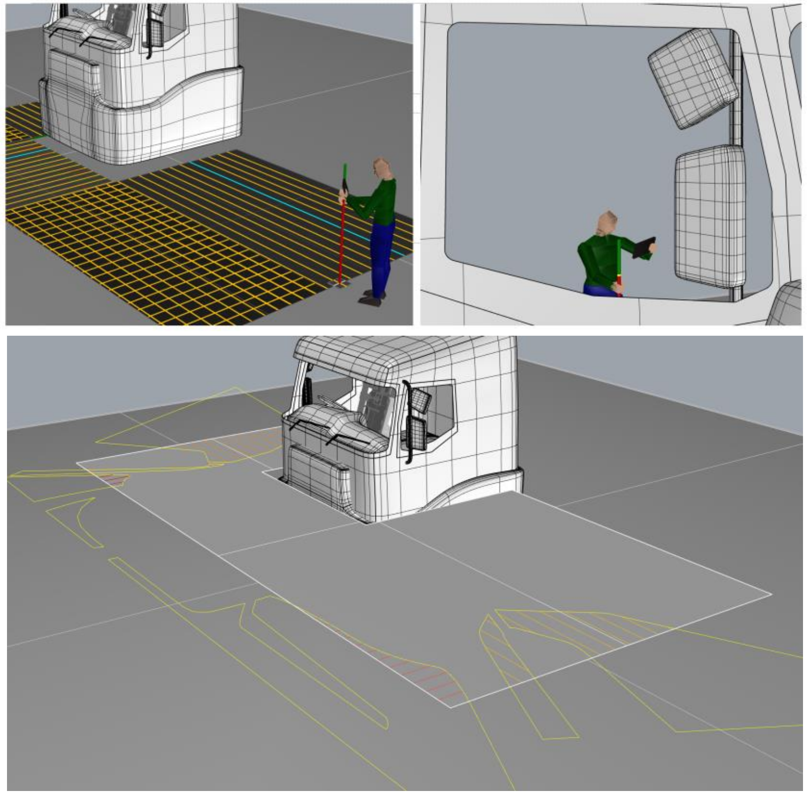




Task 2. Complete the data set for simulation of the LDS Physical test method.

50 vehicles now in the sample. Pearson's Correlation coefficient = 0.992 between DVS volume and virtual physical testing results distance. Therefore the physical testing method correlates sufficiently well with the volumetric score and is recommended for inclusion in the UNECE version of the DVS. Pilot testing has been delayed by Loughborough University Ethics board due to COVID 19 risks. The pilot testing at the Millbrook proving ground will be performed ASAP.



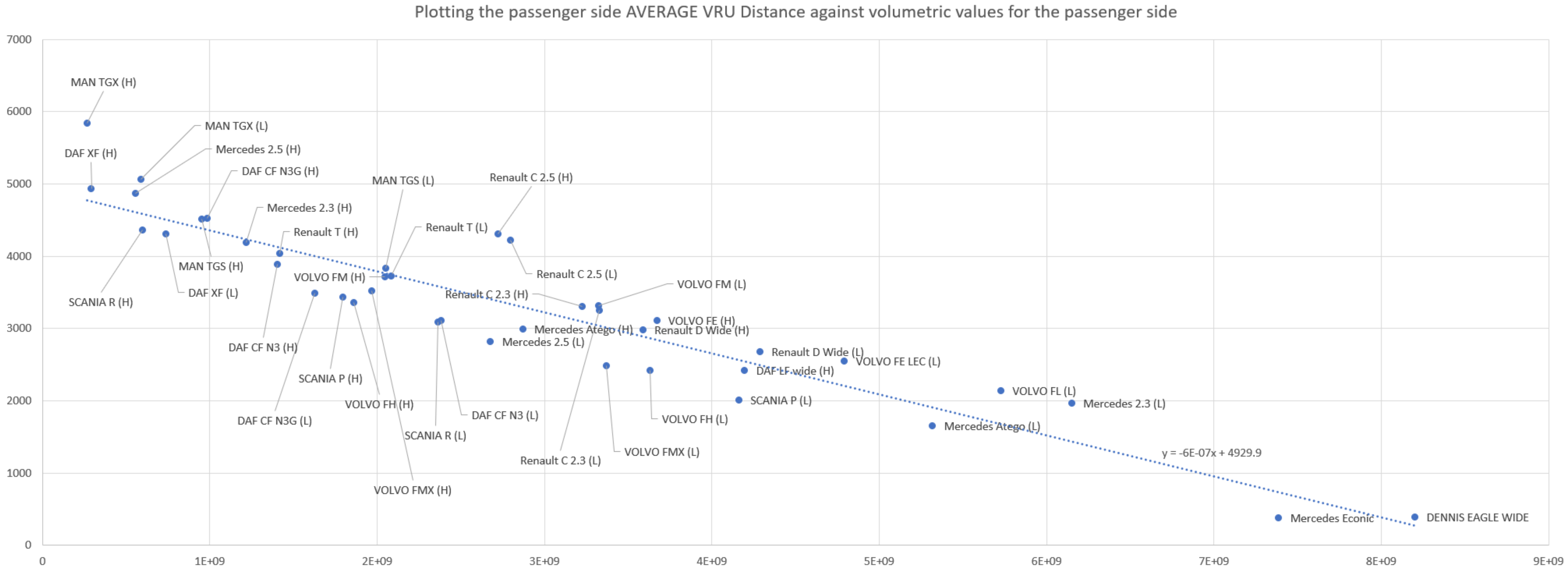


- Task 3.1: Utilise an approach where vision to the Front & Driver's side must separately meet a minimum requirement as defined by the volume for an average distance of the VRU simulations. The distance is defined as the limits of the Class V and VI mirror zone for the passenger and front. For the driver's side a value has been selected for demonstration.

- The following three slides show the previous results separated into three different directions of view i.e. plotting the average VRU distance and volume to the driver's side, passenger side and front of the vehicle.

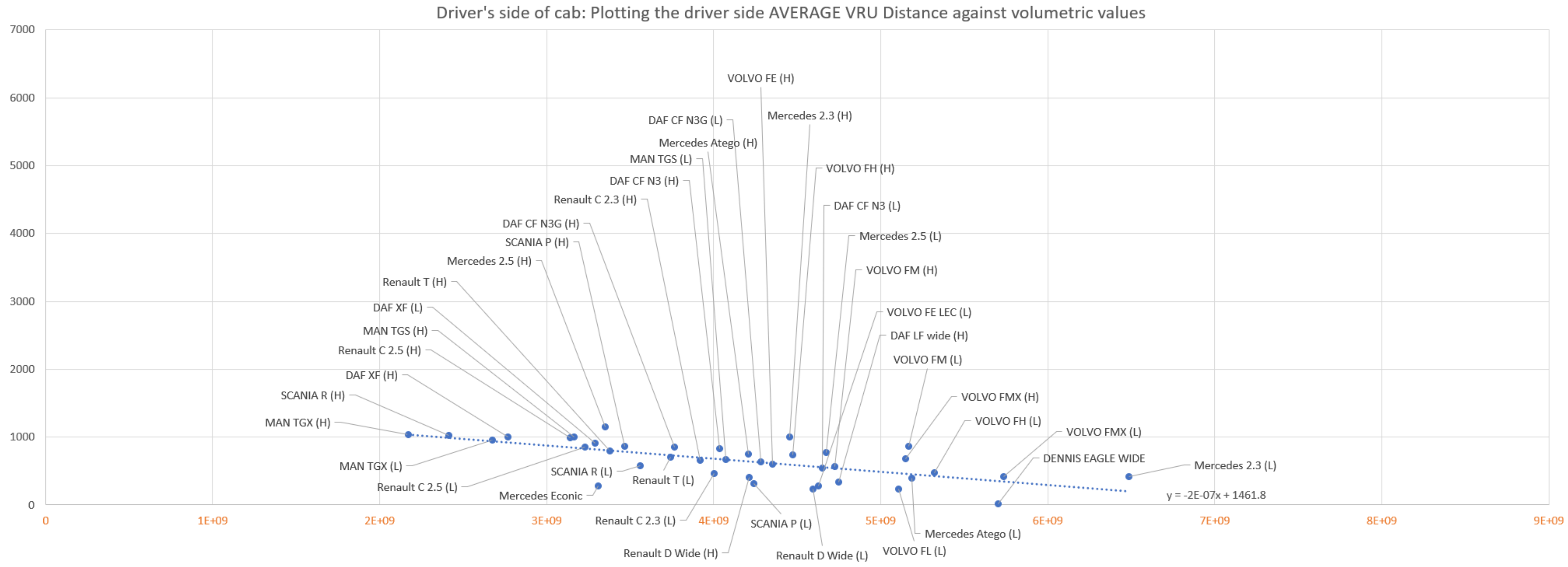
Explore the possibilities and results of two potential approaches for utilising the LDS volumetric approach – **separated approach**

Step 1. Identify the volumes that would be required as visible to each side. Therefore plot the HEAD ONLY VRU distances against volume for each side of the vehicle. Passenger side



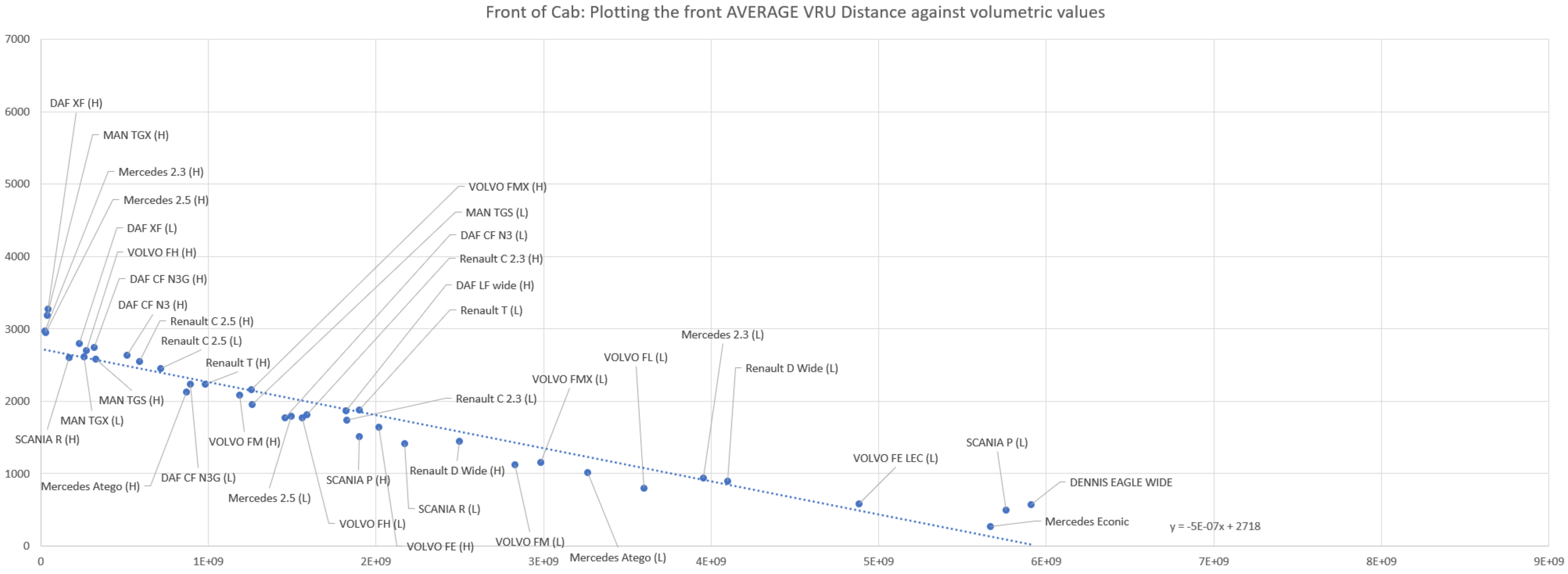
Explore the possibilities and results of two potential approaches for utilising the LDS volumetric approach – **separated approach**

Step 1. Identify the volumes that would be required as visible to each side. Therefore plot the HEAD ONLY VRU distances against volume for each side of the vehicle. Driver side



Explore the possibilities and results of two potential approaches for utilising the LDS volumetric approach – **separated approach**

Step 1. Identify the volumes that would be required as visible to each side. Therefore plot the HEAD ONLY VRU distances against volume for each side of the vehicle. Front side



Comparing the volumes to each side

Each graph uses the same scale values to allow direct comparison.

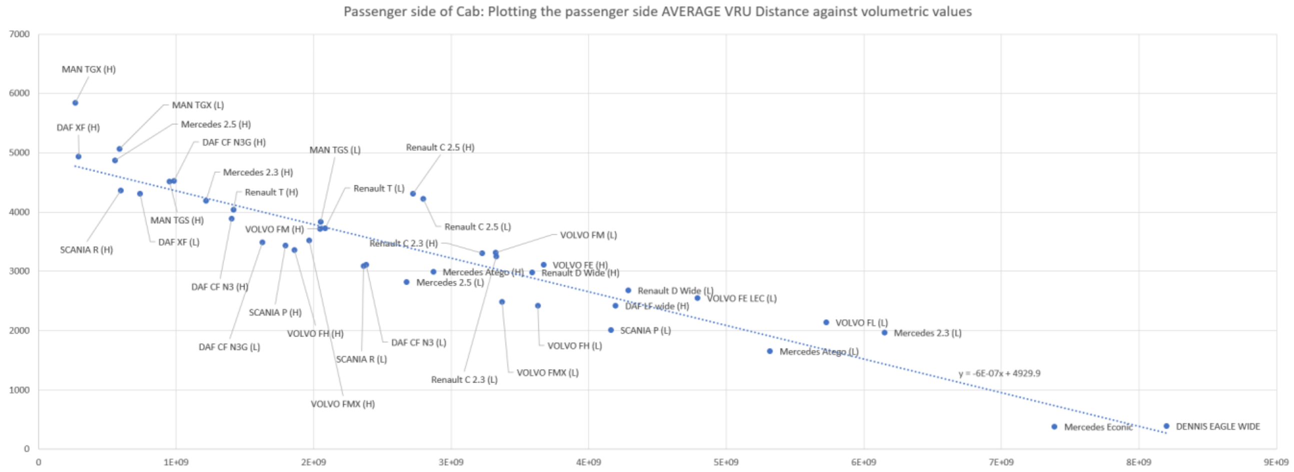
The correlations between the VRU distance and volume are as follows, where values above 0.5 are considered strong and 1 is perfect.

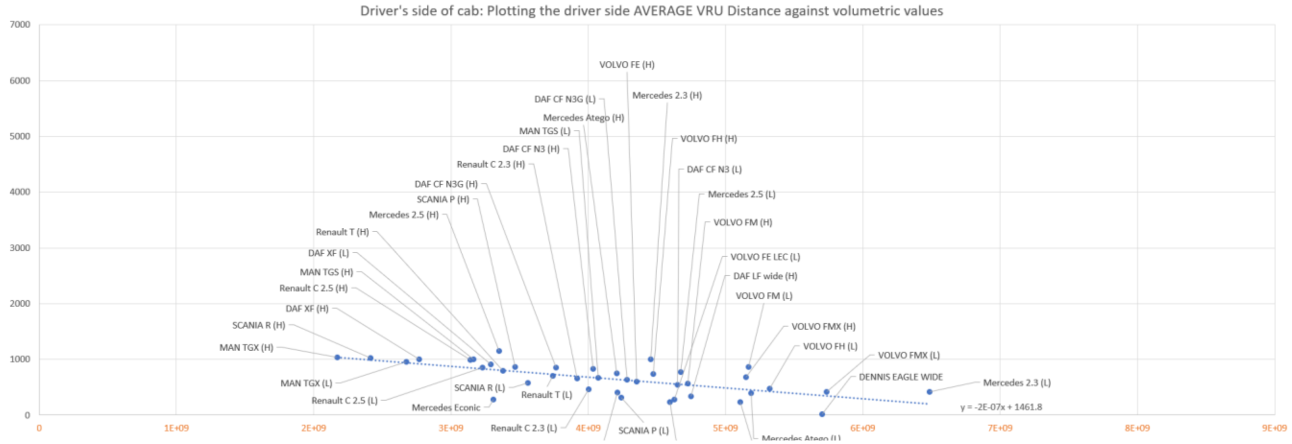
Passenger side = -0.956

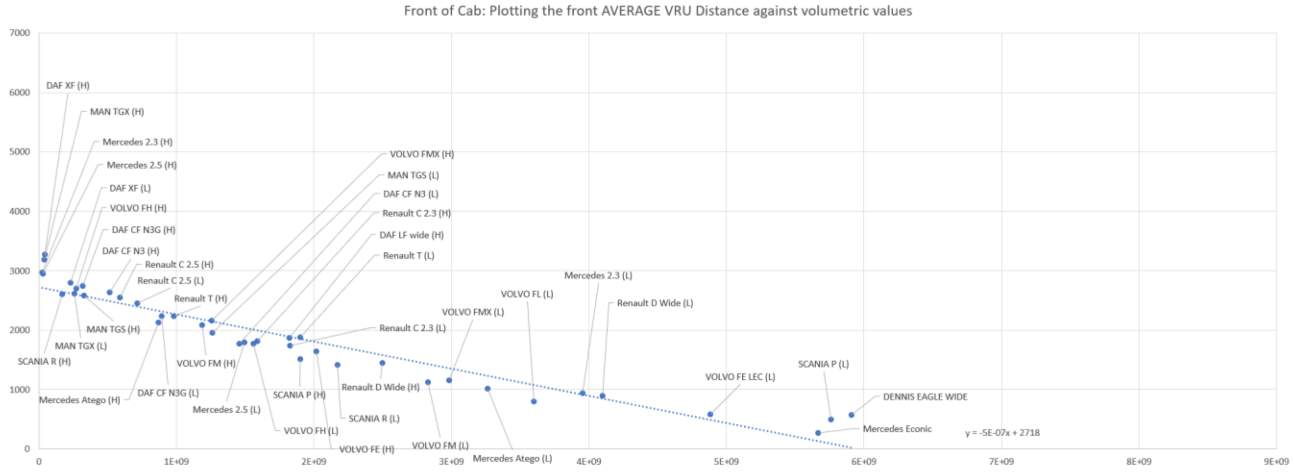
Driver’s side =-0.67

Front = -0.93

A review of why the correlation for the Drivers side is slightly weaker highlighted that the mirror mounting position within the window apertures from the drivers eye point has a strong effect, where mirrors which are mounted higher allow the VRUs to be located closer to the vehicle.







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Explore the possibilities and results of two potential approaches for utilising the LDS volumetric approach – **separated approach**

Two different methods have been used to define the minimum requirement to each side.

1. **The method discussed at the last meeting, i.e. using the equation of the trend line in the graph to derive the volumetric value from the associated MAXIMUM AVERAGE VRU distance to each side. (e.g. 4500mm to the passenger side and 2000mm to the front)**

   The 4500mm and 2000mm values are associated with the mirror coverage areas but there is no equivalent value to the driver's side. This makes selecting a limit to the driver's side problematic as the decision is arbitrary. We have used a distance of 1000mm in the analysis below. This can be varied as to the wishes of the VRU Proxy Group.

2. Using the volumetric score for the vehicle which has the AVERAGE VRU distance just below the values above.

Note: These values can be adjusted for whatever values the UNECE VRU Proxy group deem to be necessary

Two methods for defining the minimum requirement - Front

Comparison of methods 1 & 2 for the Front

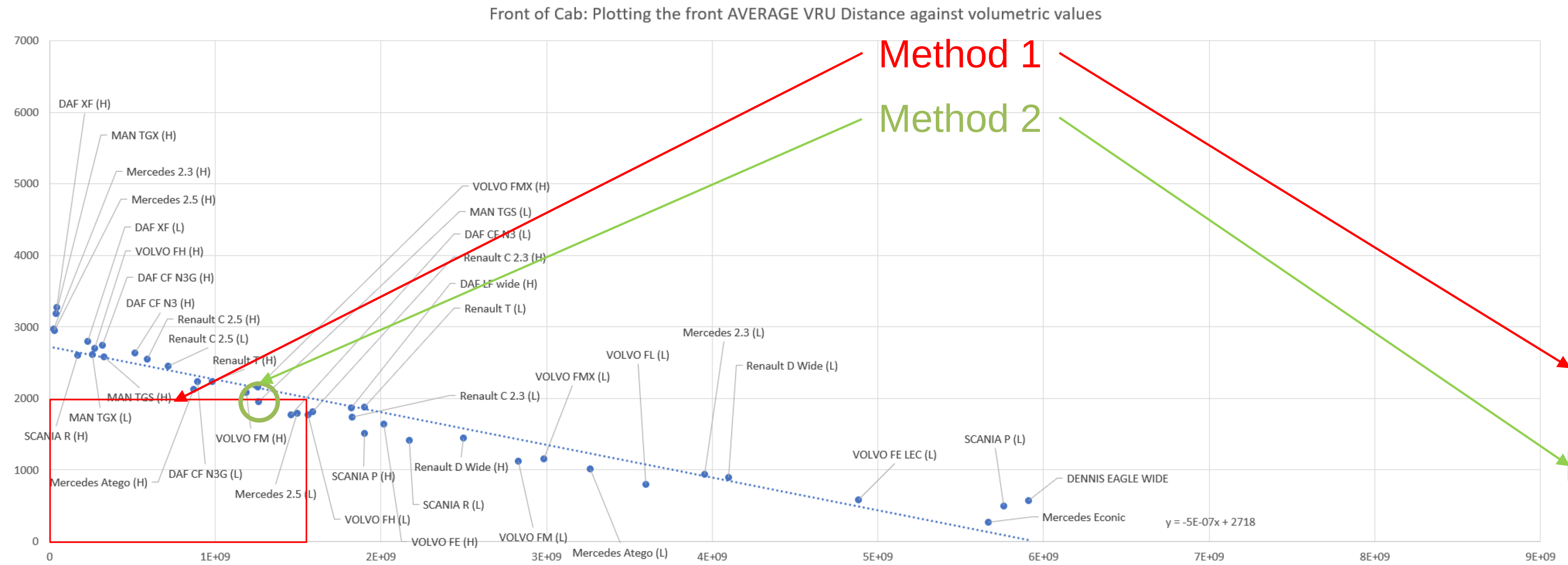


Table of average VRU distance to the front placed in numerical order

	VRU	VOL
Mercedes Econic	266.0	5.66E+09
SCANIA P (L)	500.3	5.76E+09
DENNIS EAGLE WIDE	572.0	5.91E+09
VOLVO FE LEC (L)	586.7	4.88E+09
VOLVO FL (L)	797.3	3.60E+09
Renault D Wide (L)	891.3	4.10E+09
Mercedes 2.3 (L)	942.7	3.95E+09
Mercedes Atego (L)	1012.0	3.26E+09
VOLVO FM (L)	1129.0	2.83E+09
VOLVO FMX (L)	1152.3	2.98E+09
SCANIA R (L)	1415.7	2.17E+09
Renault D Wide (H)	1445.0	2.50E+09
SCANIA P (H)	1517.0	1.90E+09
VOLVO FE (H)	1645.3	2.02E+09
Renault C 2.3 (L)	1744.7	1.83E+09
DAF CF N3 (L)	1769.0	1.46E+09
VOLVO FH (L)	1776.0	1.56E+09
Mercedes 2.5 (L)	1790.7	1.49E+09
Renault C 2.3 (H)	1816.3	1.59E+09
DAF LF wide (H)	1867.3	1.82E+09
Renault T (L)	1881.7	1.90E+09
MAN TGS (L)	1951.7	1.26E+09
VOLVO FM (H)	2084.0	1.18E+09
Mercedes Atego (H)	2126.3	8.68E+08
VOLVO FMX (H)	2156.3	1.26E+09
Renault T (H)	2238.7	9.80E+08
DAF CF N3G (L)	2239.3	8.91E+08
Renault C 2.5 (L)	2453.3	7.13E+08
Renault C 2.5 (H)	2546.7	5.90E+08
MAN TGS (H)	2582.0	3.26E+08
SCANIA R (H)	2599.3	1.67E+08
MAN TGX (L)	2619.7	2.58E+08
DAF CF N3 (H)	2641.0	5.14E+08
VOLVO FH (H)	2696.7	2.74E+08
DAF CF N3G (H)	2743.3	3.19E+08
DAF XF (L)	2803.0	2.29E+08
Mercedes 2.5 (H)	2952.3	2.99E+07
Mercedes 2.3 (H)	2970.0	2.35E+07
MAN TGX (H)	3189.0	3.64E+07
DAF XF (H)	3275.3	4.17E+07

1.44E+09

The two provide different results. Adopting the trend line approach produces a value of 1.44E+09 (1.44m3) which is close to the four vehicles highlighted in the table

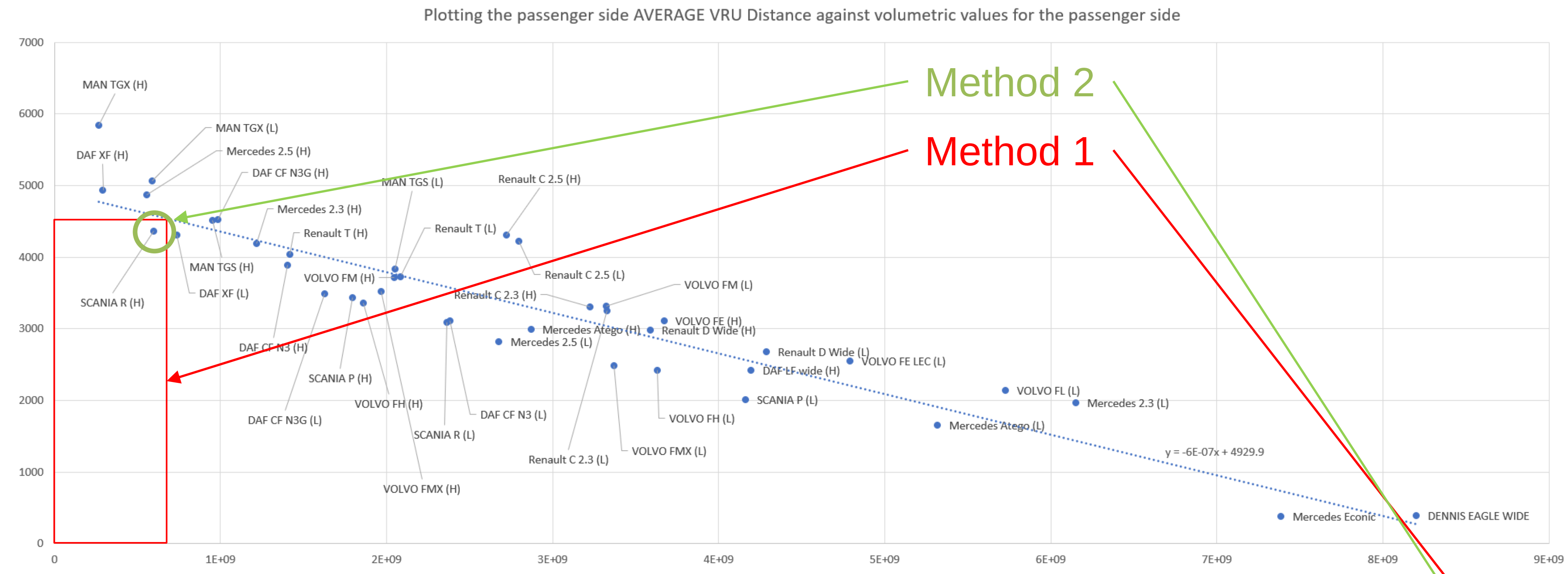
By finding the vehicle which has the closest average VRU distance to 2000mm the MAN TGS (L) would be boundary vehicle

Minimum passing Volume by Method 1 = 1.44 m^3

Minimum passing Volume by method 2 = 1.26 m^3

Two methods for defining the minimum requirement – Passenger side

Comparison of methods 1 & 2 for the Passenger side



The two methods provide different results. Adopting the trend line approach produces a result of 7.16E+08 (0.7m3) equivalent to the DAF XF (L).

By finding the vehicle which has the closest average VRU distance to 4500mm, the SCANIA R (H) would be the Boundary vehicle

Table of average VRU distance to the passenger side placed in numerical order

	VRU	VOL	
Mercedes Econic	383.6	7.39E+09	
DENNIS EAGLE WIDE	385.2	8.20E+09	
Mercedes Atego (L)	1651.4	5.32E+09	
Mercedes 2.3 (L)	1962.2	6.15E+09	
SCANIA P (L)	2008.2	4.16E+09	
VOLVO FL (L)	2143.8	5.73E+09	
DAF LF wide (H)	2414.6	4.20E+09	
VOLVO FH (L)	2419.526	3.63E+09	
VOLVO FMX (L)	2479.4	3.37E+09	
VOLVO FE LEC (L)	2549.4	4.79E+09	
Renault D Wide (L)	2679.6	4.29E+09	
Mercedes 2.5 (L)	2821.8	2.68E+09	
Renault D Wide (H)	2984	3.59E+09	
Mercedes Atego (H)	2991	2.87E+09	
SCANIA R (L)	3092	2.36E+09	
VOLVO FE (H)	3107.8	3.67E+09	
DAF CF N3 (L)	3111	2.38E+09	
Renault C 2.3 (L)	3250.6	3.33E+09	
Renault C 2.3 (H)	3308.6	3.22E+09	
VOLVO FM (L)	3318	3.32E+09	
VOLVO FH (H)	3353.8	1.86E+09	
SCANIA P (H)	3431	1.79E+09	
DAF CF N3G (L)	3487	1.63E+09	
VOLVO FMX (H)	3516.764	1.97E+09	
VOLVO FM (H)	3718.2	2.05E+09	
Renault T (L)	3726.6	2.08E+09	
MAN TGS (L)	3835	2.05E+09	
DAF CF N3 (H)	3889	1.40E+09	
Renault T (H)	4037	1.42E+09	
Mercedes 2.3 (H)	4188	1.22E+09	
Renault C 2.5 (L)	4221.8	2.79E+09	
DAF XF (L)	4308.6	7.38E+08	7.16E+08
Renault C 2.5 (H)	4309.4	2.72E+09	
SCANIA R (H)	4362.99	5.97E+08	
MAN TGS (H)	4517.4	9.54E+08	
DAF CF N3G (H)	4522	9.85E+08	
Mercedes 2.5 (H)	4866.4	5.56E+08	
DAF XF (H)	4929.4	2.89E+08	
MAN TGX (L)	5062.2	5.87E+08	
MAN TGX (H)	5837	2.69E+08	

Minimum passing Volume by Method 1 = 0.7 m^3

Minimum passing Volume by method 2 = 0.6 m^3

Two methods for defining the minimum requirement – Driver’s side

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Comparison of methods 1 & 2 for the driver side

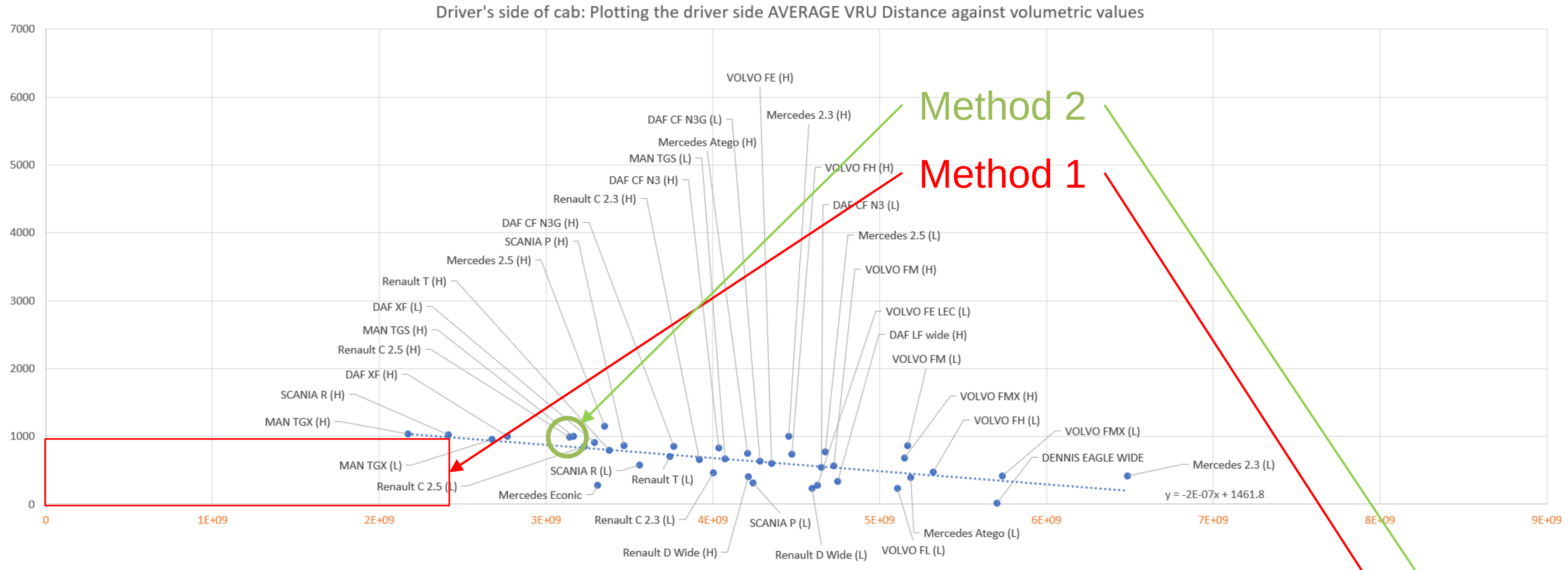

Table of average VRU distance to the Driver side placed in numerical order

	VRU	VOL	
DENNIS EAGLE WIDE	17.8	5.70E+09	
Renault D Wide (L)	231.4	4.59E+09	
VOLVO FL (L)	235.8	5.10E+09	
Mercedes Econic	275.6	3.31E+09	
VOLVO FE LEC (L)	284.2	4.63E+09	
SCANIA P (L)	316.6	4.24E+09	
DAF LF wide (H)	338.4	4.75E+09	
Mercedes Atego (L)	399.8	5.19E+09	
Renault D Wide (H)	405	4.21E+09	
Mercedes 2.3 (L)	413.582	6.48E+09	
VOLVO FMX (L)	422.8	5.74E+09	
Renault C 2.3 (L)	464.2	4.00E+09	
VOLVO FH (L)	472	5.32E+09	
DAF CF N3 (L)	540	4.65E+09	
VOLVO FM (H)	564.8	4.72E+09	
SCANIA R (L)	573	3.56E+09	
VOLVO FE (H)	597	4.35E+09	
DAF CF N3G (L)	634	4.28E+09	
Renault C 2.3 (H)	656.6	3.92E+09	
MAN TGS (L)	674.256	4.07E+09	
VOLVO FMX (H)	677.35	5.15E+09	
Renault T (L)	706.2	3.74E+09	
VOLVO FH (H)	739	4.47E+09	
Mercedes Atego (H)	755.4	4.21E+09	
Mercedes 2.5 (L)	767	4.67E+09	
Renault T (H)	795.4	3.38E+09	
DAF CF N3 (H)	828	4.03E+09	
Renault C 2.5 (L)	847.6	3.23E+09	
DAF CF N3G (H)	856.6	3.76E+09	
SCANIA P (H)	861	3.47E+09	
VOLVO FM (L)	868.6	5.17E+09	
DAF XF (L)	913.52	3.29E+09	
MAN TGX (L)	960.6	2.67E+09	
Renault C 2.5 (H)	994	3.14E+09	
DAF XF (H)	1002.8	2.77E+09	
MAN TGS (H)	1004.6	3.16E+09	
Mercedes 2.3 (H)	1007.2	4.45E+09	
SCANIA R (H)	1028.176	2.41E+09	2.25E+09
MAN TGX (H)	1040.6	2.17E+09	
Mercedes 2.5 (H)	1146.6	3.35E+09	

The two provide different results. Adopting the trend approach products a result of 2.25E+09 (2.25m3) which is between the values for the MAN TGX (H) and the Scania R High.

By finding the vehicle which has the closest average VRU distance to 1000mm the Renault C2.5 (H) would be the boundary vehicle.

Minimum passing Volume by Method 1 = 2.25 m^3

Minimum passing Volume by method 2 = 3.14 m^3

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Which method is appropriate?

- The two methods explored provide approaches for defining the minimum volumes to be seen to each side.
- The trend line approach uses data from all vehicles in the sample using the equation of the trend line to define the values and is the preferred approach by the LDS team.
- Therefore from the analysis performed and limits used the volumetric minimum requirement for a separated approach would require the following volumes to be visible to each side using a separated approach.

- **Front = 1.44 m^3**
- **Drivers side = 2.25 m^3**
- **Passenger side = 0.7 m^3**

- **Total = 4.39m^3**

- **This is much less than the TfL 1 star at 10.4m^3 and the EMSR at 8m^3. The reason for this is defined on the next slide.**

- There are negatives in taking this approach. Here we have set limits by a separated approach which are equivalent to having the VRU distance values at the edge of the assessment volume, as requested at the last meeting, which in turn requires the driver to have the mirrors adjusted accurately to allow the VRUs closer to the edges of the assessment volume to be seen.

- The result from this process is that we expect to see more from the driver's side (low risk of an accident) than we do from the passenger side, high accident risk.

Discussion of the separated approach

The tables illustrate that if a separated approach is taken using the limits of 4.5m, 2m, and 1m, there we would be a requirement for designs to be improved to allow better direct vison to the front of the cab.

However, as can be seen by the passenger side result, the majority of vehicles on the road would be meet the minimum requirement for vision. But we know that the passenger side is the area of greatest risk for accidents with pedestrians and cyclists.

These thresholds would therefore result in future designs which would improve vison to the front, but would not provide a strong impetus for improving vision to the sides.

Driver's side

	VRU	VOL
DENNIS EAGLE WIDE	17.8	5.70E+09
Renault D Wide (L)	231.4	4.59E+09
VOLVO FL (L)	235.8	5.10E+09
Mercedes Econic	275.6	3.31E+09
VOLVO FE LEC (L)	284.2	4.63E+09
SCANIA P (L)	316.6	4.24E+09
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MAN TGX (H)	1040.6	2.17E+09
Mercedes 2.5 (H)	1146.6	3.35E+09

Passenger side

	VRU	VOL
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VOLVO FL (L)	2143.8	5.73E+09
DAF LF wide (H)	2414.6	4.20E+09
VOLVO FH (L)	2419.526	3.63E+09
VOLVO FMX (L)	2479.4	3.37E+09
VOLVO FE LEC (L)	2549.4	4.79E+09
Renault D Wide (L)	2679.6	4.29E+09
Mercedes 2.5 (L)	2821.8	2.68E+09
Renault D Wide (H)	2984	3.59E+09
Mercedes Atego (H)	2991	2.87E+09
SCANIA R (L)	3092	2.36E+09
VOLVO FE (H)	3107.8	3.67E+09
DAF CF N3 (L)	3111	2.38E+09
Renault C 2.3 (L)	3250.6	3.33E+09
Renault C 2.3 (H)	3308.6	3.22E+09
VOLVO FM (L)	3318	3.32E+09
VOLVO FH (H)	3353.8	1.86E+09
SCANIA P (H)	3431	1.79E+09
DAF CF N3G (L)	3487	1.63E+09
VOLVO FMX (H)	3516.764	1.97E+09
VOLVO FM (H)	3718.2	2.05E+09
Renault T (L)	3726.6	2.08E+09
MAN TGS (L)	3835	2.05E+09
DAF CF N3 (H)	3889	1.40E+09
Renault T (H)	4037	1.42E+09
Mercedes 2.3 (H)	4188	1.22E+09
Renault C 2.5 (L)	4221.8	2.79E+09
DAF XF (L)	4308.6	7.38E+08
Renault C 2.5 (H)	4309.4	2.72E+09
SCANIA R (H)	4362.99	5.97E+08
MAN TGS (H)	4517.4	9.54E+08
DAF CF N3G (H)	4522	9.85E+08
Mercedes 2.5 (H)	4866.4	5.56E+08
DAF XF (H)	4929.4	2.89E+08
MAN TGX (L)	5062.2	5.87E+08
MAN TGX (H)	5837	2.69E+08

Front

	VRU	VOL
Mercedes Econic	266.0	5.66E+09
SCANIA P (L)	500.3	5.76E+09
DENNIS EAGLE WIDE	572.0	5.91E+09
VOLVO FE LEC (L)	586.7	4.88E+09
VOLVO FL (L)	797.3	3.60E+09
Renault D Wide (L)	891.3	4.10E+09
Mercedes 2.3 (L)	942.7	3.95E+09
Mercedes Atego (L)	1012.0	3.26E+09
VOLVO FM (L)	1129.0	2.83E+09
VOLVO FMX (L)	1152.3	2.98E+09
SCANIA R (L)	1415.7	2.17E+09
Renault D Wide (H)	1445.0	2.50E+09
SCANIA P (H)	1517.0	1.90E+09
VOLVO FE (H)	1645.3	2.02E+09
Renault C 2.3 (L)	1744.7	1.83E+09
DAF CF N3 (L)	1769.0	1.46E+09
VOLVO FH (L)	1776.0	1.56E+09
Mercedes 2.5 (L)	1790.7	1.49E+09
Renault C 2.3 (H)	1816.3	1.59E+09
DAF LF wide (H)	1867.3	1.82E+09
Renault T (L)	1881.7	1.90E+09
MAN TGS (L)	1951.7	1.26E+09
VOLVO FM (H)	2084.0	1.18E+09
Mercedes Atego (H)	2126.3	8.68E+08
VOLVO FMX (H)	2156.3	1.26E+09
Renault T (H)	2238.7	9.80E+08
DAF CF N3G (L)	2239.3	8.91E+08
Renault C 2.5 (L)	2453.3	7.13E+08
Renault C 2.5 (H)	2546.7	5.90E+08
MAN TGS (H)	2582.0	3.26E+08
SCANIA R (H)	2599.3	1.67E+08
MAN TGX (L)	2619.7	2.58E+08
DAF CF N3 (H)	2641.0	5.14E+08
VOLVO FH (H)	2696.7	2.74E+08
DAF CF N3G (H)	2743.3	3.19E+08
DAF XF (L)	2803.0	2.29E+08
Mercedes 2.5 (H)	2952.3	2.99E+07
Mercedes 2.3 (H)	2970.0	2.35E+07
MAN TGX (H)	3189.0	3.64E+07
DAF XF (H)	3275.3	4.17E+07

Which method is appropriate?

Therefore it is our view that the separated approach should be using limits that are closer to the side of the vehicle for the passenger side to determine the minimum volumetric score.

What evidence do we have for how well mirrors are adjusted to be able to meet the minimum requirements for UNECE regulation 46?

Our own work in 2015 highlighted that if the mirrors are setup perfectly for a taller driver, that these mirrors would then need to be adjusted for a smaller driver to ensure that blind spots are removed. Our own discussions with fleet operators highlighted that mirrors are not always adjusted during a handover of the same vehicle between two drivers.

Task 4: Explore the effect of removing mirrors and windscreen wipers.

- We have removed the mirrors and wipers (on the premise that they can be designed to have a resting position below the windscreen) for 14 vehicles across the range of the full sample
- The following results show how this can improve the rating of a vehicle

Loughborough University

Showing effects of removing mirrors and wipers on the star rating

Showing the improvement that can be acheived by removing the mirrors and lowering the resting postiion of the windscreen wipers below the windscreen line for 14 vehicles

Dennis Eagle, 5star

Volvo Fl (L) improves from 3 star to 4 star

Volvo FM (L) improves from 1 star to 4 star

Merc Atego (L) improves from 2 star to 4 star

Volvo FH (L) improves from 1 star to 2 star

Ren C 2.3 (L) improves from EMSR star to 1 star

Ren T (L) improves from Zero star to 1 star

Merc Atego (H) improves from Zero star to EMSR

Volvo FH (H), zero star

Ren T (H), Zero star

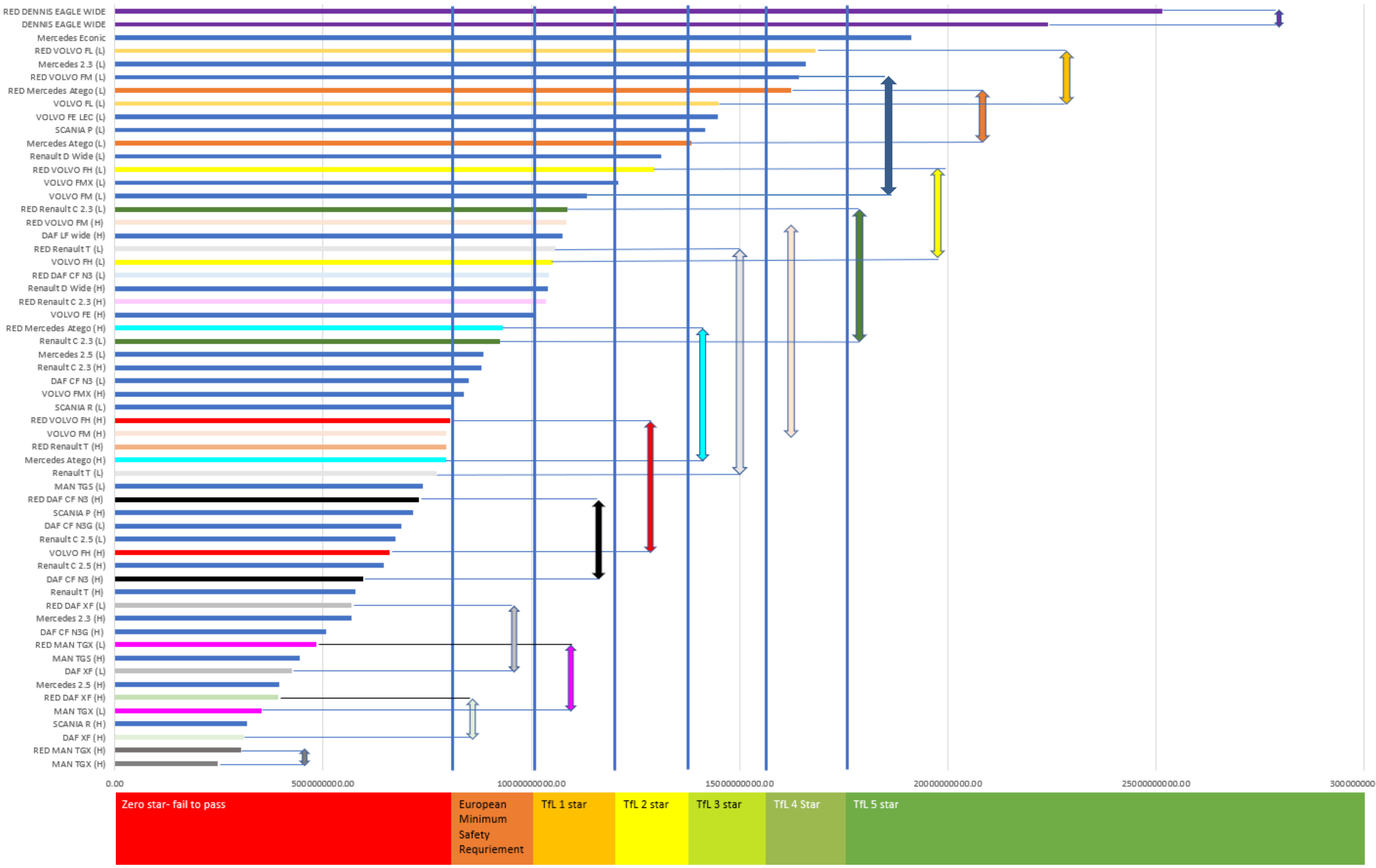
DAF CF N3 (H), Zero star

DAF XF (L), Zero star

MAN TGX (L), Zero Star

DAF XF (H), Zero Star

MAN TGX (H), Zero Star



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Summary for removing mirrors and lowering wipers where required.

- It is clear that removing mirrors and lowering wipers improves direct vision.
- The biggest improvement is for the Volvo FM (L) which improves from TfL 1 star to TfL 4 star.
- The largest improving effect is found by removing the mirrors, and so it is clearly possible for a vehicle to improve performance to the sides without improving performance to the front, especially in a case where the wipers are already set below the windscreen.
- Therefore the separate approach is recommended in order to reduce the possibility of vehicles passing the minimum requirement in a combined approach whilst having a vehicle which does not meet the minimum requirement to the front.

Final summary

- The analysis of the separated approach highlights that if vehicle designs are to be improved to the passenger side in particular, then the identification of the minimum volume to that side needs to use a VRU average distance that is less than 4.5m.
- Where the limit should be set needs to be further explored and discussed in the meeting.
- However the separated approach does have advantages and we would recommend it for the identification of volumetric limits.
- The analysis of the a situation where mirrors are removed and wipers are mounted below the windscreen line, highlighted that DVS scores can be significantly improved e.g. the Renault T (L) improves from zero star to 1 star but fails to the front. This improvement would be predominantly to the sides of the truck, and therefore it is possible for a vehicle to pass to the sides but not the front if this approach was used for a combined approach.
- Therefore the separated approach is recommended.
- It is our opinion that this analysis highlights that a Differentiated approach to the application of DVS limits to different vehicles types would improve the effectiveness of the DVS as opposed to a ‘one size fits all’ minimum requirement.