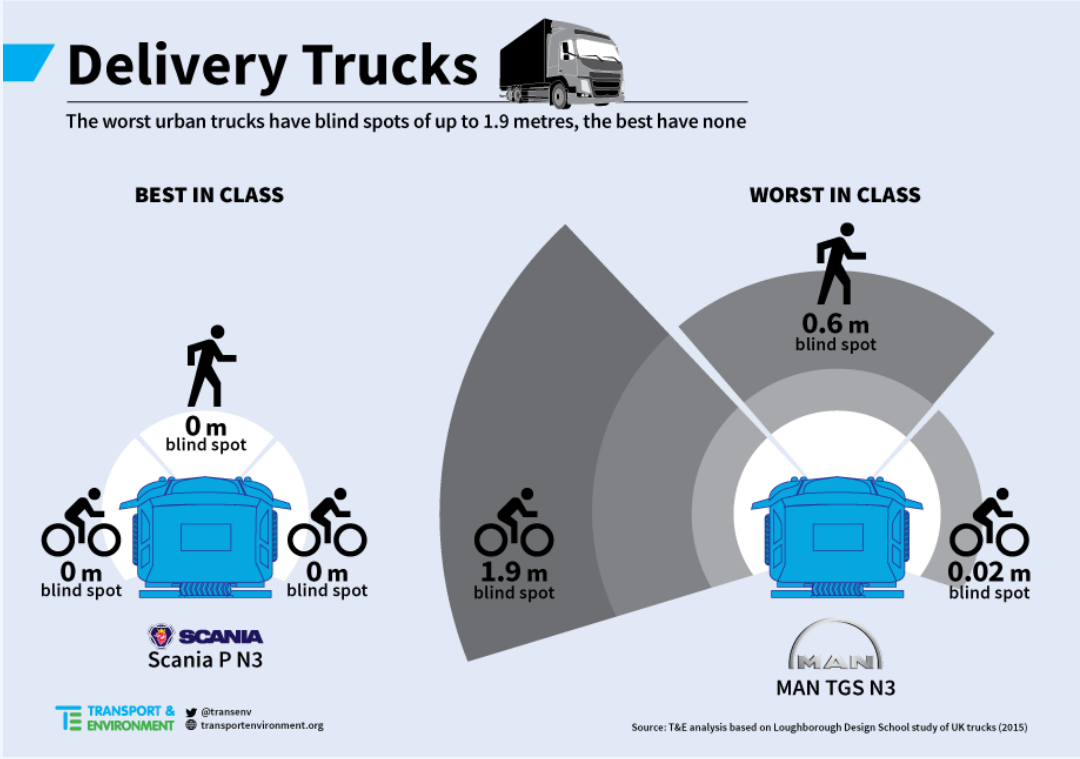
Eliminating truck blind spots – a matter of (direct) vision

A comparison of best vs worst in class truck direct vision

July 2016

Summary

The way trucks are designed and configured has a major impact on what truck drivers are able to see from their cab (direct vision). A new study by Loughborough Design School (LDS) has analysed the direct vision and blind spots of top selling trucks in all vehicle categories (long-haul, construction, urban). The study shows that there are large differences between best and worst-in-class performance. This infographic summarises the findings of the report for delivery trucks.



The EU is currently planning new vehicle safety requirement for trucks. Based on the findings of the LDS report we recommend that the EU should set direct vision standards for trucks – specifying what truck drivers need to see with their own eyes – and mandate at least best-in-class performance for different truck categories. But there is potential to do better than what is currently best in class. Indeed, the report shows how so-called "low-entry cabs" (see below) outperform virtually all of the current best-in-class performers. Generalising their application, in particular for vehicles used in urban transport, would have major safety benefits. In addition, the recently agreed directive 2015/719 provides truckmakers with 800-900mm of extra design space. This extra design space (+30%) must be used to redesign long-haul and construction cabs in a safer manner. The Commission has indicated it will introduce direct vision standards for trucks but only from 2028. This briefing shows that vehicles with good direct vision are already on the market, and that there is no reason to wait until 2028 to mandate direct vision improvements.

Figure 1: Mercedes Econic low entry cab

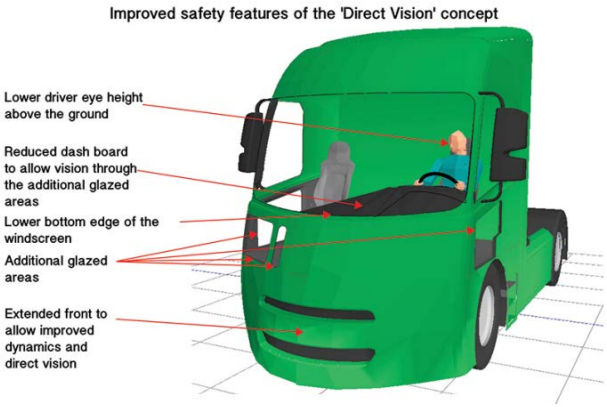


Figure 2: The Loughborough/FKA direct vision concept[i]

1. Introduction: the truck safety problem

Every year 4,000 Europeans die in truck crashes leaving many more seriously injured.[ii] Because of their weight, size and their poor (brick shaped) design trucks' safety impact is disproportionate: with just 3% of vehicles, trucks are involved in 15% of road deaths. A quarter of truck fatalities are vulnerable road users. In 2013, 978 cyclists and pedestrians (vulnerable road users) died in an accident involving a truck. Overall the number of vulnerable road user fatalities in the EU is decreasing much slower[iii] than the total fatality decrease.[iv]

Vulnerable road users (VRUs) including pedestrians, cyclists and motorcyclists account for almost half of the road victims, and their proportion is even higher in urban areas. Twenty eight percent (28%) of fatal truck crashes occur in urban environments and more than half of truck crashes involving cyclists and pedestrians in urban areas, occur at relatively low speeds.[v]

The truck blind spot problem is widespread and well-attested:

- In Belgium, 43% of cycling fatalities involve trucks, in Holland 38% and in the UK 33%. In some cities, like London, trucks cause more than 50% of cyclist deaths.[vi]
- In Denmark, over the last decade, 50 cyclists died in right-turn accidents with trucks.[vii] A survey by the Danish Road Safety Council showed that overall, right-turn accidents with trucks constitute 15 to 20 % of all cyclists killed in traffic.
- In the Netherlands on average nine cyclists die every year in blind spot/right-turn accidents (2005-2009 average).[viii]
- In Germany 23 cyclists lost their lives in right-turn accidents with a HGV in 2012.[ix]

Analysis[1] of UK statistics suggest the 3 main danger zones around the truck cab are: the front of the lorry (when the lorry pulls away), the left (rest of the EU right) and the right (rest of the EU left) crashes for turning accidents.[x]

[1] SUMMERSKILL, S., MARSHALL, R. and LENARD, J., 2014. The design of category N3 vehicles for improved driver direct vision. Loughborough Design School.

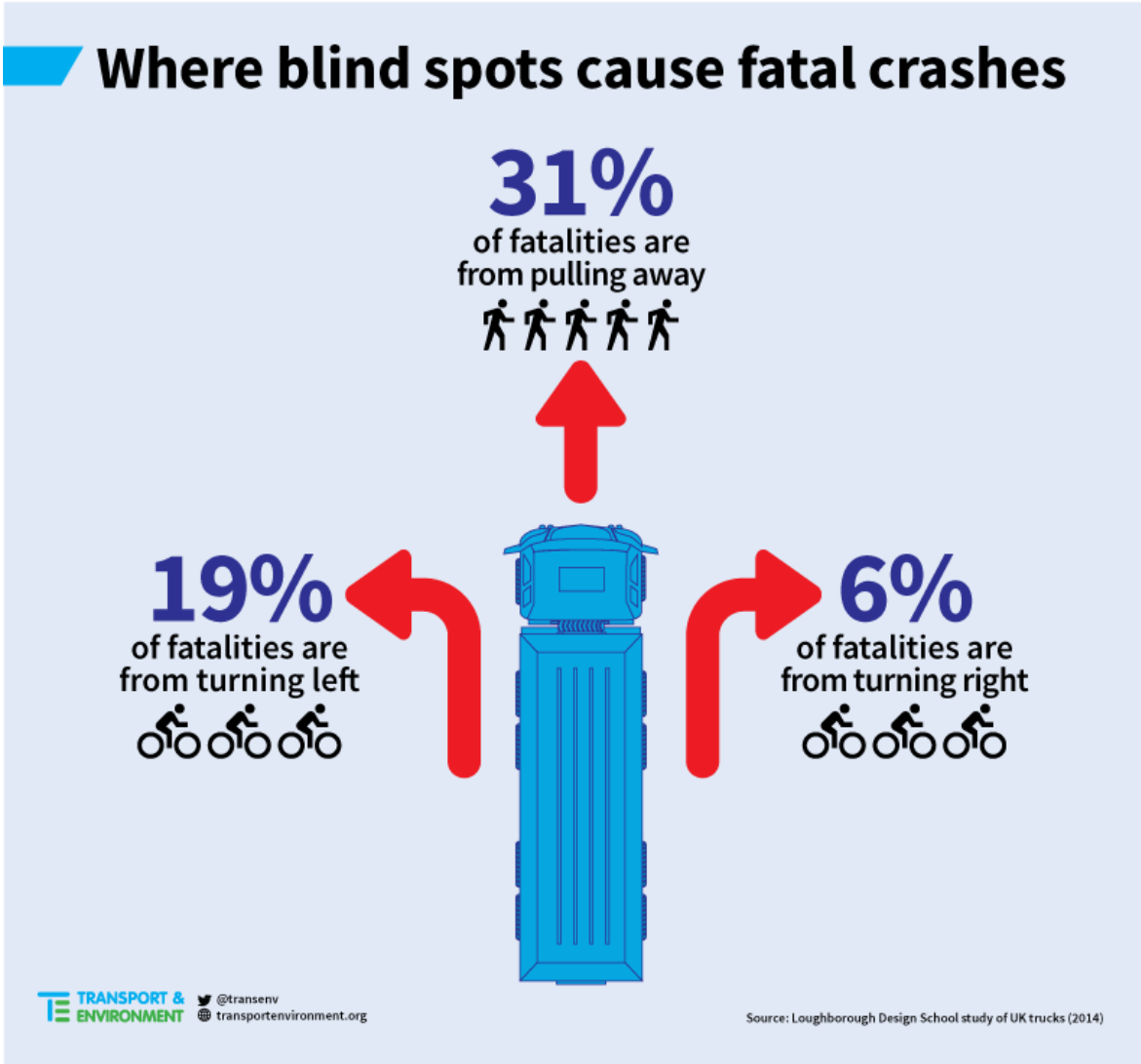


Figure 4: based on Loughborough Design School 2014[xi]

The issue of trucks and VRUs is not going to go away. Indeed, a combination of urbanisation, policies to promote cycling and walking, the rise of e-commerce and continued construction and development in and around cities means that this will become a bigger problem.

2. A once-in-a-decade opportunity: Europe's new vehicle safety standards

The European Commission is currently reviewing the EU vehicle safety regulations (General Safety Regulation/GSR and Pedestrian Safety Regulation).[xii] A communication on the Commission's assessment is scheduled after the summer of 2016 and a formal proposal is expected to come out in 2017. New vehicle safety rules would be compulsory for all newly produced vehicles in the EU. The Commission is currently assessing how it can improve truck direct vision.

The Commission's work on the vehicle safety regulations follows a recent agreement to relax the rules that regulate truck design. Historically the EU has limited the overall length of truck combinations (truck + trailer/body). This has led to the typical EU cab-over-engine designs which minimise space of the tractor and driver and maximise cargo space. This high position – the driver sits on top of the engine block - makes much of what happens around the cab invisible to the driver and explains why "blind spots are a major factor in many accidents involving trucks".[xiii] But the recently adopted Directive 2015/719 will allow extra

length (around 900mm, or 30% extra) to enable new designs. Depending on the speed of implementation new designs would be enabled – but not mandated – from around 2022.

The extra design space creates multiple opportunities for improvement, one of which is direct vision. A 2014 briefing by Transport & Environment, based on research by the Loughborough Design School suggested that by redesigning big tractor cabs you could improve their direct vision performance by 50% - see figure 2.[xiv] A preparatory report by the Transport Research Laboratory (TRL) identified truck frontal design as one of the major areas where safety could be improved. TRL estimates safer frontal design (better vision plus better crash performance) could save up to 900 lives annually.[xv]

3. EU policy to date: mirrors, mirrors and… more mirrors

In the last decades, policy makers have mainly focused on improving the **indirect vision** of trucks - the area around the truck that is visible through mirrors. This has led to six mirrors now being standard for new trucks.[xvi] In theory these mirrors should eliminate a large part of the blind spot around the truck cab. However, mirrors provide a distorted image: often only (a small) part of the cyclist or pedestrian is clearly visible. Drivers also need to check several mirrors which often are not correctly adjusted. This may help explain why the fitting of extra mirrors has not produced the safety improvements that were initially expected. In addition, research by the Loughborough Design School (LDS) shows that despite the multiple mirrors there remain blind spots where the driver is unable to see pedestrians or cyclists.[xvii]

Figure 5: Class II, IV, V, VI mirrors

4. Solving the truck blind spot problem: direct vision

Direct vision, i.e. seeing something with your own eyes, has a number of advantages over indirect vision. First of all, with direct vision you don't have problems of distorted images or poorly adjusted mirrors. Secondly, seeing something directly also reduces the time needed to "scan" a traffic situation. Thirdly, it is likely that direct vision also has a number of 'cognitive' benefits over indirect vision. That means that people react differently to something they see directly. In fact, one of the key principles of traffic safety is that you should **stop, look and wave**[xviii] and make contact with other traffic participants.

For trucks, better direct vision usually means lowering the position of the driver. This doesn't only increase what he can see, it also puts truck drivers closer to the level of other participants in (urban) traffic. The University of Leeds is currently investigating possible benefits of eye contact and direct vision as opposed to indirect vision.[2] But even today, there is broad agreement among experts that improved direct vision would be highly effective in preventing casualties. TRL 2015 estimated the lifesaving potential of better direct vision to be up to 553 lives saved per year in the EU.[xix]

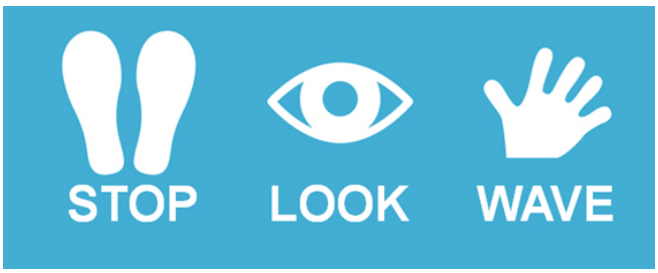


Figure 6: the "stop look wave" principle is promoted by safety organisations around the world

[2] The final report is expected after in September-October 2016.

5. Direct vision: great potential for improvements

There is significant potential to improve truck direct vision. Low entry cab vehicles such as the Mercedes Econic eliminate most of the typical blind spots around cab-over-engine trucks and are ideally suited for delivery vehicles. But there is a lot of potential for big trucks too. A 2014 study by Loughborough Design School found that big tractor cabs could have 50% better direct vision.[xx] There are also a number of other concept vehicles that could drastically improve direct vision.[xxi]

But even without moving to new designs or low entry vehicles there is significant room for improvement. A new study commissioned by Transport for London and carried out by Loughborough Design School[xxii] compares the direct vision performance of top selling vehicles in the UK and finds that the direct vision performance of trucks can be improved significantly with conventional, off-the-shelf designs and configurations whilst low entry cabs offer even more radical improvements.

5.1. Methodology of the study

LDS used a virtual modelling technique to model and simulate the different accident scenarios for a selected number of vehicles. In total 19 vehicle models have been created by digitally scanning real world vehicles. The vehicles that have been modelled are divided into four categories: large distribution (highway) vehicles, urban distribution vehicles, construction vehicles and high vision low entry cabs. The brands of the different models are DAF, MAN, VOLVO, Mercedes, Scania and Dennis Eagle and the vehicles are the top selling vehicles (cabs + cab configuration[3]) in their respective category in the UK haulage market. Although this is a UK study, the results are relevant for the rest of the EU too. The one major difference is that on the continent the position of the driver is different.

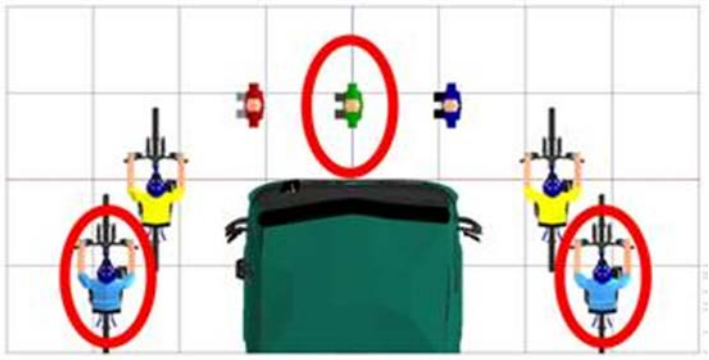


Figure 7: position of the VRU's around the truck cab for LDS assessment

The research focused on the three areas where the majority of the fatalities happen. These three areas are the front, left and right of the cab.

Figure 8: accident configurations analysed by LDS (pedestrian in front of cab, cyclist left & right of cab)

[3] It is not just about the actual cab – which can be the same for different categories - but also about the way the cab is mounted on the chassis and more generally the way an operator specifies/configures the vehicle.

5.2. Best vs Worst in Class

LDS modelled the performance of top selling trucks (in their typical configuration) in different traffic situations. For each of these traffic situations it ranked the cabs in terms of 'direct vision performance'. The LDS study shows there are large variations in the direct vision performance of the top selling cabs. Below we describe the situation for the three main categories: large distribution vehicles, urban distribution vehicles and construction vehicles. We use the LDS results but have combined the vulnerable road user obscuration – i.e. how far does a VRU need be removed from the cab to become visible (see figure 9) - of three positions: passenger side rear cyclist, the central pedestrian, and the driver side rear cyclist (see figure 7) which account for most of the blind spot fatalities involving a HGV in the UK in one year.[xxiii] We added up the obscuration scores of these three positions for each vehicle to give an overall score to all the different cab models of the different brands. The total obscuration distances – added together - are not a reflection of how long/big the blind spot actually is but a reflection of how much larger blind spots are for one model compared to another.

VRU obscuration explained: "Now you see me, now you don't"

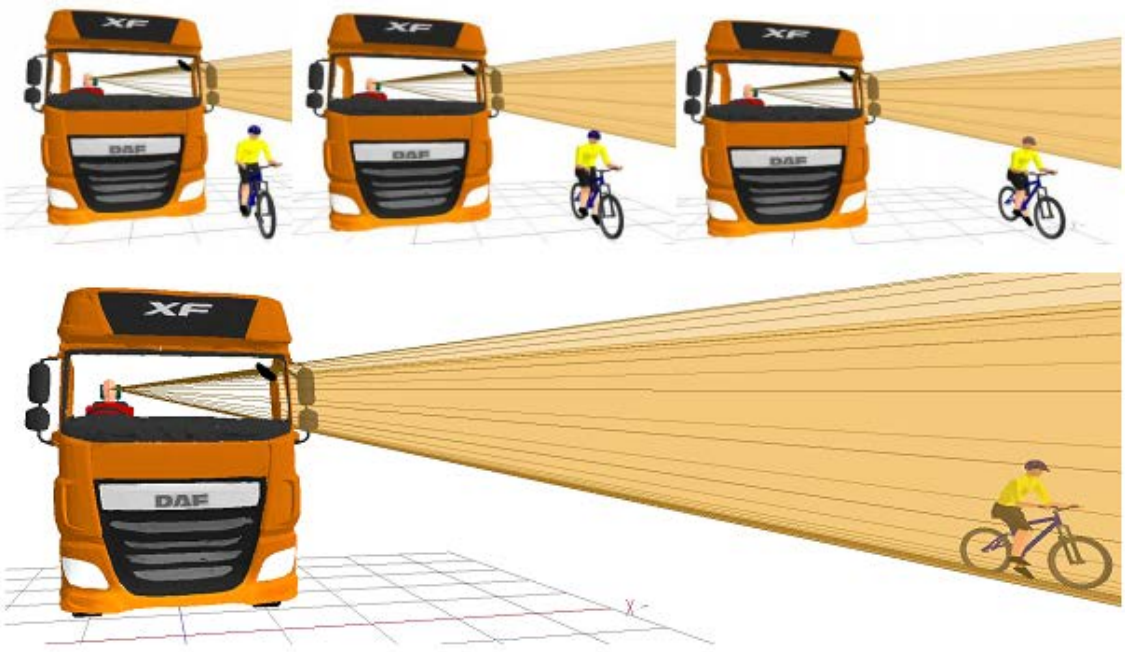


Figure 9: Top-Middle: cyclist is at the furthest point from the vehicle in which they are not visible. Top-Right: cyclist's head is visible. Bottom picture: seen from a DAF XF cab a cyclist would only become fully visible from 1,8m away from the cab.

5.2.1. Large distribution trucks (long haul)

Large distribution vehicles are the kind of tractor-trailer cabs that you typically find on highways. These vehicles are usually pulling a trailer and are designed for regional or long haul operations. However, they are also regularly used in (sub-)urban operations, e.g. when going to and from warehouses or supermarkets.

Figure 10: typical long haul tractor cabs

A comparison between the different vehicles show that there is a considerable gap between the performance of the MAN TGX and the Volvo FH N3. **Overall VRUs can be nearly twice as far away from the cab and still be hidden to the MAN TGX when compared to the Volvo FH**. In that sense the Volvo FH performs 47% better than the MAN. But even the difference between the Scania and the Volvo is significant (23%).

The comparison of the different tractor cabs demonstrates that there would be considerable benefit in moving towards the best in class direct vision performance (in this case the Volvo FH) of the market. But a direct vision standard could likely go beyond best in class, especially when you take into account the new design possibilities that arise from the review of the truck dimensions legislation. For example, the extra design space would enable a lower driver position.

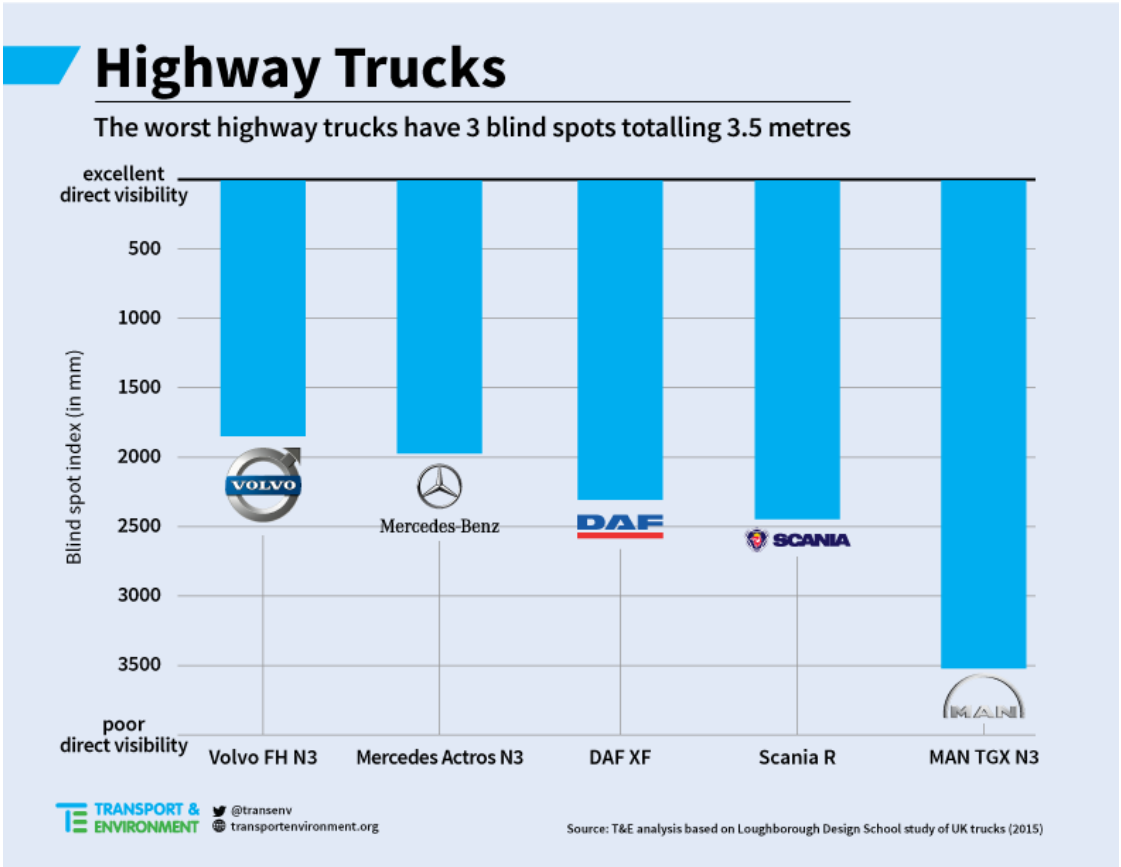


Figure 11: blind spot ranking for representative highway trucks

5.2.2. Urban distribution trucks

Urban distribution vehicles are typically used to deliver goods to shops and restaurants in and around cities. Contrary to the big trucks they are usually not pulling a trailer but instead have a fixed 'body'. These 'rigid' vehicles are smaller, more manoeuvrable, lighter and have smaller engines. This should make it comparatively easier for small rigid trucks to have good direct vision.

Figure 12: typical urban delivery cabs

The comparison of the vehicles assessed by LDS shows that the direct vision of the urban distribution vehicles varies even more than that of large distribution vehicles. The difference in direct vision between the best (Scania P N3) and worst (MAN TGS N3) is very high since you can go from 2724mm of total obscuration to no obscuration at all. The Scania P has many of the characteristics of a low entry cab and therefore scores very well. But even the difference between the MAN and the Volvo cab (configuration) is very big. Again, setting a direct vision standard that mandates at least best in class performance would enable major safety advances. However, the potential for urban distribution vehicles is even greater. As shown in section 5.2.4 low entry cabs could simply eliminate many of the most deadly blind spots for urban trucks.

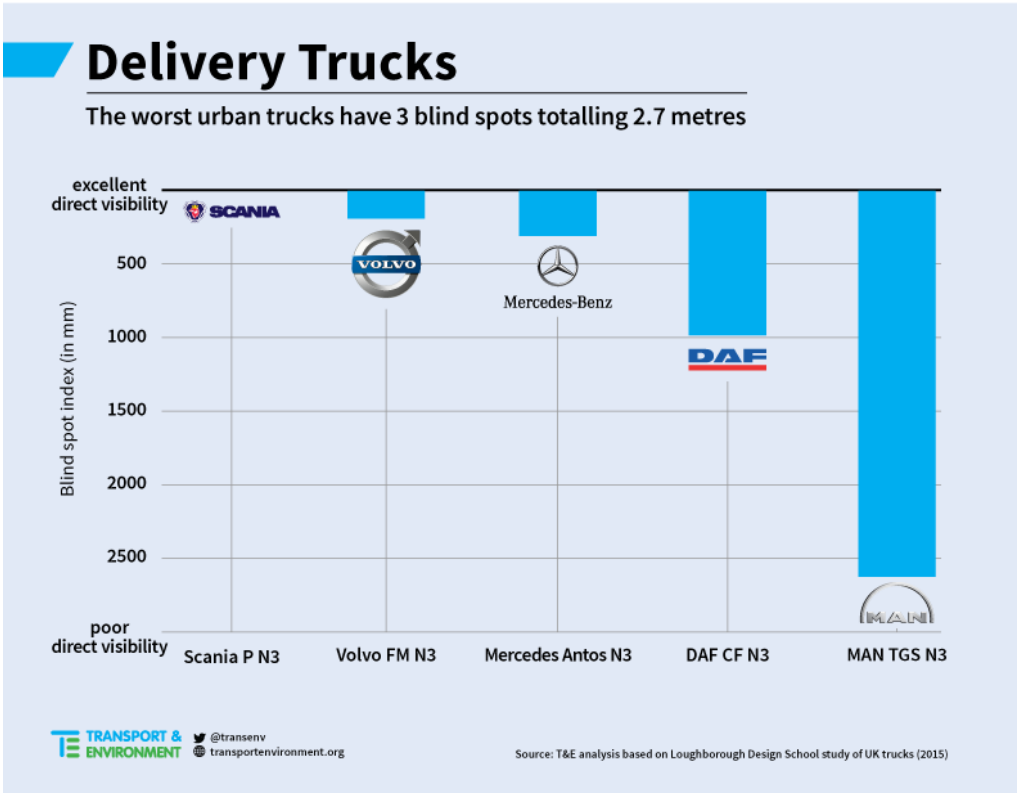


Figure 13: blind spot ranking for representative delivery trucks

5.2.3. Construction trucks

Construction vehicles are used to transport construction material (e.g. tippers carrying sand or concrete mixers). Construction vehicles are designed and configured[4] for off-road conditions – i.e. they have very high ground clearance - but very often operate in urban areas since this is where a lot of construction happens. It is debatable whether such high ground clearance is really required for the majority of construction vehicles. Operators often configure vehicles for all use cases resulting in higher cabs that are designed for a wide range of uses including off road. This suggest operators are considering factors such as resale values in their purchasing decisions.

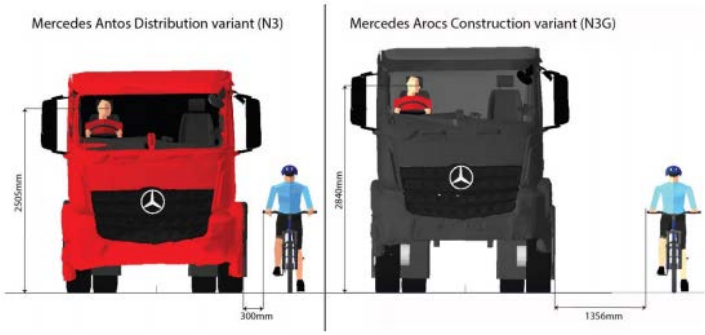


Figure 14: construction trucks typically have higher "ground clearance" which increases the obscuration distance and blind spots

The LDS study shows that construction vehicles typically have larger direct vision blind spots than large or small distribution vehicles, especially due to the higher position of the driver. On average N3G (i.e. construction) cabs are 32 percent higher than normal distribution cabs (see figure 14). This can be related to the cab itself but also to how the cab was configured. For a construction cab the obscuration distance for pedestrians is on average nearly three times bigger than the N3 cabs. With regards to cyclists to the passenger side, the obscuration distance is on average more than two times greater.

Figure 15: typical construction cabs

However, there is also a big difference *between* construction trucks. A comparison of different construction variants shows VRUs can be more than twice as far away from the cab and still be hidden in MAN TGS when compared to the Volvo FMX. In that sense you could argue an 82% improvement in direct vision could be

[4] It is not just about the actual cabin – which can be the same for different categories - but also about the way the cab is mounted on the chassis and the way you specify/configure the vehicle.

achieved by shifting to the best in class design (and configuration) on the market. It would probably be possible to do even better than. Indeed, Mercedes and Denis Eagle have recently presented 'low entry' tipper vehicles.

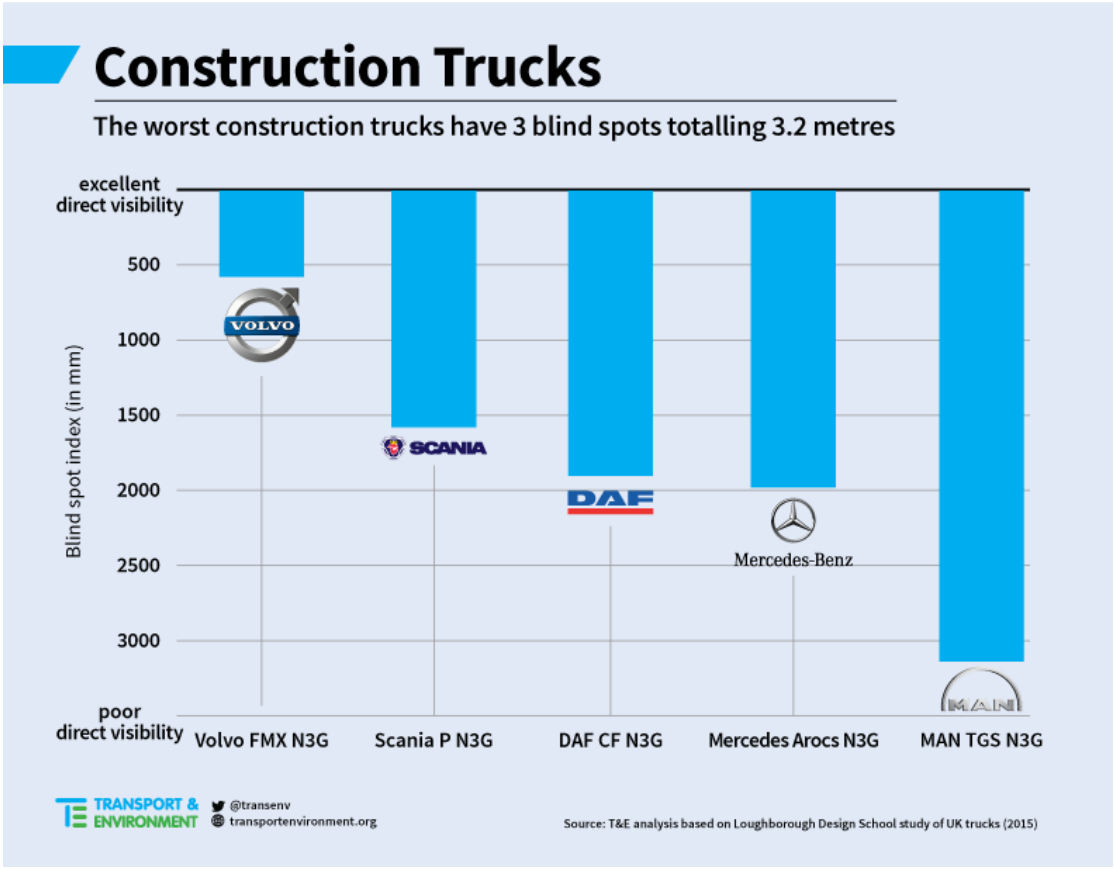


Figure 16: blind spot ranking for representative construction trucks

Hors catégorie: low entry cabs

Low entry cabs are trucks where the driver doesn't sit on top of the engine. Instead, the engine is moved a bit to the back and the driver's position is lowered almost to the level of other traffic participants. If you combine this with a good positioning of the driver in the cab (not too much to the front) and smart design of the windows and the windscreen, a driver sitting inside a low entry cab can see - with his own eyes - almost anyone walking, driving or cycling around him. In the Loughborough report all the low entry cabs are assessed as having the same excellent high direct vision performance – so ranking them makes no sense. Low entry cabs are typically used for urban delivery vehicles and are currently not available for long distance traffic (limited engine size) but Mercedes and Denis Eagle have recently presented 'low entry' construction vehicles.

Figure 17: the Mercedes Econic, Volvo FE, Denis Eagle low entry tipper provide excellent close range

visibility and are ideally suited for urban traffic

6. How to regulate truck direct vision

Transport for London (TfL) has commissioned Transport Research Laboratory (TRL) to develop a method that allows measuring the HGV direct vision. It took into account casualty data to assess the area of greatest risk in close proximity to the HGV. Based on this it determined where a pedestrian or cyclist needs to be seen in order for a driver to be able to take evasive action. It also determined *how much* of the cyclist/pedestrian need to be visible for this to be possible. Based on this TRL developed an assessment method that precisely measures the direct vision from HDVs. The protocol categorises vehicles in four performance bands based on the ability of the driver to see vulnerable road users in close proximity. The system is based on an internationally recognised format to allow it to be implemented on wider scope for example across Europe. The European Commission could build on this procedure and develop an EU direct vision standard measurement methodology. The final TRL report will be available shortly.

7. Policy recommendations

Trucks pose a disproportionate risk to vulnerable road users, especially in urban areas. This is a problem that will grow in importance, unless additional action is taken. The Commission's review of the vehicle safety regulations provides a unique opportunity to address the problem and set direct vision standards for new trucks.

This briefing has shown that there are big **differences between best and worst in class** performance of vehicles (large, urban and construction trucks) currently on sale. The height of the driver eye point above the floor is a critical factor in the direct vision performance of a truck. Setting a direct vision standard that would force at least best in class performance would already produce significant benefits but there is potential to go beyond that. Indeed, low entry cabs outperform the current best in class performers and the new design rules could enable further improvements.

Recommendations to the European Commission

1. **Introduce direct vision standards for trucks**. Contrary to passenger cars, there are currently no direct vision requirements for trucks. Direct vision – what you can see with your own eyes – has a number of benefits compared to indirect vision (mirrors and camera's). To measure direct vision the Commission should use a standardised methodology.
2. **Introduce differentiated direct vision standards for different truck categories**. Construction vehicles, long haul and urban vehicles have different characteristics and potentials for improvement. Urban trucks clearly have the biggest potential whereas construction vehicles with off-road capability are more challenging. The exact classification needs to be further researched but it is clear that one-size-fits-all approach would deliver suboptimal results. Setting a one-size-fits-all direct vision standard would end up having little impact as it would likely be tailored to the lowest common denominator.
3. Introduce a direct vision standard that effectively mandates direct vision equivalent to **low entry cab designs for urban distribution vehicles.** The Commission should also apply this standard to light commercial vehicles (vans) since these vehicles often compete with urban trucks and the direct vision standard should not lead to an additional shift from N2 to N1 vehicles.
4. **Mandate <u>at least</u> best in class direct vision for large distribution trucks** (tractor-trailer/long haul) and investigate the potential to go beyond best in class in light of the new design opportunities unlocked by the new weights and dimensions directive. The LDS/FKA concepts has shown that significant further improvements are possible.

5. **Mandate at least best in class direct vision for construction trucks** and investigate the potential to go beyond best in class. New vehicle safety standards should be designed to discourage high ground clearance. Where there are objective limits to how much the driver position/ground clearance can be lowered, additional measures must be taken to compensate for this. For example, the Commission could consider being more aggressive when it comes to the application of active safety features (e.g. AEBs linked to cyclist/passenger detection, sensors, camera's) for N3G vehicles (both in scope and timing).

When should direct vision standards become compulsory?

In March 2016 the Commission has indicated in the Motor Vehicle Working Group it thinks of 2028 as a starting date for its new direct vision rules.[5] On reason why the Commission seeks a long transition period is that by 2028 the rules would be applicable to all newly produced vehicles (first new models, then all vehicles after 2028) and the truck manufacturing industry wants time to continue selling its current products. However, given that better vision cabs are already available on the market and in all market segments (best in class, smarter configurations, low entry vehicles) a 2028 deadline is not justifiable. To provide additional flexibility to manufacturers the Commission could consider two alternative approaches:

1. **To mandate the safety requirement for all cabs benefiting from the additional design space** granted by Directive 2015/719. This would not be mandatory – manufacturers are not obliged to use the extra design space - but in practice it makes it likely that a number of new vehicle models would already comply with the new safety rules in 2022. One question mark is to what extent this would affect urban or construction vehicles since space constraints mostly affect large distribution/long haul trucks.

To gradually phase in the requirements. Instead of applying the new standard to a*ll vehicles all at once* the Commission could propose to only apply the standard to a certain percentage of vehicles (e.g. 20% in 2022). This could then be increased annually to 100% in e.g. 2028. This approach would also require a monitoring and reporting mechanism as well as corrective action for manufactures that do not comply. Alternatively the vision standard could be tightened over time (e.g. mandate small improvements first, move to best in class second and require design changes last). This is somewhat similar to the US model year approach.

Further information

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Endnotes

[i] T&E, Ending lorries' deadly track record: a matter of (direct) vision, 2014.
[ii] http://ec.europa.eu/transport/road_safety/pdf/statistics/dacota/bfs2015_hgvs.pdf
[iii] For pedestrians 11% compared to 18% and for cyclists 8% compared to 18%
[iv] http://europa.eu/rapid/press-release_MEMO-16-864_en.htm
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[xi] SUMMERSKILL, S., MARSHALL, R. and LENARD, J., 2014. The design of category N3 vehicles for improved driver direct vision. Loughborough Design School, p9.
[xii] For an outline of its plans, see this presentation: http://www.utacceram.com/images/utac/actus/Regulations_Review-General_and_Pedestrian_Safety.pdf
[xiii] http://ec.europa.eu/transport/road_safety/topics/vehicles/blind_spot_mirrors/index_en.htm
[xiv] T&E, *Ending lorries' deadly track record: a matter of (direct) vision,* 2014, p5. Please note that the calculation method for the methodology for this calculation is not the same as the one used in this briefing.
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[xv] http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8200&lang=en p 329-345.
[xvi] Transport Research Laboratory (Hynd, D., et. Al.), *Benefit and Feasibility of a Range of New Technologies and Unregulated Measures in the fields of Vehicle Occupant Safety and Protection of Vulnerable Road Users*, 2015, p. 130.
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[xviii] http://www.volvogroup.com/group/global/en-gb/volvo%20group/ourvalues/safety/stoplookwave/Pages/default.aspx
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[xxii] Loughborough University (Summerskill, S., et al), *Understanding direct and indirect vision from heavy goods vehicles*, 2015.
[xxiii] Ibidem, p 4