The identification of ‘Blind Spots’ in direct and indirect vision for Category N$_2$ & N$_3$ vehicles using Digital Human Modelling

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  - Simulation using DHM software
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The aims of the research

- Accident data in the UK highlighted;
  - ‘side swipe’ accidents (Cat. N₂ & N₃ changing lane and colliding with cars)
  - Accidents involving vulnerable road users

- The aim of the research is to identify if ‘blind spots’ in the combined driver's direct and indirect vision are a contributory factor in these accidents
Accident data analysis – UK wide data for 2008

- A sample of 704 accidents was identified where a blind spot was identified as a contributory factor (Cat. N₂ & N₃)
  - Nearly half (351) of those accidents involved a Cat. N₂/N₃ vehicle changing lane and colliding with another road user
    - Articulated left-hand drive HGVs over 7.5 tonnes changing lane to the right and colliding with cars *(25% all casualties, 14% of serious, 6% of fatal)* (N₂ & N₃ vehicles)
    - Articulated and rigid right hand drive HGVs over 7.5 tonnes changing lane to the left and colliding with cars *(24% of all casualties, 14% of serious, 6% of fatal)* (N₂ & N₃ vehicles)
  - In addition accidents where goods vehicles turn left at junctions and collide with vulnerable road users were highlighted
    - Goods vehicles (all N Classes) turning left and colliding with vulnerable road users *(5% of all casualties, 10% of serious, 19% of fatal)*.
Accident data analysis

- These data highlighted the need to explore where ‘blind spots’ exist in Category N₂ & N₃ vehicles

- A methodology was defined to allow the identification of blind spots using a ‘volumetric’ analysis in Digital Human Modelling software
Simulating direct and indirect vision from Cat. N₂ & N₃ vehicles

- The research team used Digital Human Modelling software to simulate the driver’s direct and indirect vision.
- New analysis tools were developed to represent the visible volume of space seen by drivers in curved mirrors.
  - The volume of space enclosed by the projected volume is visible to the driver.
Simulating direct and indirect vision from Cat. N₂ & N₃ vehicles

- The volume of space enclosed by the projected volumes is visible to the driver

Projection for the Class V mirror

Projections for all mirrors
Simulating direct and indirect vision from Cat. $N_2$ & $N_3$ vehicles

Direct vision: Projection through window apertures
Methodology: Stage 1 - Driver interviews and DHM setup

- Stage 1: Driver interviews
  - Driver’s opinion of blind spot locations
  - Driving postures were captured for a range of driver sizes

- 4th%ile UK male and 99th%ile UK male

<table>
<thead>
<tr>
<th>4th%ile UK male stature =</th>
<th>99th%ile UK male stature =</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st%ile Dutch male</td>
<td>97th%ile Dutch male</td>
</tr>
<tr>
<td>7th%ile German male</td>
<td>99th%ile German male</td>
</tr>
<tr>
<td>12th%ile French male</td>
<td>99th%ile French male</td>
</tr>
<tr>
<td>12th%ile Italian male</td>
<td>99th%ile Italian male</td>
</tr>
</tbody>
</table>
Methodology: Stage 1- Driver interviews and DHM setup

- 4th %ile UK male and 99th %ile UK male driver postures were recreated in the DHM system
- This provided two distinct driver eye points to be used in the analysis
Methodology : Stage 2. Vehicle selection and modelling

- Vehicle registration data from SMMT was used to identify the top ten vehicles by sales in the UK
- 6 vehicles were identified
  - Category N$_2$
    - DAF LF 45
    - Renault Midlum
    - Iveco Eurocargo
  - Category N$_3$
    - Scania R420
    - Volvo 480 (Left hand Drive)
    - Daf XF 105
- These vehicles were scanned using a FARO arm to provide CAD data for the DHM system
Methodology: Stage 3. Compliance with standards

- The following features were modelled for each vehicle in the DHM system,
  - Mirror Radius of Curvature
  - Mirror adjustment rotation point
  - Adjustment limits
- Each vehicle then had the mirrors adjusted to ensure that they comply with 2003/97/EC
Methodology: Stage 4. Identification of ‘Blind Spots’

- Mirrors and apertures projected at the ground plane
- Mirrors and apertures projected at 1m
- Mirrors and apertures projected at 1.56m

Mirror and aperture projections for the 4th%ile UK male

Mirror and aperture projections for the 99th%ile UK male
Methodology: Stage 4. Identification of ‘Blind Spots’
The analysis identified a blind spot between the volume of space visible to the driver through the Class IV and V mirrors and the direct vision through the window.

This blind spot exists for all Category N₃ vehicles modelled.

NOTE: the mirrors were adjusted to meet 2003/97/EC.
Analysis results: Category $N_3$ blind spot 2

- The red volume shows part of the area that can not be seen

2087 mm

7000 mm

Loughborough Design School
inspiring design
A specific accident scenario was identified that involved a vulnerable road user being hit by a goods vehicle turning left from a junction.

The analysis of this scenario using the road layout at which the accident occurred highlighted that it is possible for the driver to be unable to see the cyclist.
Analysis results: Applied to specific accident scenarios

- Side swipe accidents were modelled that demonstrated that category $M_1$ vehicles can be only partially visible to the goods vehicle driver in the Class V and VI mirrors.
Analysis results: Applied to specific accident scenarios
Analysis results: Applied to specific accident scenarios

- We wanted to understand what would actually be seen by a driver in this kind of situation
- We therefore simulated mirror surfaces using ray tracing software
Simulation of mirror view in the side swipe scenario
Simulation of $M_1$ overtaking $N_3$ – Volvo 480 LHD
Analysis results: Potential to poorly adjust mirrors to standard

- As the standard 2003/97/EC exists there is potential for mirrors to be maladjusted.

- The images show how a Class V mirror can be adjusted so that the corners of prescribed area are visible to the driver.

- In this situation a cyclist can be within the prescribed area, and not be visible to the driver.
Proposal for amendments to Regulation No. 46

Ground level - Proposed revision to area visible

Ground Level – Class V Mirror

Driver’s ocular points

Class VI Mirror
Justification for proposal for amendments to Regulation No. 46

- Category N₃ vehicle on the right hand edge of the middle lane (Lane width 3.5m)
- Category M₁ vehicle on the left hand edge of the left hand lane
- The proposed amendment would allow the M₁ vehicle to be visible to the N₃ driver
- DAF XF Class V mirror (red)
- Mirror designed to cover the 4.5m to the side of the vehicle
- A mirror that allows visibility of the proposed area on the ground plane removes the blind spot between the direct vision and the use of the Class V mirror
Potential solution for the identified blind spot

- A mirror solution was tested
- This mirror has an ROC of 300mm and a greater mirror height compared to the Class V mirrors fitted to the $N_3$ and $N_2$ vehicles

<table>
<thead>
<tr>
<th>Mirror Class $N_2$ &amp; $N_3$ vehicle</th>
<th>Width (mm)</th>
<th>Height (mm)</th>
<th>ROC (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category $N_2$ Renault MIDLUM Class V</td>
<td>245</td>
<td>145</td>
<td>300</td>
</tr>
<tr>
<td>Category $N_2$ IVECO Eurocargo Class V</td>
<td>255</td>
<td>155</td>
<td>300</td>
</tr>
<tr>
<td>Category $N_2$ DAF 45 Class V</td>
<td>245</td>
<td>145</td>
<td>300</td>
</tr>
<tr>
<td>Category $N_3$ DAF XF Class V</td>
<td>305</td>
<td>180</td>
<td>450</td>
</tr>
<tr>
<td>Category $N_3$ Volvo 480 Class V</td>
<td>275</td>
<td>160</td>
<td>330</td>
</tr>
<tr>
<td>Category $N_3$ SCANIA R420 Class V</td>
<td>305</td>
<td>175</td>
<td>300</td>
</tr>
<tr>
<td>SPAFAAX VM5</td>
<td>282</td>
<td>185</td>
<td>300</td>
</tr>
</tbody>
</table>
Potential mirror solutions

DAF XF 105 Class V mirror

Spafax VM5
QUALITY OF IMAGE- Driver’s view of Class V & SPAFAX

- Car nearside wheels at 4.5 m from side of truck

- In the Class V mirror the image of the car is not visible
- In SPAFAX mirror the image of the car is visible but distorted
QUALITY OF IMAGE- Drivers view of SPAFAX mirror

Progression of passing car through Spafax mirror
The research has highlighted that significant blind spots exist.

In addition, the need to scan Class II, IV, V and VI mirrors to determine if other vehicles and vulnerable road users are adjacent to the vehicle has driver workload implications.

A review of possible solutions highlighted the potential benefits of camera-based systems that remove distortion and combine multiple images into one image for driver assessment.

It is recognised that it will be sometime before these systems are applied by vehicle manufacturers.

There is potential for improving driver vision through the proposed amendment to Regulation 46.
Summary

- Accident statistics have highlighted blind spot accidents

- A virtual analysis of three Category N_3_ vehicles has highlighted that blind spots exist with mirrors that are adjusted to comply to 2003/97/EC

- A proposed revision to Regulation No. 46 has been made to solve this blind spot

- A mirror based solution has been tested using virtual and real world techniques