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Presentation to Working Party on General Safety Provisions – 100th session

ECE/TRANS/WP.29/GRSG/2011-01

The identification of 'Blind Spots' in direct and indirect vision for Category N_2 & N_3 vehicles using Digital Human Modelling

Dr. Stephen Summerskill

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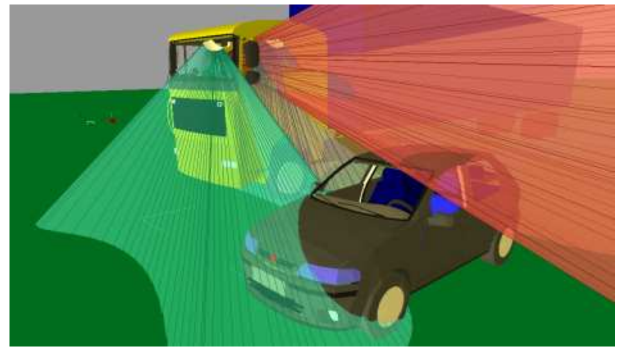

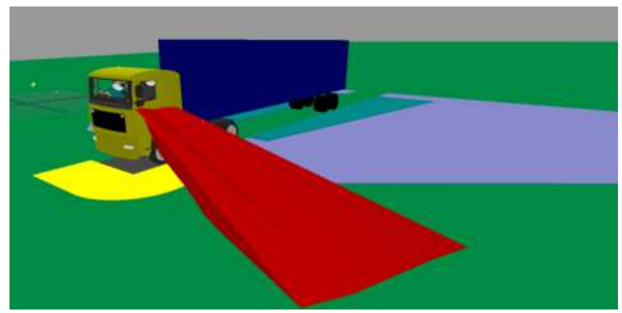

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The aims of the research

- Accident data in the UK highlighted;
  - ‘side swipe’ accidents (Cat. N_2 & N_3 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

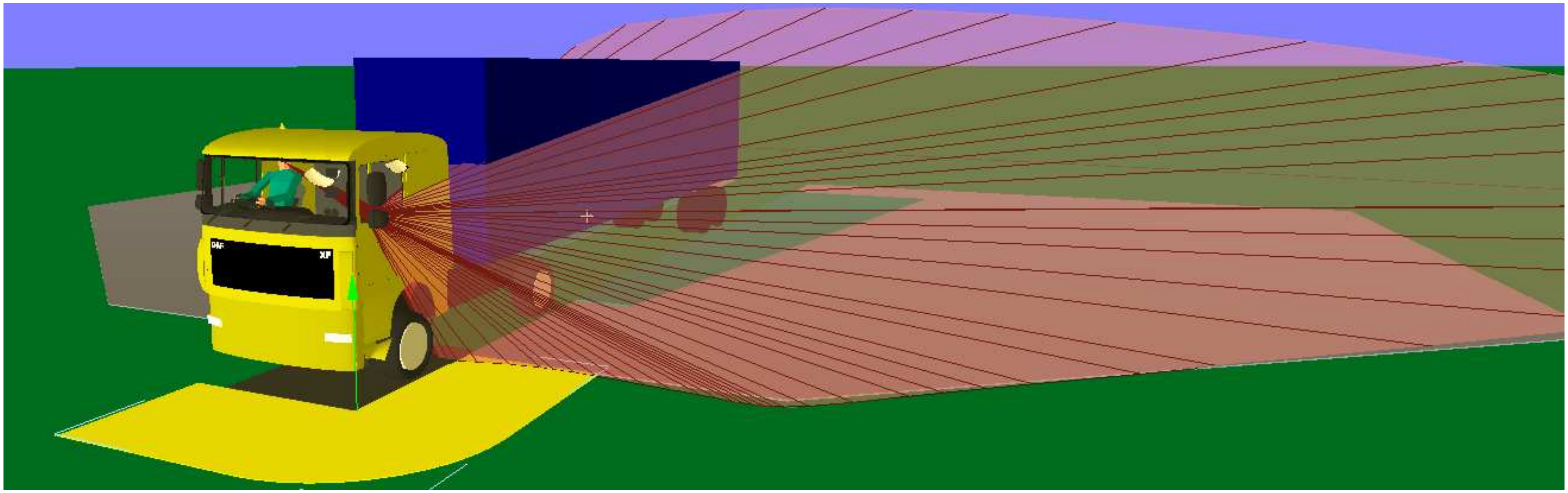
- A sample of 704 accidents was identified where a blind spot was identified as a contributory factor (Cat. N_2 & N_3)
  - Nearly half (351) of those accidents involved a Cat. N_2/N_3 vehicle changing lane and colliding with another road user
    - Articulated left-hand drive HGVs over 7.5 tonnes changing lane to the right and colliding with cars (**25% all casualties, 14% of serious, 6% of fatal**) (N_2 & N_3 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**) (N_2 & N_3 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 N_2 & N_3 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. N_2 & N_3 vehicles

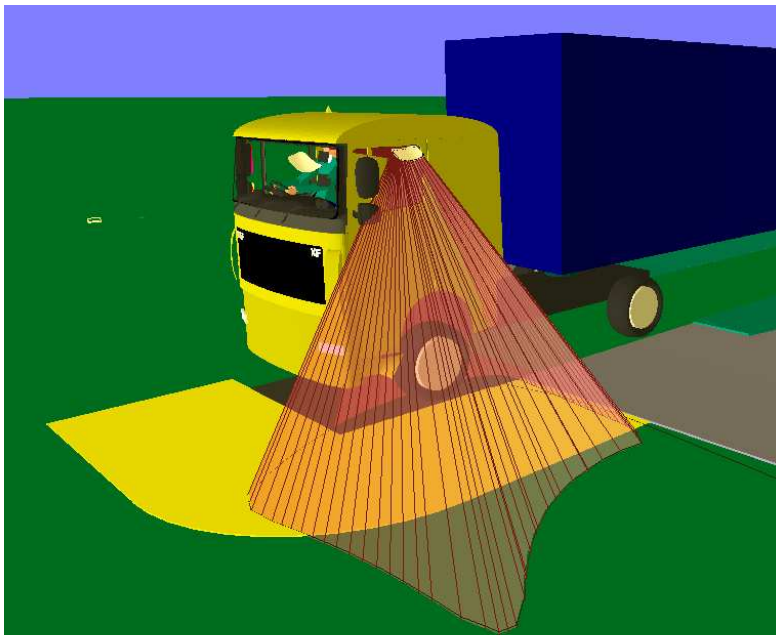
- The research team used Digital Human Modelling software to simulate the driver's direct and indirect vision
- New analysis tools were developed to represent the visible volume of space seen by drivers in curved mirrors
  - The volume of space enclosed by the projected volume is visible to the driver



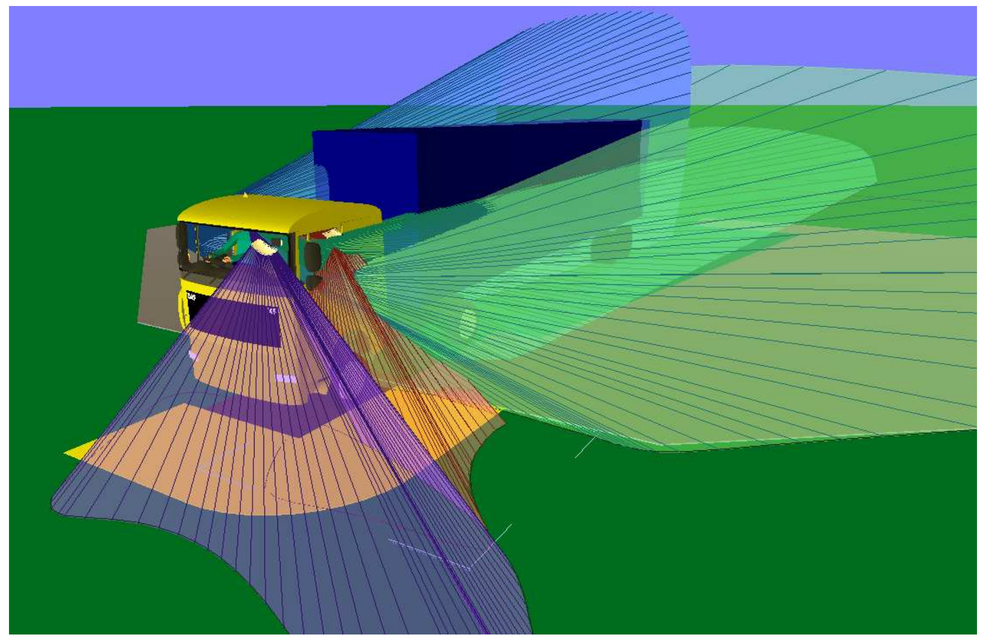
Projection for the Class IV mirror

Simulating direct and indirect vision from Cat. N_2 & N_3 vehicles

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

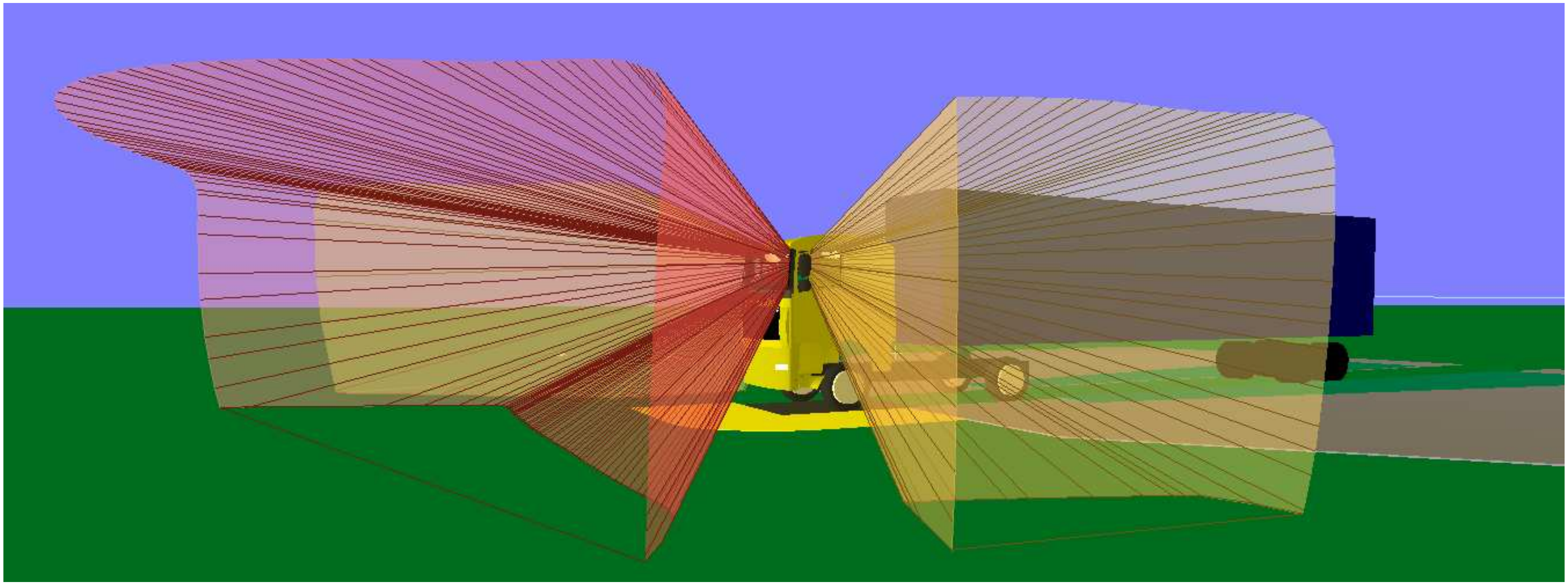


Projection for the Class V mirror



Projections for all mirrors

Simulating direct and indirect vision from Cat. N_2 & N_3 vehicles



Direct vision: Projection through window apertures

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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

4th%ile UK male stature =	99th%ile UK male stature =
1st%ile Dutch male	97th%ile Dutch male
7th%ile German male	99th%ile German male
12th%ile French male	99h%ile French male
12th%ile Italian male	99th%ile Italian male

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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

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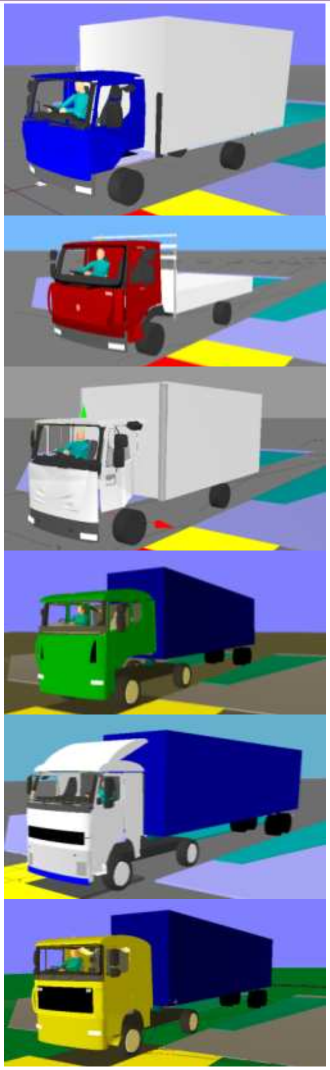
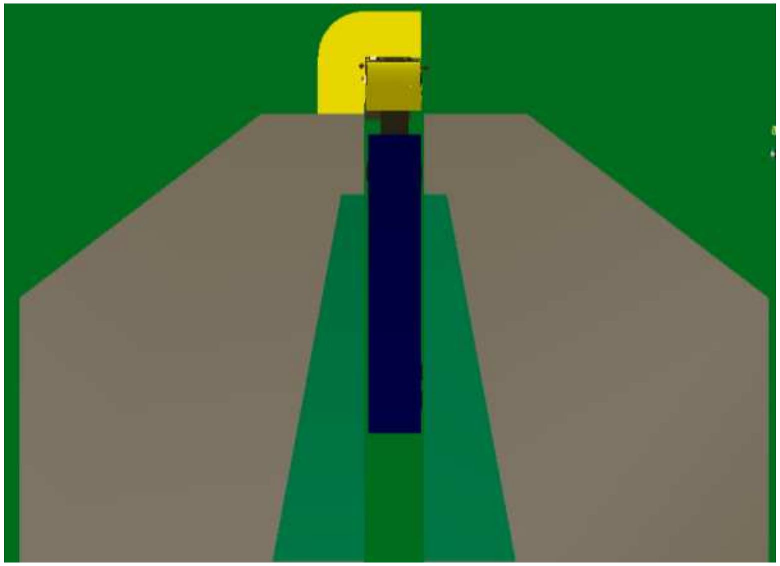
Methodology :Stage 2. Vehicle selection and modelling

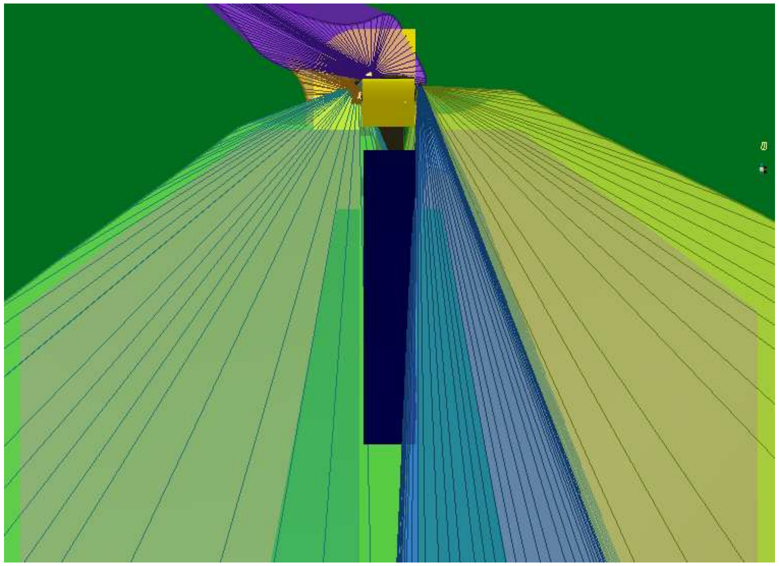
- Vehicle registration data from SMMT was used to identify the top ten vehicles by sales in the UK
- 6 vehicles were identified
  - Category N_2
    - DAF LF 45
    - Renault Midlum
    - Iveco Eurocargo
  - Category N_3
    - Scania R420
    - Volvo 480 (Left hand Drive)
    - Daf XF 105
- These vehicles 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





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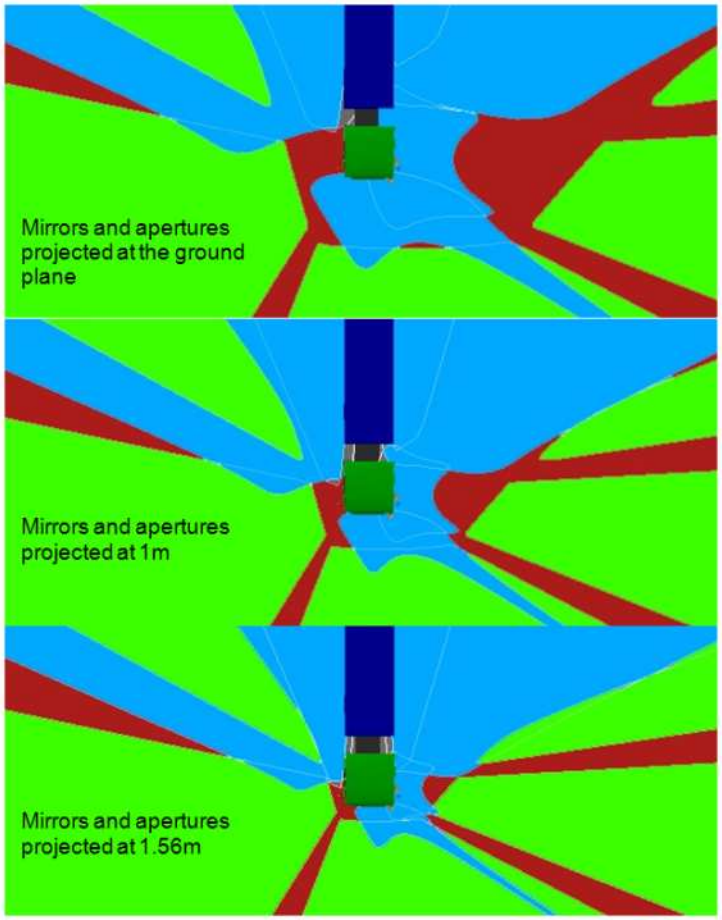
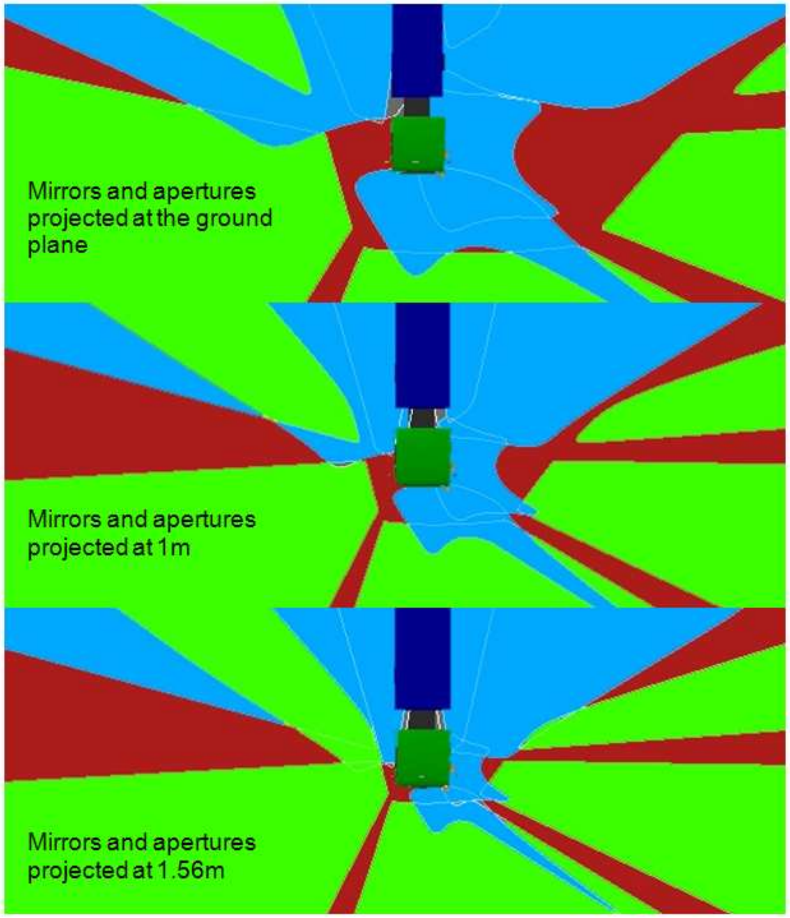
Methodology :Stage 4. Identification of 'Blind Spots'



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



Mirror and aperture projections for the 99th%ile UK male

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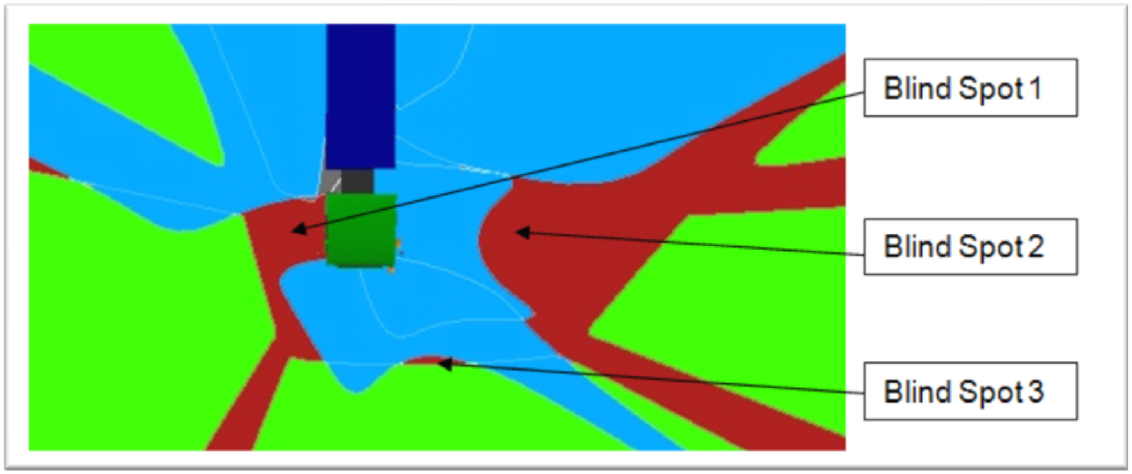
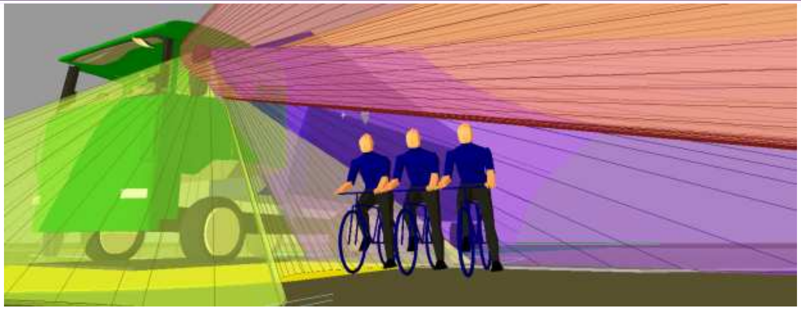
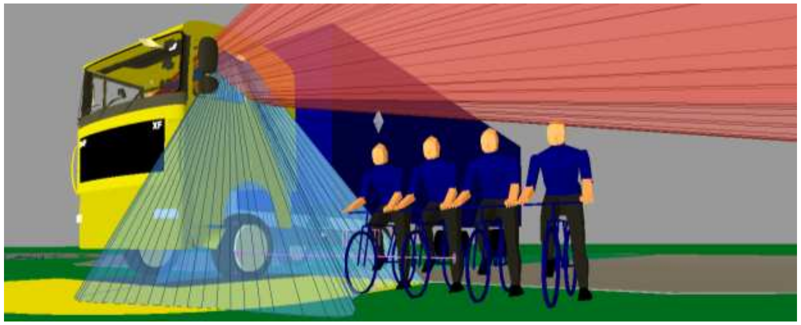
Methodology :Stage 4. Identification of 'Blind Spots'

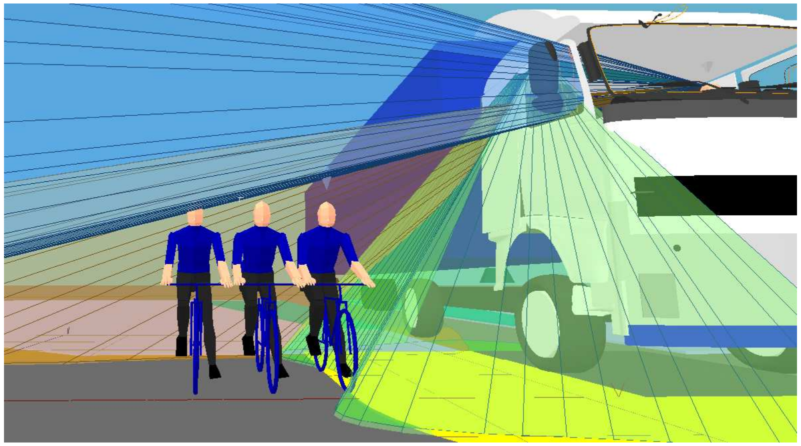


Analysis results: Category N_3 blind spot 2

- 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 N_3 vehicles modelled
- NOTE: the mirrors were adjusted to meet 2003/97/EC







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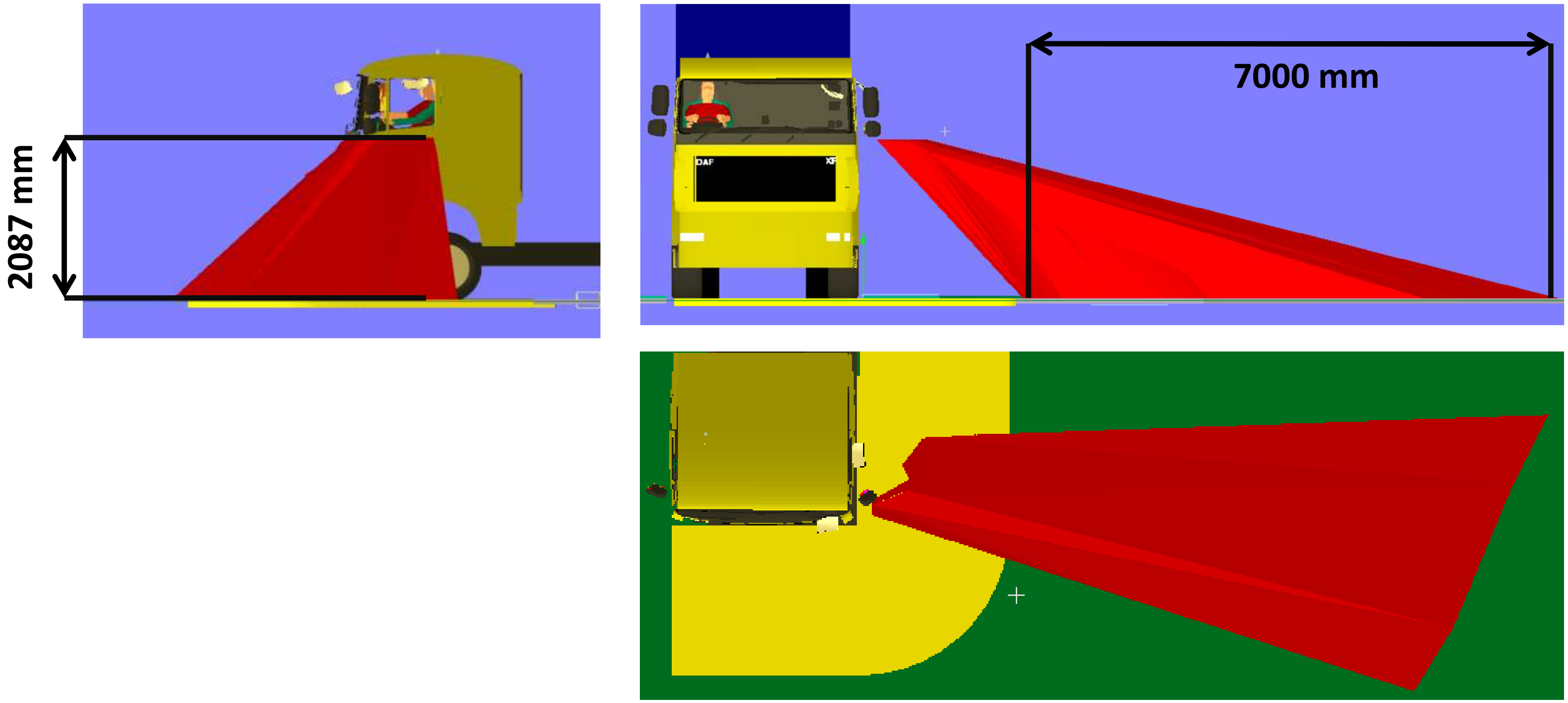
Analysis results: Category N_3 blind spot 2

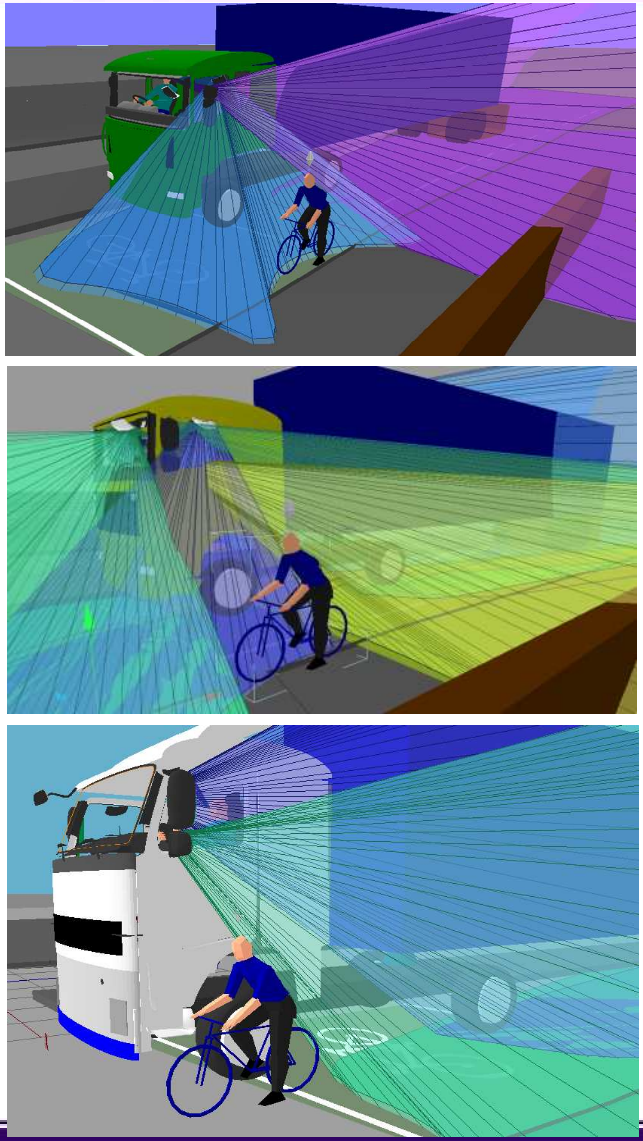


- The red volume shows part of the area that can not be seen

Analysis results: Applied to specific accident scenarios

- 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



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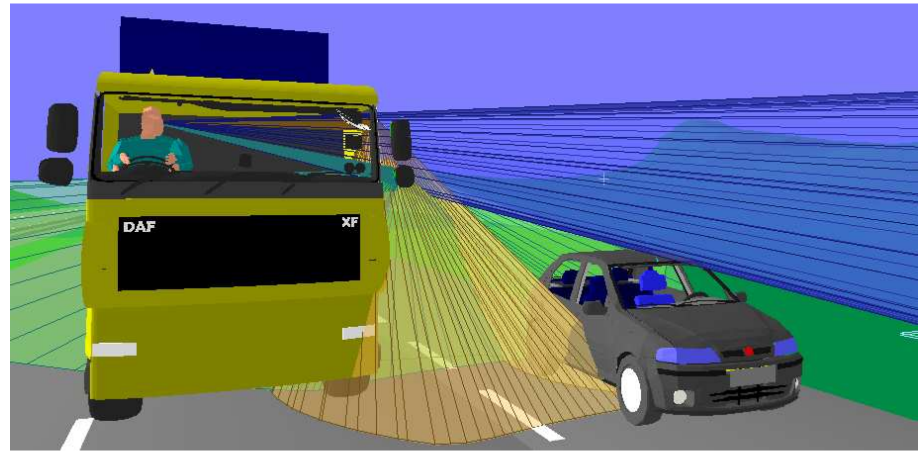
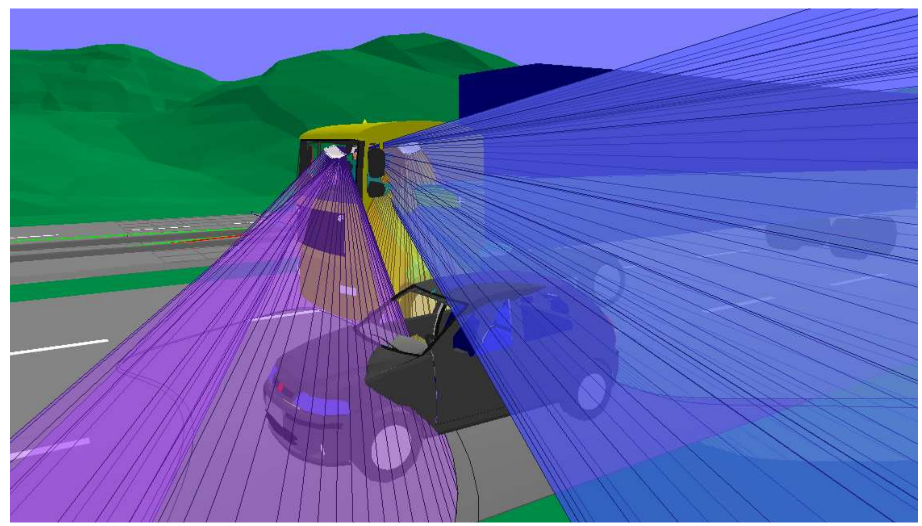
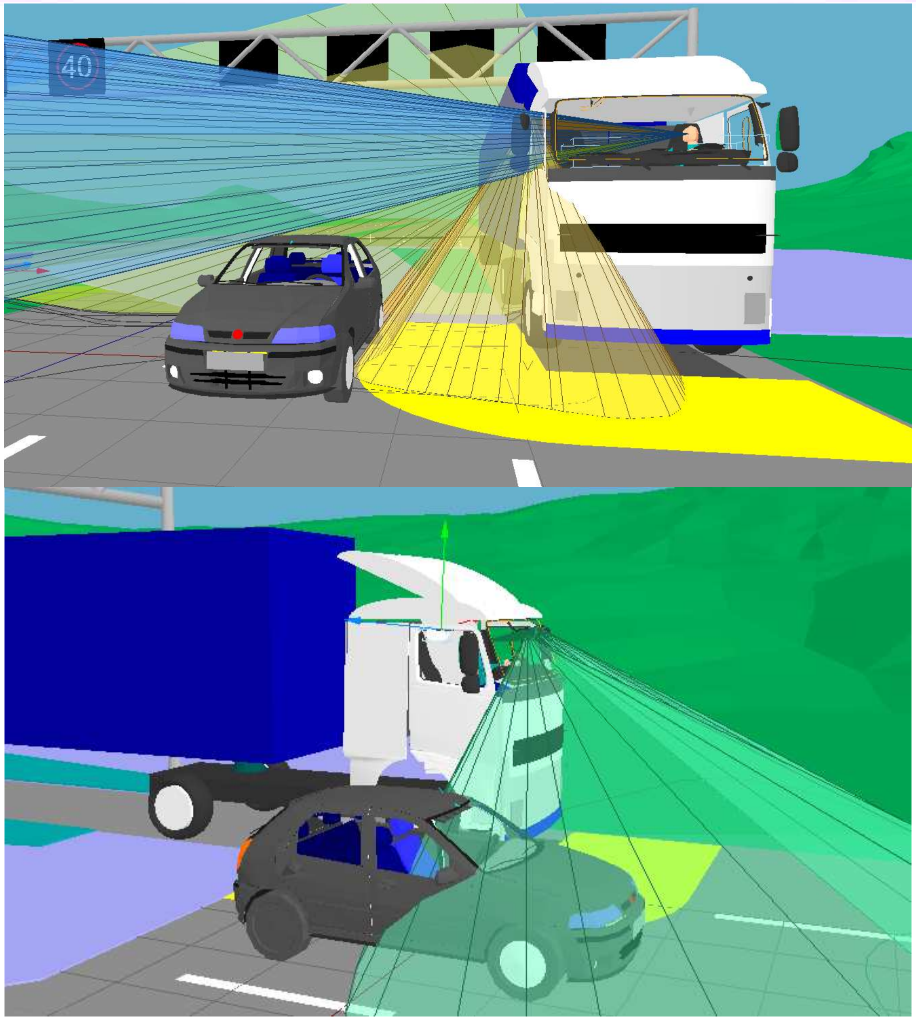
Analysis results: Applied to specific accident scenarios

- 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



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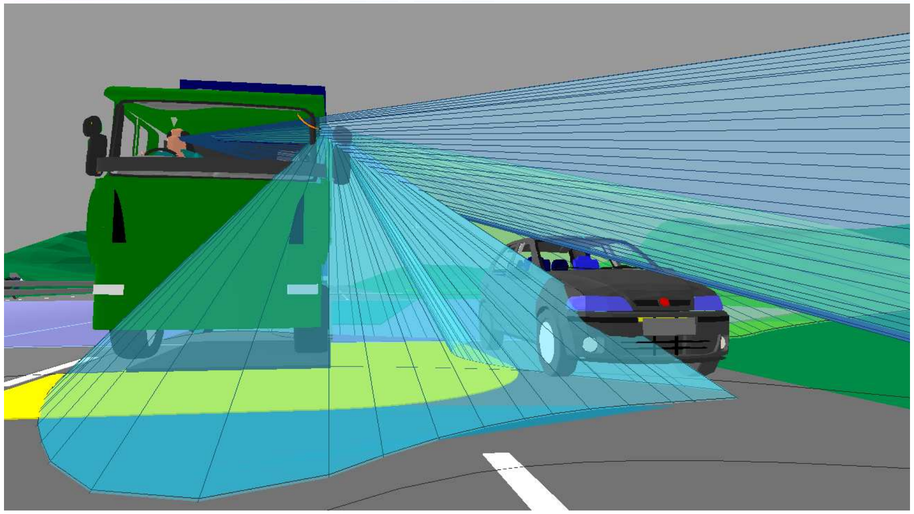
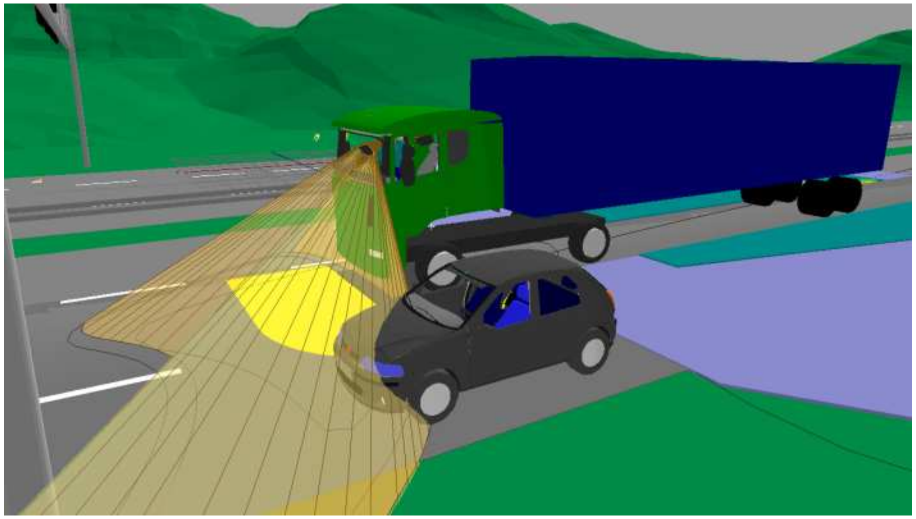
Analysis results: Applied to specific accident scenarios

- 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





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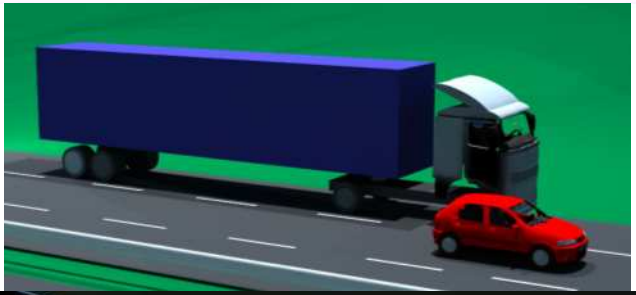
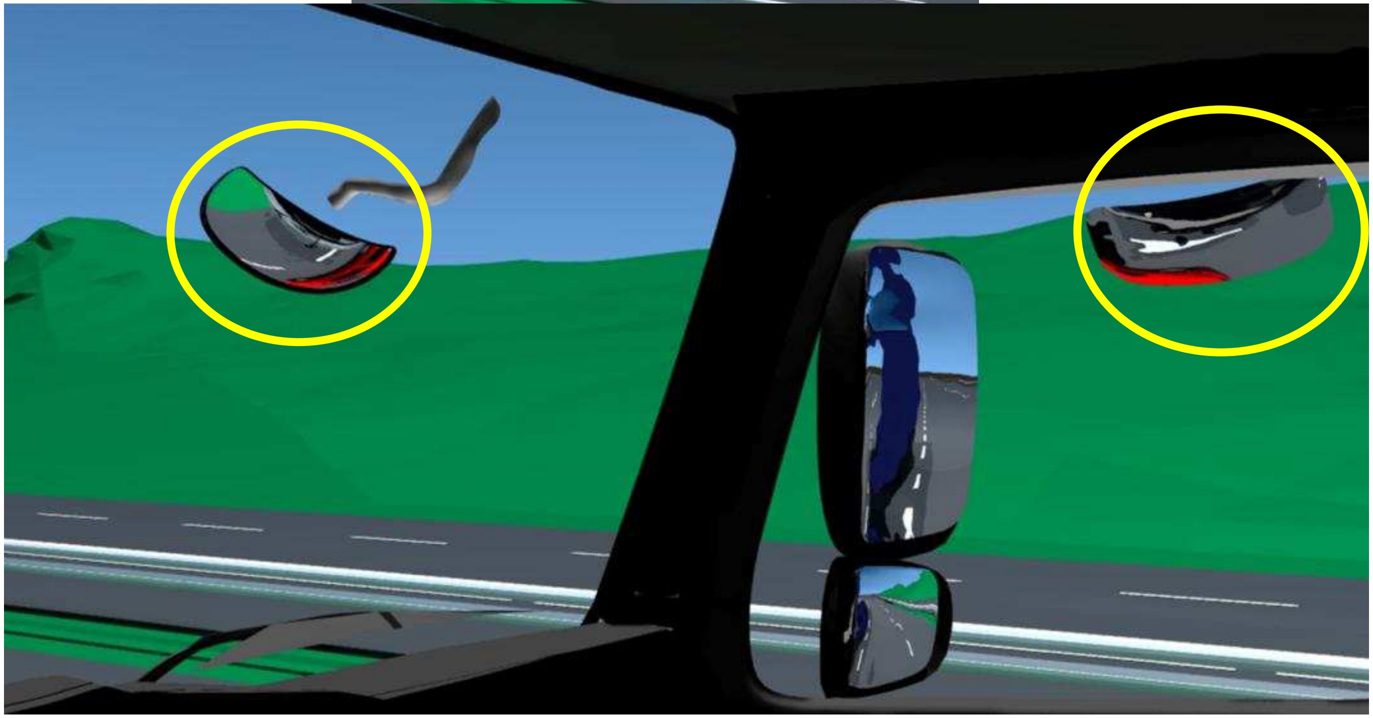
Simulation of mirror view in the side swipe scenario

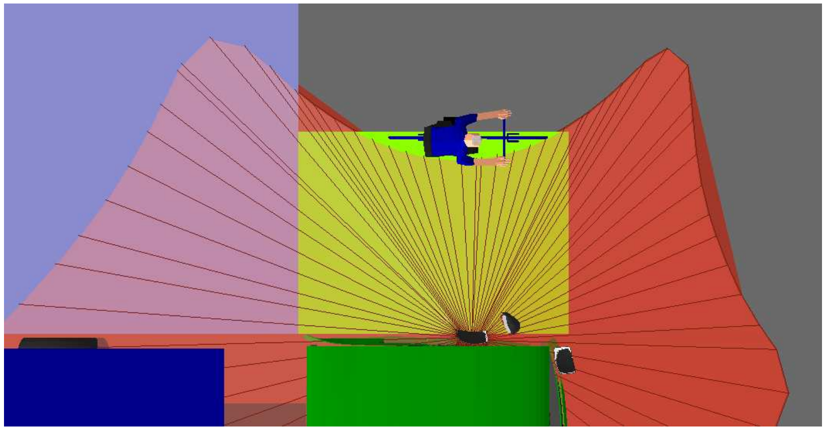


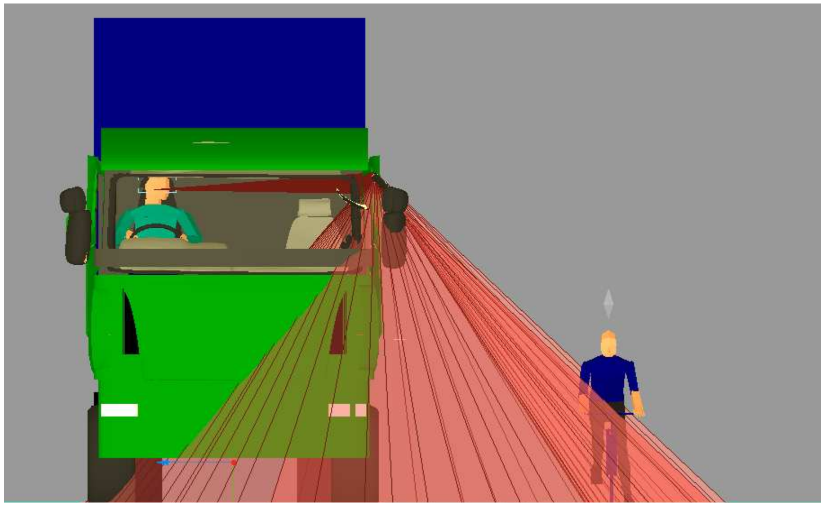


Simulation of M_1 overtaking N_3 – Volvo 480 LHD

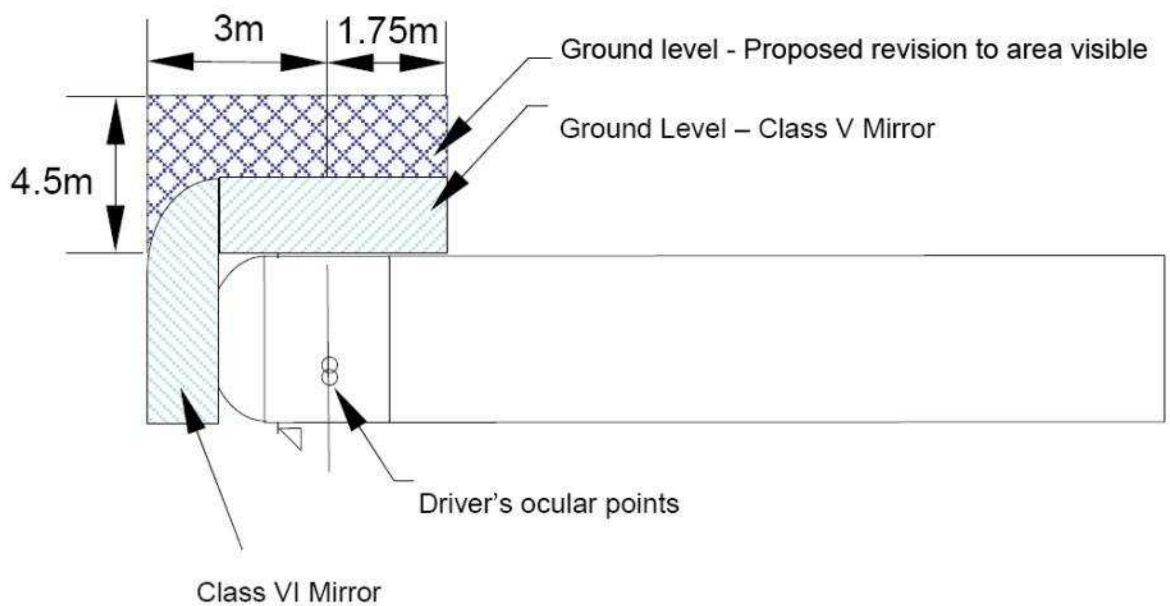
Analysis results: Potential to poorly adjust mirrors to standard

- 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



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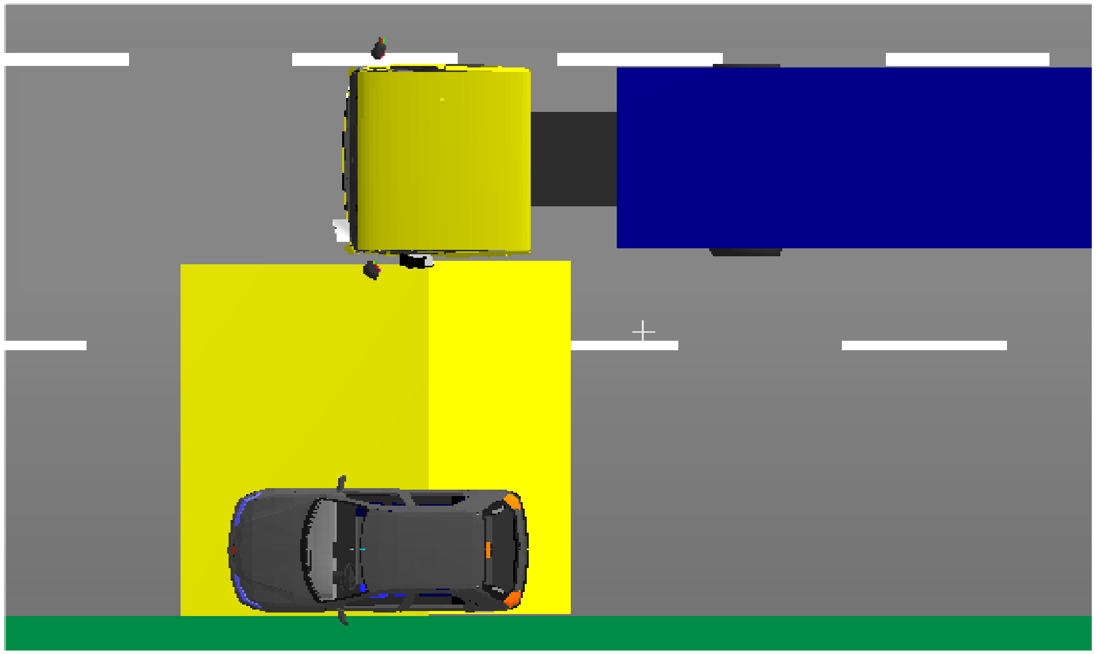
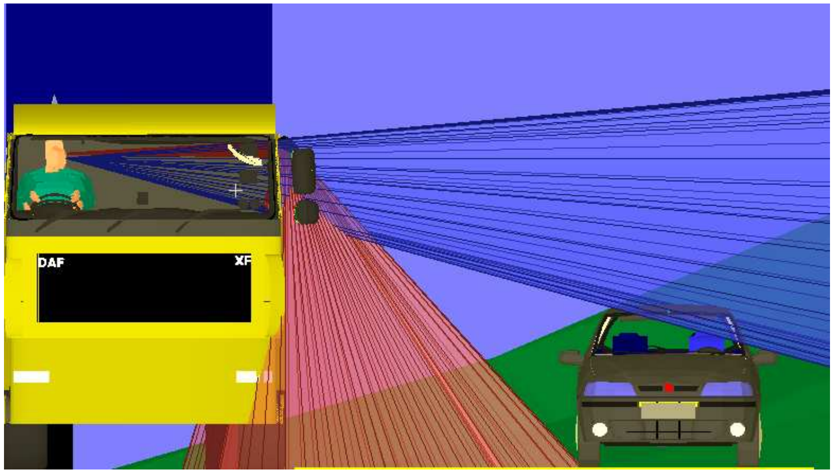
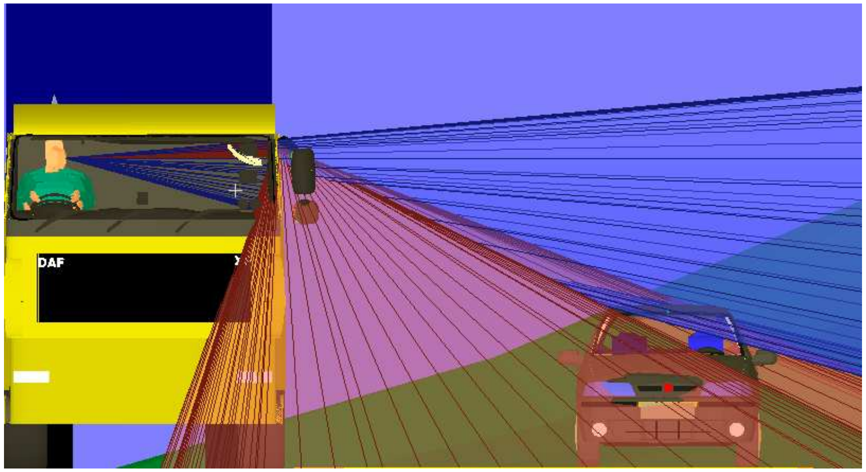
Justification for proposal for amendments to Regulation No. 46



- Category N_3 vehicle on the right hand edge of the middle lane (Lane width 3.5m)
- Category M_1 vehicle on the left hand edge of the left hand lane
- The proposed amendment would allow the M_1 vehicle to be visible to the N_3 driver

Justification for proposal for amendments to Regulation No. 46





- DAF XF Class V mirror (red)
- Mirror designed to cover the 4.5m to the side of the vehicle

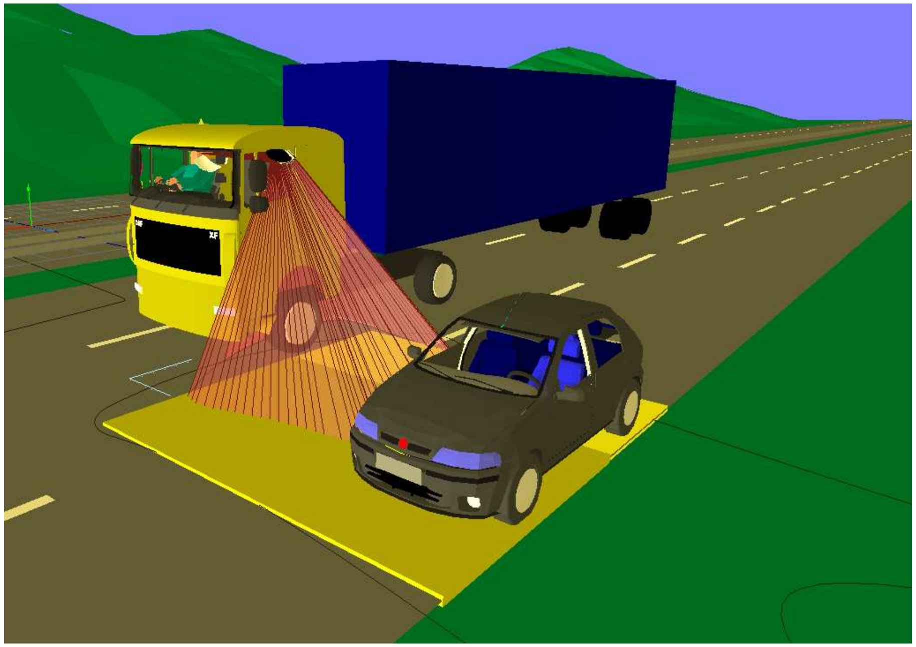
- A mirror that allows visibility of the proposed area on the ground plane removes the blind spot between the direct vision and the use of the Class V mirror

Potential solution for the identified blind spot

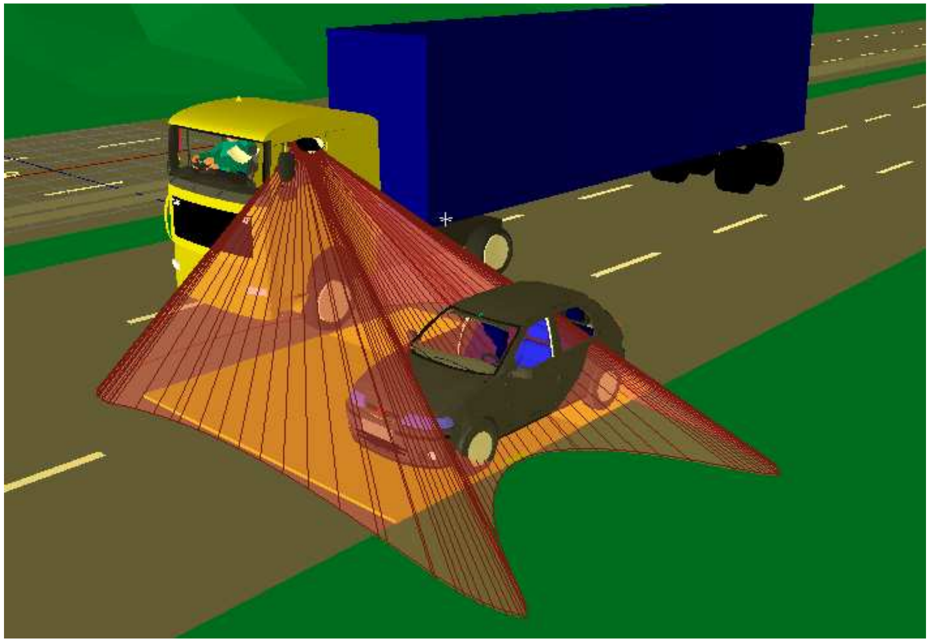
- A mirror solution was tested
- This mirror has an ROC of 300mm and a greater mirror height compared to the Class V mirrors fitted to the N_3 and N_2 vehicles

Mirror Class N_2 & N_3 vehicle	Width (mm)	Height (mm)	ROC (mm)
Category N2 Renault MIDLUM Class V	245	145	300
Category N2 Iveco Eurocargo Class V	255	155	300
Category N2 DAF 45 Class V	245	145	300
Category N3 Daf XF Class V	305	180	450
Category N3 Volvo 480 Class V	275	160	330
Category N3 SCANIA R420 Class V	305	175	300
SPAFAX VM5	**282**	**185**	**300**

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**

Class V (RHD Volvo 480)

Spafax

- **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

Front of car **in line** with front cab

Front of car **1m** to front of cab

Front of car **2m** to front of cab

Front of car **3m** to front of cab

Front of car **4m** to front of cab

Front of car **5m** to front of cab

Progression of passing car through Spafax mirror

Discussion

- 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