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# The Development of Improvements to Drivers' Direct and Indirect Vision from Vehicles – Impact Assessment

For: Department for Transport
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Loughborough University

The development of improvements to drivers' direct and indirect vision from vehicles. Impact assessment. (AR2640)

Department for Transport [DfT]

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# 1 INTRODUCTION

## 1.1 Background

The Transport Technology and Standards (TTS) Division of the Department for Transport has a responsibility for providing technical support to policy formulation and development. This is achieved through a broad research programme pertaining to vehicle-related safety issues to support the development of vehicle standards and regulations and the enforcement of standards. Within this remit, TTS wished to investigate the issues and implications for extending regulations relating to drivers' field of view requirements. Currently all M and N vehicles have to comply with European legislation with respect to indirect vision (vision through mirrors and cameras); however when direct vision (through the windscreen and side windows) is considered this is only mandated for $M_1$ vehicles. If the legislation is to be extended then the Department needs to be able to take an informed stance on any proposals to it. To facilitate this, it therefore wishes to understand:

- What the direct field of vision requirements for $M_2$, $M_3$ and all N category vehicles are, since it cannot be assumed that the requirements for $M_1$ can be directly transferred.
- The implications for RH drive and LH drive vehicles being used in LH drive and RH drive environments respectively.
- The effect of vehicle size.
- The relationship between direct and indirect field of view requirements in order to support as close as possible a 360° visual field requirement.

## 1.2 Aim

The over-arching aim of the project is to investigate the drivers' direct forward field of view and indirect field of view requirements for all 'M' and 'N' category vehicles with the intention to identify solutions to achieve, as far as is practicable, a 360° field of vision in which other road users can be easily seen.

## 1.3 Objectives

The stated objectives of the project cover:

**Vision**

The research needs to provide information on what drivers of 'M' and 'N' category vehicles:

- Should be able to see.
- What they actually see in the real world.
- How their field of vision may be affected by vehicle design.

**Blind spots**

The research needs to:

- Identify blind spots in both drivers' direct and indirect fields of view.
- Propose practical solutions to eliminate the identified blind spots.

**Solutions**

The solutions should facilitate drivers in easily seeing other road users at all times. The solutions should aim to:

- Minimise obscuration of the direct field of view relating to vehicle design, exterior mirrors and other vehicle features.
- Maximise the drivers' indirect field of view.
- Provide recommendations for amendments to the European legislations, where appropriate.

The context in which the objectives need to be considered includes:

- Right and left hand drive vehicles.
- Basic vehicle design and the drivers' environment.
- Future potential vehicle design features.

## 1.4 Approach

The research approach was undertaken in two phases:

- Phase 1 whose aim was to scope the existing knowledge base in order to prioritise and direct activities within Phase 2.
- Phase 2 whose aim was to investigate the specific driver vision problems prioritised in Phase 1 and determine solutions to them.

# 2 DESCRIPTION OF RESEARCH

## 2.1 Phase 1

The approach undertaken within Phase 1 was to use triangulated research methods to investigate the aspects relating to drivers direct and indirect vision by means of:

- A literature review.
- A review of previous accident data studies.
- Consultations with major interest groups.
- A legislative review.

The data derived from these activities was used to address the key issues raised within the project's work specification regarding:

- What should the driver be able to see (section 3).
- What do drivers need to see (section 4).
- What can drivers actually see (section 5).
- Blind spots (section 6).
- Accident scenarios (section 7).
- Solutions (sections 8, 9 and 10).

Using the data gathered, an assimilation activity was undertaken to identify the vision-related risk factors pertinent for each vehicle category and prioritise areas for further investigation within Phase 2 (section 12).

An Initial Impact Assessment was also undertaken (section 13).

A preliminary research plan was then proposed for discussion with the Department (section 14).

Following this, the research programme for Phase 2 was developed as follows:

**$N_2$ and $N_3$ Category vehicles**

- <u>Work package 1: Blind spot determination</u>
  - Task 1: Accident data analysis.

- Task 2: Driver and trainer interviews.
- Task 3: Digital Human Modelling.
- Task 4: Technology review.

- Work package 4: Mirror image quality
- Work package 5: Reliability of detection systems

**$M_1$ vehicles**

- Work package 2: Forward field of view – A/B pillar obscuration
  - Task 1: Accident data analysis.
  - Task 2: Digital Human Modelling.

**$M_1$ and $M_2$ vehicles**

- Work package 3: Rear field of view – Visibility of rear obstacle
  - Task 1: Digital Human Modelling

**Impact Assessment** – Work package 6

## 2.2 Phase 2 – $N_2$ and $N_3$ blind spot determination

This work area formed the main areas of investigation within the Phase 2 research programme.

### 2.2.1 Accident data

STATS19 data for 2008 was analysed using cluster analysis to obtain representative scenarios for light and heavy goods vehicles (N category vehicles) where 'Vision affected by vehicle blind spot' was recorded on the database as a contributory factor (no. 710). Seven cluster scenarios were identified, four of which were considered to be of interest to the study:

- Articulated left-hand drive HGVs over 7.5 tonnes changing lane to the right and colliding with cars.
- HGVs over 7.5 tonnes changing lane to the left and colliding with cars.
- HGVs changing lane to the right and colliding with cars.
- Goods vehicles turning left and colliding with vulnerable road users.

### 2.2.2 Driver/Trainer interviews

Interviews with HGV drivers and trainers identified driving scenarios in which blind spots may be an issue as: changing lanes, pulling away, reversing, manoeuvring and negotiating junctions. Problematic blind spot areas were cited as the rear, the front corners and along the sides. These findings tend to corroborate the accident scenarios identified.

In addition, it was found that drivers considered that their awareness of the visual difficulties associated with blind spots was good. The trainers supported this view highlighting the role of training and the importance of mirror set-up and checking. Most drivers were content with the number and coverage of their mirrors (although the validity of this finding is dependent upon their understanding of what an appropriate level of coverage is).

### 2.2.3 Field of vision – Digital Human Modelling

In order to add validity to the modelling, cases from the On The Spot (OTS) database were used to exemplify the accident cluster scenarios selected for investigation. The category $N_2$ and $N_3$ vehicles selected for modelling were chosen from a top ten list of vehicle registrations in the UK using SMMT.

- $N_2$ – DAF LF 45; Renault Midlum; IVECO Eurocargo.
- $N_3$ – DAF XF 105; Volvo 480 (Left hand drive); Scania R420.

Drivers' direct and indirect vision was modelled using anthropometric data for the $99^{th}$%ile and $4^{th}$%ile UK males combined with the observed postures to provide two distinct eye positions for the testing of mirrors.

Analyses were first undertaken to identify the limits to the combined direct and indirect vision for both percentile measures in all six vehicles. These variables were then applied to the OTS cases and the implications of these limits to vision investigated.

Vision related issues identified from this work included:

- Blind spot between the volume of space visible through the Class V mirror and the volume of space visible through the window apertures.

- Poor alignment of mirrors reduces the area of coverage. (This links to the driver interviews confirming the importance of correct set-up and drivers being enabled in this).
- Image distortion at the edge of the mirrors.

### 2.2.4 Quality of vision

Concerns raised in phase 1 and within the DHM work above regarding the quality of the image provided by mirrors and the drivers' ability to correctly interpret what they see was the focus of field trials undertaken within Phase 2 of the project.

The Class IV, V and VI mirrors of a Volvo FH tractor unit were assessed within the trials. The areas of ground plane visibility prescribed for each were centralised within the mirror and visual targets (car, cyclist, child pedestrian and a bin bag) were presented to twenty trial participants who were $N_3$ truck drivers. Each target was presented singularly to the drivers who took representative glances in the mirror. Following each observation, the driver was asked to report:

- If the target was visible (on some occasions no target was presented).
- What the target was (car, cyclist, child pedestrian or bin bag).
- Their confidence in that interpretation on a scale of 1-7.
- Whether the target was visible by direct vision.

To assess the potential impact of distortion at the mirror edges, an additional target position just outside the prescribed area was assessed for the Class V and VI mirrors.

The study found:

- Correct detection rates across all mirrors exceeded 93%.
- Correct recognition rates were at least 90% across all mirrors.
- Correct detection and recognition rates were compromised towards mirror edges.

These findings suggest that Class IV, V and VI mirrors are capable of providing good indirect vision of the prescribed areas. However correct adjustment is important since a misaligned mirror may cause some of the prescribed area to only be viewable at the mirror edge where detection and recognition rates are poorer. It is recommended that the scale of the problem of poor adjustment is investigated and mechanisms to assist improved step-up encouraged e.g. the adoption of mirror adjustment bays, improved mirror designs that require no adjustment or provide a mechanism for easy adjustment by the driver. It should be recognised that other factors may impact accurate mirror use including: rain; dirt on the mirror and windows; driver inattention; driver attending to another visual task; time pressures, etc. Alternative technologies such as cameras and sensors were also discussed.

### 2.2.5 Indirect vision technologies

An expert appraisal to investigate the performance of standard mirrors, an extended view mirror (Spafax), cameras and sensors was undertaken. A 1m ground plane grid system was marked out extending 3m to the front of the truck; 5m to the nearside and 2m to the offside. This was sufficient to cover the Class V and VI prescribed areas and the extended area specified in the GRSG proposal amendment to regulation No. 46 (January 2011).

The data recorded included:

- If, and to what extent, the target could be seen by direct vision.
- If, and to what extent, the target could be seen by the indirect vision system.
- The approximate orientation of the target as presented in the system.
- A rating of the level of confidence in recognising the target via the system.

Maps showing detection and recognition responses over the grid were produced to aid the comparison of the technologies. These indicated that:

- with respect to detection:
  - Within the Class V prescribed area, all systems provided complete detection.
  - Within the GRSG proposed area, the extended mirror outperformed the standard Class V mirror; indicative results suggest that the camera system would also outperform the standard Class V mirror.
  - To the side there was less overlap between direct and indirect vision indicating a greater potential for blind spots (and reflecting the findings in the DHM task).
  - Within the Class VI prescribed area, the standard mirror and the camera system provided complete coverage – the sensor system showed failures at the nearside edge and along the front of the truck.

- The camera system helps to address blind spots caused by the mirrors themselves.

- with respect to recognition:
  - The mirror systems presented the most extreme changes in orientation of the target, often presenting the target in positions ranging form on its side to upside down.
  - The camera system displayed a greater proportion of the target compared to the standard mirrors.
  - Both mirror and camera images are likely to be impacted by external factors such as rain, dirt, glare, etc.
  - Distortion of larger objects resulted in a pronounced bending effect of the image.
  - Such distortions were most pronounced at the edges of the mirrors.
  - Due to the greater impacts of orientation and distortion, the mirror images were less intuitive in interpreting the external scene e.g. for direction of motion of the target.

## 2.3 Phase 2 – $M_1$ forward field of view (A/B pillar obscuration)

### 2.3.1 Accident data

STATS19 data for 2008 was analysed using a new Cluster analysis methodology to obtain representative scenarios for $M_1$ vehicles where 'Vision affected by vehicle blind spot' was recorded on the database as a contributory factor (no. 710).

Nine cluster scenarios were identified, three of which were considered to be of interest to the study:

- Entering or using a roundabout and colliding with a pedal cyclist.
- Entering or using a junction and colliding with a motorcycle or car that approached from the right-hand side of the driver.
- Entering or using a junction and colliding with a pedal cyclist or car that approached from the left-hand side of the driver.

### 2.3.2 Field of vision – Digital Human Modelling

In order to add validity to the modelling, cases from the On The Spot (OTS) database were used to exemplify the accident cluster scenarios selected for investigation. The category $M_1$ vehicles selected for modelling were based on prevalence within the fleet as follows:

- Volkswagen Golf.
- Volkswagen Touran.
- Hyundai i10.

The Volkwagen models share the same platform with the Touran having a split A-pillar compared to the single A-pillar of the Golf. Drivers' direct and indirect vision was modelled using two different driver extremes – $99^{th}$ percentile Dutch male and the smallest UK female capable of driving the vehicle.

Analyses were first undertaken to identify the limits to the combined direct and indirect vision for both percentile measures in all vehicles. These variables were then applied to the OTS cases and the implications of these limits to vision investigated.

Vision related issues identified from this work included:

- Blind spots are variable in both size and position based on the design of the A-pillar, the position of the pillar and the eye-point of the driver.
- 'Looking around' the pillar eliminated the blind spots caused by A and B-pillar obscuration of the modelled vehicles.
- A-pillar size would need to be substantially reduced to have a noticeable effect on the driver's view.
- Whilst structural strength is important for secondary safety, manufacturers should be encouraged to balance this against the primary safety needs for improved vision and so should be looking to reduced A-pillar thickness.

## 2.4 Phase 2 – $M_1$ and $M_2$ rear field of view (Visibility of rear obstacle)

### 2.4.1 Field of vision – Digital Human Modelling

The vehicles selected for modelling were:

- $M_1$ – Volkswagen Touran.
- $M_2$ – Ford Transit long wheelbase minibus.

Drivers' direct and indirect vision was modelled using two different driver extremes – 99th percentile Dutch male and the smallest UK female capable of driving the vehicle.

Analyses were undertaken to identify the limits to the combined direct and indirect vision for both percentile measures in both vehicles. These variables were used to assess direct and indirect vision.

- Direct vision was assessed by means of:
  - Target markers defined within ISO/TR 12155.
  - A wall-like target (5m wide, 1m high).
  - Defining minimum target heights necessary in order to be seen by direct vision.
- Indirect vision was assessed by means of:
  - The mirror requirements as specified for each class of mirror within the relevant standards – ECE46-1, ECE46-02, 2006/96/EC and FMVSS111.

Vision related issues identified from this work included:

- $M_1$ vehicle
  - Class I are fully compliant.
  - Class III mirrors when set up optimally to provide an appropriate rearwards view fall marginally short of the field of view requirements for ECE46-02 and 2006/96/EC in relation to the areas closest to the rear of the vehicle, particularly on the nearside. It is likely that they could be adjusted to comply, but only with compromising rearwards view.

  - Class I compliance is theoretical since in reality the rearwards field of view is compromised by internal fixtures such that it is only applicable to the uppermost half of the rear window.
  - The same rearward limitation impedes direct vision where only objects greater than 1400mm in height could be seen directly behind the vehicle.
  - The areas of obscuration to the rear of the vehicle range from 6.5-10m on the ground plane and 0.5-1.1m on a plane 1m above the ground. Thus there is potential for a child or other obstacle lower than 1m to be obscured.
- $M_2$ vehicle
  - Class I and II mirrors are fully compliant.
  - Class I compliance is theoretical since in reality the rearwards field of view is heavily compromised by internal fixtures such that it is minimal and as such the mirror fails to comply with the standard.
  - The same rearward limitation impedes direct vision where only objects greater than 1800mm in height could be seen directly behind the vehicle.
  - For practical purposes the rearwards visibility of this vehicle is essentially zero and could not be relied upon.
  - The specification given in Directive 2001/85/EC that a person 1.3m tall standing 1m behind the vehicle is considered to be visible in direct vision is not met.

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# 3 IMPACT ASSESSMENT

## 3.1 Introduction

In the description of work for Phase 2 of the project, the team undertook to complete an impact assessment for solutions to each of the issues studied in Work Packages 1 to 4, that is:

- WP1: $N_2$ and $N_3$ Blind Spot Determination
- WP2: $M_1$ Forward Field of View, A/B Pillar Obscuration
- WP3: $M_1$ and $M_2$ Rear Field of View, Visibility of Rear Obstacle
- WP4: Mirror Image Quality.

The proposal had this to say about the impact assessment that would be conducted:

> "Where the research determines that there is a real problem in terms of risk of accidents, the most cost-effective solution will be identified. Where this solution calls for changes to be made to existing legislative standards, an impact assessment will be carried out. This sets out a range of possible measures that the responsible minister can adopt, and provides guidance for him in choosing which of these, if any, to approve. The assessment evaluates as precisely as possible the cost and benefit of the courses of action on society in general and specific stakeholders. The procedure for carrying out the Impact Assessment has been standardised across government and is set out by the Department for Business, Innovation and Skills on its website".

Solutions have been proposed for Work Packages 1 and 3, and impact assessments carried out for a variety of options to these. However, in the case of Work Package 2, although A- and B-pillars on cars can be shown to impair forward and side vision, there is no solution in the area of vehicle legislation that could benefit this impairment without having a serious effect on other safety aspects of the vehicle. In the case of Work Package 4, a number of recommendations have been made, including a firm proposal to require all new $N_2$ and $N_3$ vehicles to be fitted with all mirrors (including Class II, IV, V and VI) that are capable of being adjusted from the driver's seat. The cost of installing such mirrors in the current vehicle fleet was estimated. However, the project did not provide the data needed to estimate the benefits that would result, so it was not possible to determine the magnitude of the benefit that might accrue from this measure.

## 3.2 Methodology

The first step in the impact assessment was to define the range of practical measures that were identified as solutions to the problem in each of the work packages. The range of measures was limited to those actions that the Department for Transport might be able to undertake, either on its own or in collaboration with other stakeholders. Where changes in vehicle engineering standards were required, these can generally only be made on the basis of the internationally-agreed standards that govern vehicle type approval.

The second step was to identify the engineering changes that would be necessary to vehicles or operating procedures in order to conform to the changes in legislation. In most cases, these comprised additional systems that must be added to the vehicle, or changes to its existing systems. In other cases, there may be changes in the operators' procedures. The project carefully evaluated the options available to a stakeholder.

The third step was to evaluate the costs and benefits to the stakeholders resulting from implementing the measures identified above. In most cost-benefit studies the total costs and benefits are evaluated separately and compared against each other. In this case, however, a slightly different technique was employed. This starts by evaluating the total benefits that will accrue in one year once the measures are fully in place, using the accident data. Once each improved vehicle has been put into service, these annual benefits will continue to accumulate each year for as long as the system remains active. For the purposes of this assessment, it has been assumed that the system will operate for a period of 5 years before requiring replacement or major overhaul. Therefore, the annual benefits are multiplied by 5 to give the total benefits, and these can be balanced against the additional vehicle cost. This total value is then divided by the number of vehicles per year that are affected by the engineering changes, to give a value for the benefit that will arise from each vehicle. This represents in effect a budget cost per vehicle for implementing these changes, if the measure is to have a positive benefit. The range of engineering solutions that might achieve these benefits are then evaluated and reviewed. There are several advantages to this approach, compared with the conventional technique:

The numbers are much more comprehensible than the tens or even hundreds of millions of pounds of total benefit and cost that might be involved in the case of an effective measure that requires changes across a large number of vehicles.
The market for engineering solutions can be assessed in a more comprehensive way. For example, where a range of systems that could alleviate a problem is on the market, the assessment is no longer limited to the "cheapest" or "average" price, but can examine in detail that portion of the market that meets the necessary budgetary constraints.

In the market review for solutions, allowance has been made for:

- The retail cost of devices.
- The labour for installing them.
- Where this can be estimated, any changes in operating costs of the vehicle, such as fuel consumption, loss of productivity etc.

The benefits that accrue from making the proposed change in most cases correspond to the value of the deaths and injuries that will be prevented by adopting the proposed measure. This is done on the basis of expert judgement as to the number of injuries that are potentially preventable by the measure, and an estimate of the effectiveness of the measure in achieving this. In the UK, there are accepted monetary values than are assigned to each fatal, serious and slight injury, and for each fatal, serious and slight injury accident. These figures are published by the Department for Transport, in the annual Recorded Road Casualties for Great Britain document. They are based on "willingness to pay" studies conducted by the Department and updated at regular intervals. Using these standard values, we are able to compare the value of the costs and benefits for each single measure.
As mentioned above, most of the legislative changes that are proposed can only be implemented on an EU-wide basis. However, evaluating costs and benefits over the EU as a whole is not practical within the scope of the project. The reason for this is that comparable accident and vehicle fleet figures are not always available for the whole of the EU, and other member states adopt widely differing values for the cost of injury. Therefore the costs and benefits have been evaluated for the United Kingdom alone. Broadly, it could be assumed that the balance of costs and benefits would be similar across the Union, but it would be for the other national representatives at the ECE working groups to estimate these for their own territories.

A full evaluation of costs and benefits needs to take account of the fact that these arise at different times, insofar as the costs occur when the vehicle is manufactured, but the benefits accumulate gradually during the time it is in service. Current UK statistics show an average age of just over 7 years for the UK LGV fleet, so it is likely to take well in excess of 10 years before this transition period is complete. For the purposes of the assessment, the comparison is made on the basis that the benefits of a fully compliant vehicle fleet exist; in other words the situation that will occur once the changes have spread over the full vehicle fleet.

## 3.3 Solutions and cost-benefit analysis

### 3.3.1 Blind-Spot prevention for $N_2$ and $N_3$ vehicles

#### 3.3.1.1 Proposed measures

Work Package 1 showed that there was a deficiency in the driver's vision to the front nearside on $N_2$ and $N_3$ vehicles, and that this was largely responsible for many injuries, typically those in Clusters 1, 2 and 7 of the accident analysis. These corresponded to three different collision scenarios as follows:

- Cluster 1: Side-swipe collision of a left-hand drive LGV with a car during a lane change manoeuvre to the right (in other words, the side opposite the driver).
- Cluster 2: Side-swipe collision of a right-hand drive LGV with a car, during a lane change manoeuvre to the left, or collision with vehicle merging from the left (essentially, a mirror image of Cluster 1).
- Cluster 7: Collision of the LGV with a vulnerable road user, during a left-turn manoeuvre.

It identified two measures that need to be made in order to reduce injuries in these types of collision. One of these was judged to have the potential to eliminate collisions where the driver looked but was unable to see the hazard, and the other the potential to eliminate all of the collisions, including those where the driver failed to look.

These two measures were, respectively:

- To introduce legislation to require the extension of the driver's field of view on the passenger side of all new $N_2$ and $N_3$ class vehicles (using the Class V mirror) in the lateral dimension, from the current 2m minimum distance from the vehicle side (specified in Directive 2003/97/EC and Regulation ECE46.02) to 4.5m from the vehicle side, and in the longitudinal direction from the current 1m forwards of the driver's ocular points to 3m forwards. The current longitudinal dimension to the rearmost edge of the zone of 1.75m behind the driver's ocular points remains unchanged.
- To introduce legislation to require the installation on all new $N_2$ and $N_3$ category vehicles of an automated system capable of detecting a pedestrian or cyclist close to the nearside of the LGV, and to alert the driver when this occurs as they are about to make an abrupt left turn.

#### 3.3.1.2 Engineering changes proposed

For the first measure, it was concluded that it is practical to extend the field of view to the necessary extent by simply fitting a larger Class V mirror. Alternatively, a vehicle manufacturer may choose to comply with the proposed change to the legislation by installing a camera-monitor system to view the nearside of the LGV.

The project examined an extended view mirror by a leading manufacturer that will meet the proposed requirements. It also examined the range of camera-monitor systems currently on the market and concluded that systems suitable for meeting the proposed change already exist. Both of these have been demonstrated to work effectively on demonstrator and concept vehicles, and are already fitted to a small number of LGVs in service. It is therefore concluded that there are no technical problems that will prevent manufacturers from installing either of these on most conventional designs of LGV. It should be noted that ECE46.02 already allows camera systems to be fitted in place of Class V mirrors, so there is already a legal basis for using either type of system.

For the automated alert systems proposed as the second measure, there are a number of technologies that can be used as the basis of such a system; for example, ultrasound, radar, infra-red or machine vision. Some of these technologies are mature, have been demonstrated on safety concept vehicles and are already on the market. An important question that has been raised in relation to such systems is the effectiveness of the Human-Machine Interface (HMI) that delivers the warning to the driver. This is whether it can deliver the warning effectively, but without annoying the driver or overloading them with unnecessary alerts to the extent that they begin to ignore them completely. Discussions with manufacturers suggest that a good form of HMI is the combination of a small LED positioned next to or within in the Class IV mirror that illuminates when the system detects a person close to the side of the LGV, supplemented with an audible or haptic warning to the driver whenever the left-turn indicator is activated.

It is believed that the benefits of such types of system justify the establishment of an EU-wide requirement to fit them on all new LGVs. However, there is currently no standard for assessing how effectively they are capable of detecting a Vulnerable Road User in the appropriate zone, and this must be established before a European standard can be put in place. The technical requirements of this standard have not yet been established and are outside the scope of this project. However, most of the requirements will apply to the component approval of the system and not its installation on the vehicle. This means that the majority of the cost of developing and approving the system will be spread over the full sales of the system, rather than for its installation in a specific vehicle type.

#### 3.3.1.3 Benefits

Both of the measures proposed have the potential to prevent a large proportion of the injuries that fall into Cluster 7 of the accident analysis, that is, the collision of left-turning LGVs with vulnerable road users. The accidents in this cluster comprised the following numbers for year 2008:

- Slight 27, Serious 5, Fatal 3.

These were accidents involving LGVs, where there was some indication that driver blind spot might have been a contributory factor. However, the numbers include all types of LGV, including light goods vehicles in the $N_1$ class. Since the proposal is only to require $N_2$ and $N_3$ vehicles to adopt the changes, then those accidents to $N_1$ vehicles will not be affected. Cluster 7 contains 18 $N_1$ vehicles, within a total of 35. Since no evidence can be found to evaluate the involvement of the different categories according to severity, it is assumed that this is equal for all categories.

Therefore, the above figures have been reduced in the ratio of 18/35 or 0.514 to eliminate the $N_1$ vehicles. With these eliminated the totals are:

- Slight 13.11, Serious 2.43, Fatal 1.46.

#### 3.3.1.4 Benefits of first two measures (larger mirror or camera system)

"Failed to look properly" was the most common contributory factor in STATS 19 reports and was noted in 39% of slight accidents, 32% of serious accidents, and 24% of fatal accidents that occurred in 2009. For this measure, it was assumed that giving the driver a better field of view would make no difference in these cases, so the above figures were multiplied by 0.61, 0.68 and 0.76 respectively to account for this. The resulting figures were multiplied by the standard costs per accident for each class of injury noted in Reported Road Casualties Great Britain 2009, to give the following annual benefits value for the UK.

| Injury Class | Number of accidents prevented | Value of preventing each accident £ | Prevention value (rounded to nearest £) |
|---|---|---|---|
| Slight | 8.00 | 1880 | 15 039 |
| Serious | 1.65 | 21 370 | 35 291 |
| Fatal | 1.11 | 1 790 200 | 1 982 519 |
| All | 10.76 | | 2 032 849 |

**Table 1 Annual Benefits from Eliminating Cluster 7 Accidents to $N_2$ and $N_3$ Vehicles where "Driver Failed to Look Properly"**

*Please note that whilst the 'Number of accidents prevented' are reported to two decimal places, their actual values have been used in the calculation of the 'Prevention value'. Therefore differences which may arise when comparing the 'Prevention value' with the result of multiplying the second and third column of each table are due to rounding.*

As well as preventing some of the injuries in Cluster 7, the same measures if implemented on the overseas LGVs associated with this cluster would also reduce the number of side-swipes in Cluster 1 and the injuries associated with them, so these can also be counted in the benefits. The accidents in this cluster comprise

- Slight 168, Serious, 7, Fatal 1.

According to the accident data, all of these accidents involved $N_2$ or $N_3$ category vehicles, so all of them will be affected by the measure. As for the Cluster 7 results, these are scaled to eliminate the failed to look properly cases, using the same factors. The resulting number of accidents and benefits value is given below.

| Injury Class | Number of accidents prevented | Value of preventing each accident £ | Prevention value (rounded to nearest £) |
|---|---|---|---|
| Slight | 102.48 | 1880 | 192 662 |
| Serious | 4.76 | 21 370 | 101 721 |
| Fatal | 0.76 | 1 790 200 | 1 360 552 |
| All | 108.00 | | 1 654 936 |

**Table 2 Annual Benefits from Eliminating Cluster 1 Accidents to $N_2$ and $N_3$ Vehicles where "Driver Failed to Look Properly"**

*Please note that whilst the 'Number of accidents prevented' are reported to two decimal places, their actual values have been used in the calculation of the 'Prevention value'. Therefore differences which may arise when comparing the 'Prevention value' with the result of multiplying the second and third column of each table are due to rounding.*

Again, we can count the benefits from preventing some of the Cluster 2 accidents as above. The accidents in this cluster comprise

- Slight 161, Serious 7, Fatal 1

In this case, there were 2 light goods vehicles that would not be affected out of a total of 169, so these figures have been multiplied by 167/169, or 0.988. Discounting the number who failed to look properly, this gives the following numbers and values.

| Injury Class | Number of accidents prevented | Value of preventing each accident £ | Prevention value (rounded to nearest £) |
|---|---|---|---|
| Slight | 97.05 | 1880 | 182 450 |
| Serious | 4.70 | 21 370 | 100 517 |
| Fatal | 0.75 | 1 790 200 | 1 344 451 |
| All | 102.50 | | 1 627 418 |

**Table 3 Annual Benefits from Eliminating Cluster 2 Accidents to $N_2$ and $N_3$ Vehicles where "Driver Failed to Look Properly"**

*Please note that whilst the 'Number of accidents prevented' are reported to two decimal places, their actual values have been used in the calculation of the 'Prevention value'. Therefore differences which may arise when comparing the 'Prevention value' with the result of multiplying the second and third column of each table are due to rounding.*

Adding the benefits for Cluster 7, Cluster 1 and Cluster 2 accident figures, the total annual value of benefits per year resulting from the measures is £5 315 203. Over the assumed 5 year life of the system, the total benefits come to £26 576 013 (allowing for rounding errors). If the measure is to prove economic, the average budget for parts and installation per affected vehicle will be the total 5 year benefits, divided by the number of vehicles affected. For the purpose of this assessment, it is assumed that the measure will apply to all new $N_2$ and $N_3$ LGVs in the UK. Currently, very few LGVs are fitted with systems of this type, so it is assumed that all of these vehicles will be affected. Using figures from SMMT for new vehicle registrations, the number of $N_2$ and $N_3$ LGVs registered in the UK in 2010 was 30200. Dividing the total benefits by this figure, this represents a budget of £880 per vehicle for the purchase and installation of a suitable system, if a positive benefit is to be achieved by this measure.

#### 3.3.1.5 Benefits of the third measure (driver alert)

Unlike the camera system, which is not likely to affect those accidents in which the driver failed to look properly, the driver alert has the potential to eliminate all of the accidents in Clusters 1, 2 and 7. Therefore, the estimation of benefits for this measure counts all of these accidents.

The resulting reduction in accidents and associated values for the Cluster 7, Cluster 1 and Cluster 2 accidents are given in the following tables.

| Injury Class | Number of accidents prevented | Value of preventing each accident £ | Prevention value (rounded to nearest £) |
|---|---|---|---|
| Slight | 13.11 | 1880 | 24 655 |
| Serious | 2.43 | 21 370 | 51 899 |
| Fatal | 1.46 | 1 790 200 | 2 608 577 |
| All | 17.00 | | 2 685 131 |

**Table 4 Annual Benefits from Eliminating All Cluster 7 Accidents to $N_2$ and $N_3$ Vehicles**

*Please note that whilst the 'Number of accidents prevented' are reported to two decimal places, their actual values have been used in the calculation of the 'Prevention value'. Therefore differences which may arise when comparing the 'Prevention value' with the result of multiplying the second and third column of each table are due to rounding.*

| Injury Class | Number of accidents prevented | Value of preventing each accident £ | Prevention value (rounded to nearest £) |
|---|---|---|---|
| Slight | 168.00 | 1880 | 315 840 |
| Serious | 7.00 | 21 370 | 149 590 |
| Fatal | 1.00 | 1 790 200 | 1 790 200 |
| All | 176.00 | | 2 255 630 |

**Table 5 Annual Benefits from Eliminating All Cluster 1 Accidents to $N_2$ and $N_3$ Vehicles**

| Injury Class | Number of accidents prevented | Value of preventing each accident £ | Prevention value (rounded to nearest £) |
|---|---|---|---|
| Slight | 159.09 | 1880 | 299 098 |
| Serious | 6.92 | 21 370 | 147 820 |
| Fatal | 0.99 | 1 790 200 | 1 769 014 |
| All | 167.00 | | 2 215 932 |

**Table 6 Annual Benefits from Eliminating All Cluster 2 Accidents to $N_2$ and $N_3$ Vehicles**

*Please note that whilst the 'Number of accidents prevented' are reported to two decimal places, their actual values have been used in the calculation of the 'Prevention value'. Therefore differences which may arise when comparing the 'Prevention value' with the result of multiplying the second and third column of each table are due to rounding.*

Adding the benefits for Cluster 7, Cluster 1 and Cluster 2 accident figures, the total annual value of benefits per year resulting from the measures is £7 156 692 (allowing for rounding errors). Over the assumed 5 year life of the system, the total benefits come to £35 783 462 (allowing for rounding errors). If the measure is to prove economic the average budget for parts and installation per affected vehicle will be the total benefits, divided by the number of vehicles affected. For the purpose of this assessment, it is assumed that the measure will apply to all new $N_2$ and $N_3$ vehicles in the UK. Currently, very few LGVs are fitted with systems of this type, so it is assumed that all of these vehicles will be affected. Using figures from SMMT for new vehicle registrations, the number of $N_2$ and $N_3$ LGVs registered in the UK in 2010 is 30200. Dividing the total benefits by this figure, this represents a budget of £1185 per vehicle for the purchase and installation of a suitable system, if a positive benefit is to be achieved by this measure.

#### 3.3.1.6 Costs

Consultations with system suppliers were carried out to evaluate the cost of purchasing a system that would just meet the requirements of the proposed measure, if this were part of a deal with a vehicle manufacturer to fit to all their vehicles. They were also asked for the time that one of their skilled fitters might take to install the system, which was multiplied by a figure of £35 per hour for current labour costs in the automotive industry.

For the mirror system, it was not possible to undertake a full market survey because only one suitable mirror is known to exist at the present time. However, the manufacturer of this mirror estimated a retail price of £40 for their product. This falls within the range of prices for existing Class V mirrors. Fitting is the same as the current Class V mirror, so it is assumed that there is no additional labour associated with installation. The cost represents less than 5% of the budget figure of £880, so this represents a strong balance of benefit over cost.

For the camera system, the average purchase price quoted was £420, with a typical installation time of 2 hours, representing £70, making a total of £490. Since the system would replace a Class V mirror (average cost £40) this represents a net additional cost of £450. This represents 51% of the budget figure of £880, so this also represents a strong balance of benefit over cost, although not quite as strong as the mirror. Since camera-monitor systems are already covered by the legislation, mandatory installation will not require the manufacturer to undertake any additional testing for type-approval, so there will be no additional costs associated with approval that would be imposed on either the system or vehicle manufacturer.

The costs for mandatory installation of a driver alert system have been derived in a similar way, by costing systems incorporating ultrasound sensors, activating a flashing LED and an audible alarm when reverse gear is selected. The average purchase price for such a system is £360, with an estimated £70 cost for installation, making £430 in all. This represents 36% of the budget price of £1185 per vehicle for a system of this type. Again, this represents a balance of benefit over cost.

#### 3.3.1.7 Other considerations

All of the measures proposed here have been assessed for their effect on Government targets for CO2 emissions and other environmental considerations.
In the case of the larger mirror, its overall dimensions are only marginally greater than a conventional Class V mirror, and in any case the contribution of the Class V to the overall aerodynamic drag generated by all of the mirrors is small. Therefore, it is assumed that any increase in fuel consumption and CO2 emissions due to changes in drag will be negligible.

In the case of the camera-monitor systems, these normally house the camera inside a streamlined housing mounted flush with the surface of the cab, so the aerodynamic drag is quite low. If an operator chooses to fit a camera system, then they may have the option of dispensing with the Class V mirror, in which case there may be a small saving in fuel costs due to the reduction in aerodynamic drag. However, it is not known whether the operator would prefer to do this, or whether they would prefer to retain the Class V mirror as a back-up.

Considering the power required to operate the system, this is estimated to be less than 100w on average. This is negligible, compared with the motive power of a typical LGV.

The alerting system would have an even smaller effect on $CO_2$ emissions, since the external sensors would project at most a few millimetres from the vehicle bodywork, and the power consumption would be less than the camera-monitor.

#### 3.3.1.8 Conclusions

Considering the UK alone, if the regulations for driver vision required an extension of the area visible to the nearside from 2m to 4.5m from the side of the vehicle, this could be accommodated by fitting either a slightly larger Class V mirror, or by installing a suitable camera-monitor system. For the larger Class V mirror, there would be a negligible additional cost to the manufacturer or operator, but the measure has the potential to save 2.6 fatal, 11.1 serious and 207.5 slight injuries per year on UK roads, representing a saving of £5 315 203 per year, or £26 576 013 over an assumed 5 year life for the mirror (allowing for rounding errors). This represents a significant saving for negligible additional cost.

If manufacturers chose to meet the requirements by installing a camera-monitor system, it is assumed that the same number of injuries would be saved so the total value of the benefits would be the same. Dividing this total by the 30 200 heavy LGVs registered in the UK per year represents a budget of £880 per vehicle, if it is to achieve a positive balance of benefit over cost. MIRA has surveyed the market for camera-monitor systems and there are many systems that could meet the requirements for less than this budget. Overall, the average price is £490 per vehicle, including installation, giving a total cost of £14 798 000 per year for all $N_2$ and $N_3$ vehicles registered in the UK. Therefore, the camera-monitor system represents a positive balance of benefit over cost.

If all LGVs in the UK were required to install driver alert systems, this would have the potential to save 3.4 fatal, 16.3 serious and 340.2 slight injuries per year, representing £7 156 692 per year, or £35 783 462 (allowing for rounding errors) over the 5 year life assumed for the system. Spread over the 30 200 LGVs registered per year in the UK, this represents a budget of £1185 per vehicle, if it is to achieve a positive balance of benefits over cost. From a market survey of alert systems suitable for meeting the requirements, it is apparent that there is a range of systems available within the budget price. Overall, the average price per vehicle for such systems, including installation, amounts to £430. This represents a positive balance of benefit over cost in the ratio of 2.76.

| Measure | Larger Class V Mirror | Camera / Monitor | Driver Alert |
|---|---|---|---|
| Total benefits over 5 years | £26.5 m | £26.5m | £35.7m |
| No of vehicles affected | 30200 | | |
| Target unit cost | £880 | £880 | £1185 |
| Average net cost per vehicle | £40 | £490 | £430 |
| Benefit / cost | 22.5 | 1.80 | 2.76 |

**Table 7 Cost-benefit summary for potential solutions to blind-spot prevention for $N_2$ and $N_3$ vehicles**

On this basis, it appears that the engineering changes to accommodate both of the proposed measures would prove economic, insofar as the benefits of reducing injuries over the working life of the systems exceed the additional cost of purchasing and installing the system.

This conclusion should be weighed against the assumptions that have been made in this assessment. These are detailed elsewhere but may be summarised as follows:

- That the measure is introduced throughout Europe, and that the overall costs and benefits in the other member states will be commensurate with the UK figures quoted here.
- That all $N_2$ and $N_3$ vehicles in service are fitted with a compliant system.
- That the enlarged mirror or camera systems will prevent all of the $N_2$ / $N_3$ collisions identified in Clusters 1, 2 and 7 of the accident analysis, except those in which "failed to look properly" is identified as a contributory factor.
- That the rate of involvement of $N_1$ in the collisions identified in the clusters is the same as for $N_2$ and $N_3$ vehicles.
- That the driver alert system will prevent all of the $N_2$ / $N_3$ collisions identified in Clusters 1, 2 and 7, including those where "failed to look properly" is identified as a contributory factor.
- That the benefits will be realised over a 5-year service life of the system.
- That there will be no additional running costs for the vehicles over this period.

## 3.3.2 Visibility of rear obstacle

### 3.3.2.1 Proposed measures

The project has demonstrated that there is a deficiency in the rear vision from certain $M_1$ and $M_2$ vehicles, and that this is largely responsible for many injuries associated with vehicles that are reversing.

From the research and testing carried out in Work Package 3, the following engineering changes to vehicles are proposed, in order to reduce the number of injuries that occur when these vehicle types are reversing:

- To mandate the installation of a camera-monitor system on all $M_1$ and $M_2$ category vehicles, to allow the driver to view the area to the rear while reversing.
- To mandate the installation of a driver alert system on all $M_1$ and $M_2$ vehicles, to warn the driver of persons close to the rear of the vehicle while reversing.

### 3.3.2.2 Engineering changes proposed

In the case of the camera-monitor system, the minimum equipment level would be a single camera mounted in a position that gives the field of view specified. Although some cameras offer a "night vision" capability, this is not considered to be a necessary part of the minimum fitment, since the reversing lamp will provide sufficient illumination at the range required. A basic monochrome monitor would be sufficient. No minimum screen size needs to be specified. The most basic systems currently offered for sale incorporate a 2.5inch colour monitor.

In the case of the driver alert system, the minimum equipment level would be a single sensor with an audible alarm. However, the most basic systems currently on sale offer 2 sensors with a multi-tone buzzer. Many suitable systems are already on the market as reversing aids.

### 3.3.2.3 Costs for the camera-monitor system

The camera-monitor and driver alert systems proposed as reversing aids for $M_1$ and $M_2$ vehicles are different from the systems proposed for $N_2$ / $N_3$ blind spot. The latter are of much more rugged design to withstand the working environment of a LGV, and are designed for a 24volt electrical system. The devices proposed for this application do not require these qualities and are therefore generally cheaper.

The partners have reviewed 8 reversing camera-monitor systems currently on sale as retrofit devices and also the systems offered by manufacturers as factory-fitted accessories in 2 popular mid-range saloon cars. All of these meet the minimum specification detailed above. The retrofit systems cover a range of prices from £40 to £205 with an average price of £130; some of the higher priced systems offer features that are not necessary for the basic functionality envisaged such as combined sensor alerts and night vision. On this basis, the typical price for a basic system is considered to be £125, which covers the 5 cheapest systems. Installation of these systems (some of which use wireless connectivity for the monitor unit) is judged to require less than 1 hour's labour, representing an additional cost of £35, making a total cost of £160 per car. The additional cost charged by car manufacturers for their original equipment reversing camera systems varies between £200 and £400 and is therefore consistent with the above costs.

Currently, reversing cameras are classed as surveillance cameras and are therefore not subject to mandatory performance standards. If their fitment was made obligatory, then it might be appropriate to introduce some form of minimum performance requirements for them, and these could be incorporated into ECE46.02, since this already addresses camera-monitor systems as alternatives for some mirror types. This could impose an additional cost on manufacturers, which could increase unit costs by a small amount, depending on sales volumes.

Although some new cars are already fitted with reversing cameras as standard, these are believed to form a very small proportion of the total number produced. If all of the 1 996 300 new cars registered in the UK in 2010 were required to be fitted with reversing camera-monitor systems, therefore, the total cost would be approximately £319 408 000. However, this only considers $M_1$ vehicles and not $M_2$.

#### 3.3.2.4 Benefits for the camera-monitor system

The cluster analysis referred to in the previous section was confined to category N vehicles only, and did not include accidents to category M vehicles, as per the agreed project plan. Hence it is not possible to examine the benefits of preventing reversing accidents in the same way. To overcome this difficulty, access was granted by DfT to some earlier unpublished data for reversing accidents. This data was only available for $M_1$ vehicles in 2007, where vehicle blind spot was judged to be a contributory factor. Due to the lack of data availability for $M_2$ vehicles, the following sections therefore only consider benefits with respect to $M_1$ vehicles. The data contained the following classes of injury:

- Slight 118, Serious 41, Fatal 0.

For the purposes of benefits calculation, it was assumed that all of these accidents could potentially have been prevented by the provision of a reversing camera or a driver alert on the affected vehicle. The benefits for the two measures were assumed to be the same.

The value of these benefits is given in the table below:

| Injury class | Number of accidents prevented | Value per accident, £ | Benefits, £ |
|---|---|---|---|
| Slight | 118 | 1880 | 221 840 |
| Serious | 41 | 21 370 | 876 170 |
| Fatal | 0 | 1 790 200 | 0 |
| All | 159 | | 1 098 010 |

**Table 8 Annual Benefits from Eliminating Reversing Accidents to $M_1$ Vehicles where Blind Spot was a Contributory Factor**

As with the blind-spot camera and alert systems in the previous section, it is assumed that these systems will have a life of 5 years before requiring replacement of major overhaul. Therefore, we can count that the total benefits will be 5 times the annual benefits given above. This represents a total benefit of £5 490 050, if the measures are effective.

According to SMMT figures, the number of new cars registered in the UK in 2010 was 1 996 300. Very few of these were fitted with a reversing camera, so in the case of the camera system, it is assumed that this is the number of affected vehicles. Dividing the total benefits by this number of vehicles gives £2.75 per vehicle, which is effectively the budget for a suitable system, if a positive benefit is to be achieved.
In the case of reversing alarms, a survey by MIRA showed that approximately 20% of vehicles are already equipped with systems of this type. Therefore, the number of affected vehicles is approximately 1 597 040. Using a similar calculation as the above, the total benefits require a system cost of less than £3.43 per vehicle.

#### 3.3.2.5 Costs for the driver alert system

MIRA reviewed 18 parking sensors currently on sale as retrofit devices, and also the systems offered as factory fitted accessories on 5 mid-range saloon cars. All of these meet the minimum specification detailed above. The retrofit devices range in price between £30 and £110, with an average price of £62. In general, the more expensive systems do not offer more features, so it is assumed that the difference in price is determined by quality. Installation of these systems is judged to require 1 hours labour, representing an additional cost of £35, making a typical total cost per vehicle of £97.

It is difficult to identify an accurate price for factory-fitted systems since most of these are offered as a package together with other features. However, two of the manufacturers reviewed offer 2-sensor "parking systems" for £130 and £199, and one offers a 4-sensor system for £249.

Unlike the reversing camera system, a significant proportion of new cars are already fitted with parking sensors as standard. No statistics could be found for this. However, MIRA conducted a small survey of current vehicles and estimates that 20% of 2007-2011 cars have such systems already fitted. Therefore, the additional number of systems that will be needed if all cars are to be fitted is estimated as 1 597 040. Therefore, the estimated total cost for installing these across the fleet in the UK is £154 912 880.

| Measure | Reversing camera / monitor | Driver alert |
|---|---|---|
| Total benefits over 5 years | £5.5m | £5.5m |
| No of vehicles affected | 2.0m | 1.6m |
| Target unit cost | £2.75 | £3.43 |
| Average net cost per vehicle | £160 | £97 |
| Benefit / cost | 0.02 | 0.04 |

**Table 9 Cost-benefit summary for potential solutions to rear visibility for $M_1$ vehicles**

#### 3.3.2.6 Other considerations

Currently, camera systems are permitted as an alternative to certain classes of mirrors by ECE46.02. Therefore, this regulation would form the regulatory basis for the performance of reversing camera systems. On the other hand, there is currently no mandatory standard for the performance of reversing alarms, and it might be necessary to draft such a standard if these are to be made mandatory. Approval of systems to this standard could impose a cost burden on manufacturers, with a consequent additional cost per component passed on.

Calling for the mandatory installation of camera-monitor or driver alert systems for the most numerous sector of the motor industry (even in the UK, let alone Europe) would call for a significant increase in the production of such devices, even on a world-wide basis. It is not known whether the industry is capable of responding to this increase in demand, or what the effect on raw material resources would be, or what effect this might have on the price structure.

Both of the measures proposed here have been assessed for their effect on Government targets for CO2 emissions and other environmental considerations. External cameras and sensors of this type do not significantly alter the external profile of the car and their power consumption is negligible in comparison with the motive power of the vehicle. They would therefore not be expected to affect the fuel consumption or CO2 emissions of cars. However, the change in CO2 emissions associated with the increased production of these devices is not known.

#### 3.3.2.7 Conclusions

On the basis of these figures, it is estimated that requiring all $M_1$ vehicles in the UK to install reversing cameras or driver alerts could prevent 0 fatal, 41 serious, and 118 slight injuries per year on UK roads, representing a saving of £1 098 010. Since very few cars are currently fitted with reversing cameras, this represents a per-vehicle benefit of £2.75. On the other hand, since an estimated 20% of new cars are already fitted with a reversing alert system, the average benefit from equipping the remaining cars with one of these is higher, at £3.43 per vehicle. Against this, a survey of the market for these systems indicates that the average price for a reversing camera system is approximately £160 per vehicle, while the average price for a reversing alert system is £97 per vehicle. None of the systems surveyed was available for less than the budget price. On balance therefore, the cost of equipping the entire UK car fleet with either type of system would be more than the benefits arising from the reduction in injuries.

Instead, it is recommended that a further review should be carried out in 5 to 10 years time, when it seems likely that the majority of cars will be equipped with reversing cameras or alerts as standard. If this happens, the costs of implementing the measures will have reduced significantly, making their adoption across the whole of the $M_1$ fleet more attractive economically.

### 3.3.3 Mirror image quality

#### 3.3.3.1 Proposed measure

From the research undertaken, it appears that drivers of $N_3$ vehicles may not adjust their mirrors correctly, although no quantitative data appears to be available on this. Thus, even though the vehicle mirrors could potentially allow the driver to see the minimum areas prescribed in the regulation, the full extent of these areas may not be seen from the driver's seat. It is believed that the main reason for this is that the driver is too busy to check or adjust the mirrors at the start of shift or does not know how to do so correctly. However, there may also be cases where the driver is using the mirror for a purpose other than that for which it is intended e.g. close manoeuvring.

Difficulties in adjusting the mirrors may be problematic for drivers. For many LGVs the mirrors are located too far above the ground to be reached without steps. Class II and IV mirrors are often located too far forwards to be reached easily through the driver's window. Even where access is possible, the nearside mirrors require the driver to leave their seat to make the adjustment, and this may require some backward and forward movement while the position of the mirror is checked and re-adjusted.

There is a widely-held belief that the wide angle view of Class V and VI mirrors makes it less important to set them correctly, and that once set they will offer an adequate view for a wide range of driver sizes and driving positions. Simulation work in WP1 has shown that this is not so.

The technology for adjusting mirrors remotely is now quite common on $M_1$ vehicles, and is being offered as standard equipment on some $N_2$ / $N_3$ vehicles for the Class II mirrors. However, the number of Class IV, V and VI mirrors incorporating electric adjustment is currently very small.

The measure proposed is that all new $N_2$ and $N_3$ LGVs in the UK should be required to be fitted with mirrors, including Class IV, Class V and Class VI, that are adjustable from the driver's seat. In the case of Class II mirrors, most manufacturers already have such mirrors available so it will only be necessary to offer them as standard, rather than an option. However, they would face a greater obstacle in fitting Class V and VI mirrors that are electrically adjustable. A market survey failed to find any manufacturers who currently offer such mirrors so it would be necessary for them to develop new products to meet this demand, even though the necessary actuators already exist.

#### 3.3.3.2 Costs

MIRA has conducted a survey of parts prices to estimate the additional cost of electric Class V and VI mirrors over the equivalent manually adjustable mirrors, and this would be approximately £50 per mirror to include switches, actuators and wiring. Thus, for a LGV that currently has electrically adjustable Class II mirrors only, the cost of full electrical adjustment would be £200, for two Class IV's, one Class V and one Class VI.

#### 3.3.3.3 Benefits

It is not possible at this stage to evaluate the benefits of the measure, because it was not practical for the project to survey the proportion of vehicles on the road where the mirrors are mal-adjusted to a dangerous extent, or to judge to what extent a particular degree of mal-adjustment affects the accident risk. Furthermore, even if such mirrors make adjustment easier, it is not known whether this will encourage drivers to adjust them more frequently, without other measures such as publicity campaigns being put in place. Therefore, it is not possible to make a case for whether the proposed measure would be economic or not.

#### 3.3.3.4 Conclusion

Although it seems likely that there would be a reduction in the injuries arising in vision-related accidents by requiring all mirrors on $N_2$ and $N_3$ vehicles to be adjustable from the driver's seat, it is not possible to estimate how many injuries would be saved by this measure. In addition, it is critical that drivers understand the rationale for the defined visible area and are capable of adjusting mirrors to meet that specification. The average cost of installing these on a LGV would be approximately £200, but it is not known whether this would result in a positive overall balance of benefit over cost.