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Commercial vehicle safety priorities – ranking of future priorities in the UK

Based on detailed analysis of data from 2006–2008

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Transport Research Laboratory

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Commercial vehicle safety priorities - Ranking of future priorities in the UK

Based on detailed analysis of data from 2006-2008

by T L Robinson and W Chislett (TRL)

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Contents

Executive summary

Goods vehicles, large passenger vehicles and other large vehicles such as agricultural vehicles and mobile machinery make up a relatively small proportion of the vehicles on the roads in Great Britain (GB). However, the frequency and/or severity of their involvement in accidents can be disproportionate to the distances they travel and in 2008 they were involved in accidents that resulted in approximately 29% of all GB road fatalities. Large vehicles can, therefore, have a significant influence on the UK's road safety performance. The purpose of this study was to develop further the methodology for assessing the potential safety measures in relation to these vehicle types and to establish a ranking for future commercial vehicle safety priorities.

Background

A review of the effectiveness of existing safety measures and a ranking of future research priorities for larger commercial vehicles was reported by Smith *et al* (2007). That study aimed to:

- Determine how previous research and resulting safety measures have performed;
- Define the status of current research and regulatory activity; and
- Establish the most cost-effective priorities for future action on commercial vehicle safety.

In order to achieve the stated objectives, the research consisted of three phases:

- **Phase one** reviewed the implementation and effectiveness of current and past measures such as underrun protection, fitment of speed limiters, anti-lock braking systems and seatbelts.
- **Phase two** identified the (then) current accident patterns involving the vehicles of interest (VOI) and defined a comprehensive list of accident types and casualty groups.
- **Phase three** assessed the potential costs and benefits of new vehicle safety measures that could be implemented in the future.

The analysis of the countermeasures was primarily based on data from accidents that occurred between 2003 and 2005 inclusive, as recorded by Stats19 (the national police reported accident database) and data from the Heavy Vehicle Crash Injury Study (HVCIS) Fatal Accident Database Phase 1, which covered accidents occurring between 1997 and 2002.

Study Objectives

The objective of this study was to provide an update of the previous analyses using the most recent data available. This has involved updating:

- The ranked table of casualty groups defined in phase 2 of the previous study – this involved using Stats19 data from 2006-2008 inclusive and considering the results in the context of the different ways in which the Government may set future casualty reduction targets.
- The analysis of potential countermeasures – which involved incorporating the results of more recent research and accounting for recent changes in the accident and casualty patterns where vehicles of interest were involved.
- The analysis of the effectiveness of front underrun protection – this involved updating the Stats19 analysis with data from 2006 to 2008 and adding an investigation of relevant accidents using the HVCIS fatal accident database.

Study findings

<u>Casualty trends for commercial vehicles</u>

Analysis of the number of casualties from accidents involving each of the VOI that occurred between 1999 and 2008 showed, in general, that whilst commercial vehicles were involved in accidents resulting in a significant proportion of GB casualties, there has been a continuous reduction in the number of casualties and proportionally this has been slightly greater than the reduction for all vehicles. In 2008, commercial vehicles were involved in accidents resulting in 28.6% of all GB fatalities, a reduction from 31.2% in 1999. However, within this total the record of different vehicle types varies and the number of fatal and serious casualties from accidents involving Other Motor Vehicles (OMVs), such as refuse vehicles, mobile cranes and fire engines, is relatively small but has increased in recent years.

The use of casualty rates per vehicle km allows the exposure to risk to be taken into account. However, the data that is required (vehicle kms) to calculate casualty rates are only available for heavy goods vehicles (HGVs), large passenger vehicle (LPVs) and light commercial vehicles (LCVs). Analysis of the fatality rate shows a reduction across all three vehicle types, indicating a genuine reduction in the fatality risk associated with each vehicle type. These rates continued to reduce in 2008, showing that the low casualty numbers for that year were not solely a function of reduced exposure to risk (distance travelled) as a result of the economic recession.

The most direct way to assess the contribution of specific accident or vehicle types to the overall casualty population is via the relative casualty rate. This indicates whether a particular type of accident involves more or less casualties per billion vehicle kilometres than the aggregate value for all accident types. It was found that:

- LCVs are continuing to out-perform the overall vehicle fleet in terms of casualty reduction;
- HGVs are over involved in serious collisions but continue to reduce their contribution faster than the overall vehicle fleet; and
- Since 2003 the relative casualty rate for LPVs has increased indicating that the LPV casualty rate is not reducing as quickly as for other vehicle types.

<u>Who are the casualties?</u>

A list of 253[1] casualty groups was compiled from Stats19 data from 2006 to 2008 and compared to equivalent tables of 244 casualty groups for 2003 to 2005. The casualty groups were based on the vehicle of interest involved, its collision partner and the impact configuration. For each entry on the list, the number of casualties occurring in that collision type was recorded, by casualty severity. This list was ranked in order of priority (based on the casualty prevention values associated with those that were killed or seriously injured – “KSI cost”) so as to determine the relative importance of different casualty groups.

When considering the total number of fatalities from accidents involving the vehicles of interest, heavy goods vehicles appear to be the main priority. However, large passenger vehicles have a killed and seriously injured casualty rate that is three to four times higher than the overall casualty rate for all vehicle types and is reducing more slowly than the overall casualty rate.

Car occupants in collisions with heavy goods vehicles remain the highest ranked casualty group. When considering the financial value associated with preventing fatalities and serious injuries, head-on collisions between cars and heavy goods vehicles are the

[1] To minimise the number of casualty groups, the sub-division of casualty groups by impact location was restricted to those where the number of fatalities was greater than ten.

highest ranked individual casualty group that a single countermeasure is likely to influence.

Potential countermeasures

A wide range of countermeasures had been assessed in the previous study and this assessment was:

- Updated to account for the accident and casualty data from 2006-2008;
- Expanded to include new measures not previously considered; and
- Refined so that new information on the characteristics, performance, effectiveness or cost was reflected in the definition and analysis of previously assessed measures.

From this analysis, the following five countermeasures that could be implemented through vehicle construction standards were selected for a more detailed cost-benefit analysis:

- Safer fronts for heavy goods vehicles;
- Faster response braking systems for heavy goods vehicles;
- Low speed vulnerable road user warning systems for heavy goods vehicles;
- Driver alertness warning systems for heavy goods vehicles; and
- Safer fronts for large passenger vehicles;

Front underrun protection (FUP) was mandated for heavy goods vehicles in 2003 and was expected to result in significant benefits for car occupants in collision with the front of an HGV (the most important commercial vehicle casualty group identified in the list of casualty groups). However, analysis of the effectiveness of front underrun protection has found no evidence that this measure has had the effect on the casualties that had been expected, though there are substantial limitations in the analysis techniques and data available that limit confidence in the findings. However, historically FUP was expected to be the number one commercial vehicle safety priority and some of the new countermeasures assessed in the current research rely on it being effective (for example, safer vehicle fronts). This means that further investigation of this preliminary result and, if confirmed, identification of alternative means of protecting the casualties FUP was intended for, could be considered as high a priority as the five new measures identified.

Cost-benefit analysis

The five selected countermeasures were evaluated further using the following three cost-benefit methods:

1. Evaluation over a ten year implementation period using forecast casualty data, casualty valuations and fleet penetration (in line with Government guidelines);
2. Steady-state evaluation using forecast casualty data; and
3. Steady-state evaluation using the existing casualty data

The table below shows the results from method 1, which indicated that the faster response braking system for HGVs and the safer front for large passenger vehicles are most likely to provide a positive return on investment. The range in benefit cost ratio (BCR) for the safer front for heavy goods vehicles and the driver alertness system spanned one, although the best estimate was less than one. The whole range of BCR estimates for the vulnerable road user sensor system was less than one.

Counter-measure	KSI benefit-cost ratio calculated over a 10 year evaluation period from the date of implementation			Effects in year 10 after mandatory fitment				
				Countermeasure KSI casualty prevention value (£M, 2008 prices)			Reduction in number of fatalities	Reduction in number of serious injuries
	Min	Best estimate	Max	Min	Best estimate	Max	Best estimate	Best estimate
Safer HGV front	0.2	0.8	2.1	8	23	35	14	22
Faster response braking system for HGV	0.3	1.4	11.3	8	22	31	12	25
HGV low speed VRU collision warning[2]	0.2	0.2	0.4	17	17	17	10	18
HGV driver alertness monitoring – warning	0.1	0.5	1.8	6	16	24	9	22
Safer LPV front	1.1	2.9	7.2	8	14	19	7	25

However, it is relatively rare in the field of vehicle safety for cost benefit analyses to use this method and there is some evidence to suggest it may under-estimate the benefits. All countermeasures except for the VRU collision warning system had a best estimate benefit-cost ratio exceeding one when calculated using the steady state evaluation methods that are more commonly deployed in the assessment of vehicle safety measures.

Conclusions

Commercial vehicles are involved in a substantial proportion of GB casualties, particularly fatalities. The study has defined, quantified and prioritised a list of casualty groups that can be used to inform the relative priority of new developments in vehicle safety. An assessment of potential safety measures has been undertaken and identified a list of 5 priorities that could be implemented through commercial vehicle standards.

In addition to these priorities, initial analyses has identified no evidence that FUP has had its intended casualty reduction effect and further investigation of this result could be considered as high a priority as any of the new measures evaluated. Such an investigation could be referred to an appropriate European body such as the EEVC (European enhanced vehicle safety committee), whose working group 14 was responsible for much of the research behind FUP legislation.

The analysis has shown that the assessment of future priorities can be influenced by the ranking criteria, changes in the accident data and the information available about the countermeasures. Periodic updates of the analysis would help to ensure that future priorities remain aligned with casualty reduction targets, state-of-the-art knowledge and accident patterns of the time.

[2] The casualty benefit is estimated in two parts, the scope and the effectiveness. The scope of the countermeasure is generated using a number of criteria and where any one criteria has unknown values this produces a range in the scope. In this case, there were no unknown values and the scope was a single value, and when combined with a single value of effectiveness, this generated a single value for the benefit estimate. The benefit-cost ratio has a range of values because the single benefit value was divided by a range of costs.

Abstract

Goods vehicles, large passenger vehicles and other large vehicles such as agricultural vehicles and mobile machinery make up a relatively small proportion of the vehicles on the roads in Great Britain (GB). However, the frequency and/or severity of their involvement in accidents can be disproportionate to the distances they travel. In 2008 they were involved in accidents that resulted in approximately 29% of all GB road fatalities and so these vehicles can have a significant influence on the UK's road safety performance.

This study has defined, quantified and prioritised a list of casualty groups that can be used to inform the relative priorities for future developments in vehicle safety. An assessment of potential safety measures has been undertaken and five measures that could be implemented through vehicle design and construction standards were selected for more detailed cost-benefit analysis. This is the second review of this kind, the first having taken place in 2006.

1 Introduction

Casualties from accidents involving commercial vehicles represent a substantial proportion of all casualties that occur on GB roads. Safety improvements targeted at such vehicles therefore have the potential to have a significant effect on casualty reduction targets but it is important to ensure that such measures are effective and make best use of the available resources. An evaluation of the effectiveness of existing safety measures and a ranking of future research priorities for larger commercial vehicles was, therefore, undertaken by Smith *et al* (2007). This was reviewed and updated in 2009 to incorporate the latest accident data, the findings of which are documented in this report.

The vehicles of interest (VOI) to the study were defined as:

- **Heavy goods vehicles (HGVs)** – vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3.5tonnes;
- **Light commercial vehicles (LCVs)** – vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3.5tonnes;
- **Large passenger vehicles (LPVs)** – vehicles designed and constructed for the carriage of passengers, comprising more than 16 seats in addition to the driver's seat;
- **Minibuses** – vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat but not exceeding 16 seats;
- **Agricultural vehicles**;
- **Other motor vehicles (OMVs)** – powered vehicles that are not classified as agricultural vehicles, goods vehicles or passenger vehicles. Examples are refuse vehicles, mobile cranes, fire engines, etc.

The objectives of the research by Smith *et al* (2007) were to:

- Determine how previous research and resulting safety measures have performed;
- Define the status of current research and regulatory activity; and
- Establish the most cost-effective safety priorities for future action on large vehicle safety.

In order to achieve the stated objectives, the research consisted of three phases:

- **Phase one** reviewed the implementation and effectiveness of current and past measures such as underrun protection, fitment of speed limiters, anti-lock braking systems and seatbelts.
- **Phase two** identified the (then) current accident patterns involving the VOI and defined a comprehensive list of accident types and casualty groups. The casualty groups were ranked in order of importance by calculating the casualty prevention value[3] associated with the killed and seriously injured casualties from each group. This list was used to illustrate the relative importance of different accident configurations for the different VOI and road user types injured.
- **Phase three** assessed the potential costs and benefits of new vehicle safety measures that could be implemented in the future. The output from phase three included three lists of potential measures separated by their likely date of implementation: short term (pre-2012); medium term (2013-2018) and long term (post 2018). Five countermeasures were selected for further analysis using statistical modelling techniques to estimate the benefit-to-cost ratio associated with mandatory fitment of each system. Calculations were based on forecasts of future casualty figures, the size of the vehicle fleet and casualty valuations.

The analysis of the countermeasures was primarily based on data for 2003 to 2005 inclusive from Stats19 (the national police reported accident database) and the Heavy Vehicle Crash Injury Study (HVCIS) Fatal Accident Database Phase 1.

The objective of this report is to provide an update of phases 2 and 3 of the previous study using the most recent data available. This has involved updating:

- The ranked table of casualty groups with Stats19 data from 2006-2008 inclusive and considering possible changes in the definition of casualty reduction targets.
- The analysis of potential countermeasures to incorporate the results of more recent research and to account for changes in the types of casualties involving the vehicles of interest.
- The analysis of the effectiveness of front underrun protection, including an investigation of relevant accidents using the HVCIS fatal accident database.

[3] Calculated by multiplying the number of casualties at each severity by the associated casualty prevention value published by the Department for Transport (DfT, 2009a)

2 Casualty trends

The data presented in this section provide the context for the analysis in the subsequent sections. Trends in the number of casualties and the associated casualty rates are presented. It should be noted that the under-reporting of serious and slight casualties has been identified in a number of studies, for example Simpson (1996) and Ward *et al* (2006). This should be taken into consideration when examining the numbers of serious and slight casualties throughout this report.

2.1 Number of casualties from accidents involving all types of motor vehicle

Figure 1 shows the trend in the number of fatalities from accidents involving all types of commercial vehicle. For comparison, the number of casualties from accidents invovling cars and accidents involvng powered two wheelers are also shown. The data represented by these three casualty groups are not additive (an accident could inovlve both a car and a commercial vehicle) and therefore the trend in the total number of killed and seriously injured is also shown.

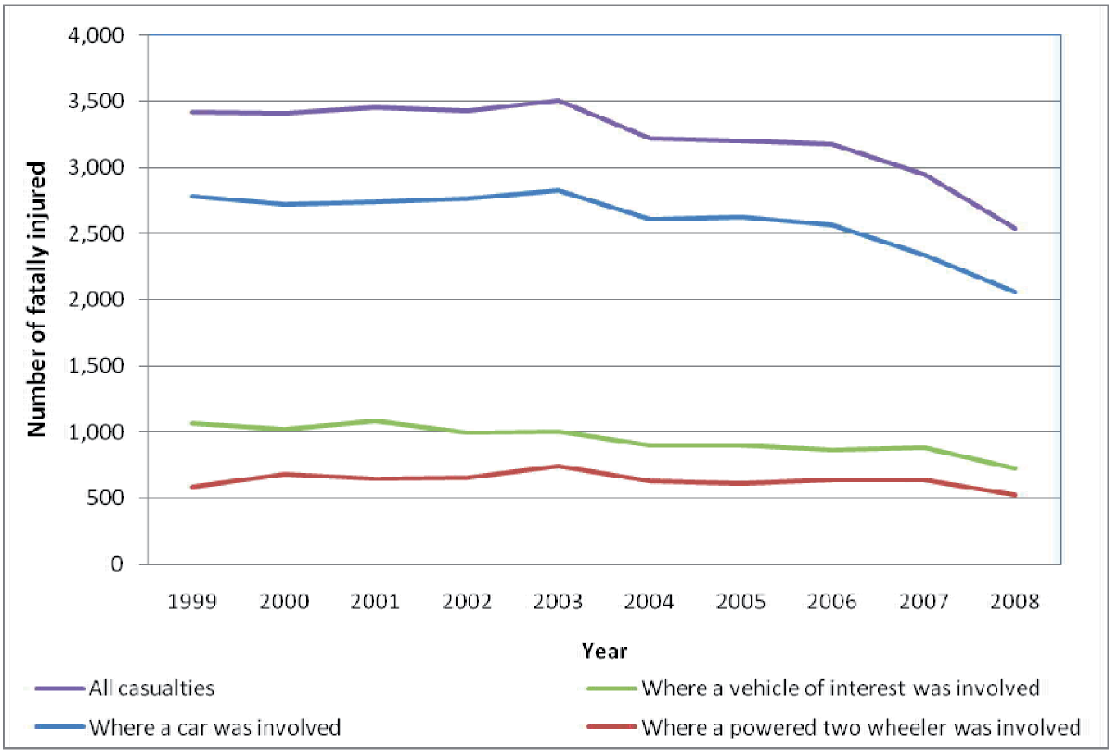


Figure 1. Comparison of trends in number of fatalities from accidents involving cars, powered two-wheelers and all commercial vehicles (vehicles of interest).

Figure 2 shows the equivalent trends for serious casualties and Figure 3 shows the trends for KSI. Figure 4 shows the trends for slight casualties.

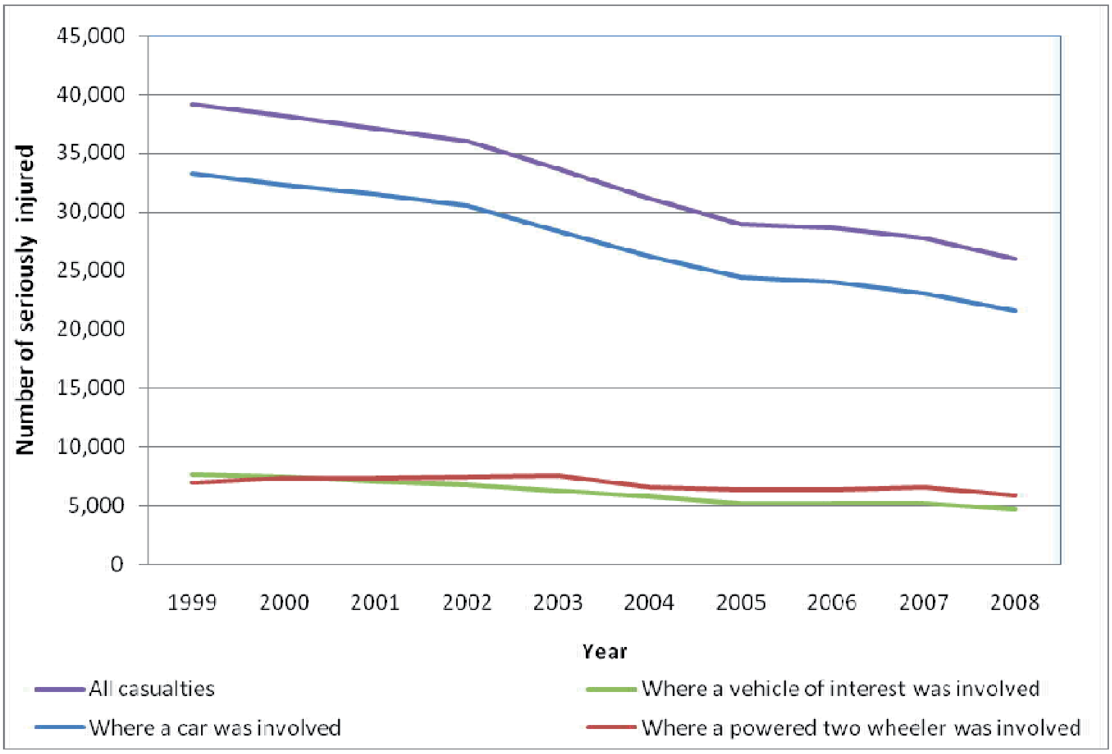


Figure 2. Comparison of trends in number of seriously injured from accidents involving cars, powered two-wheelers and all commercial vehicles (vehicles of interest).

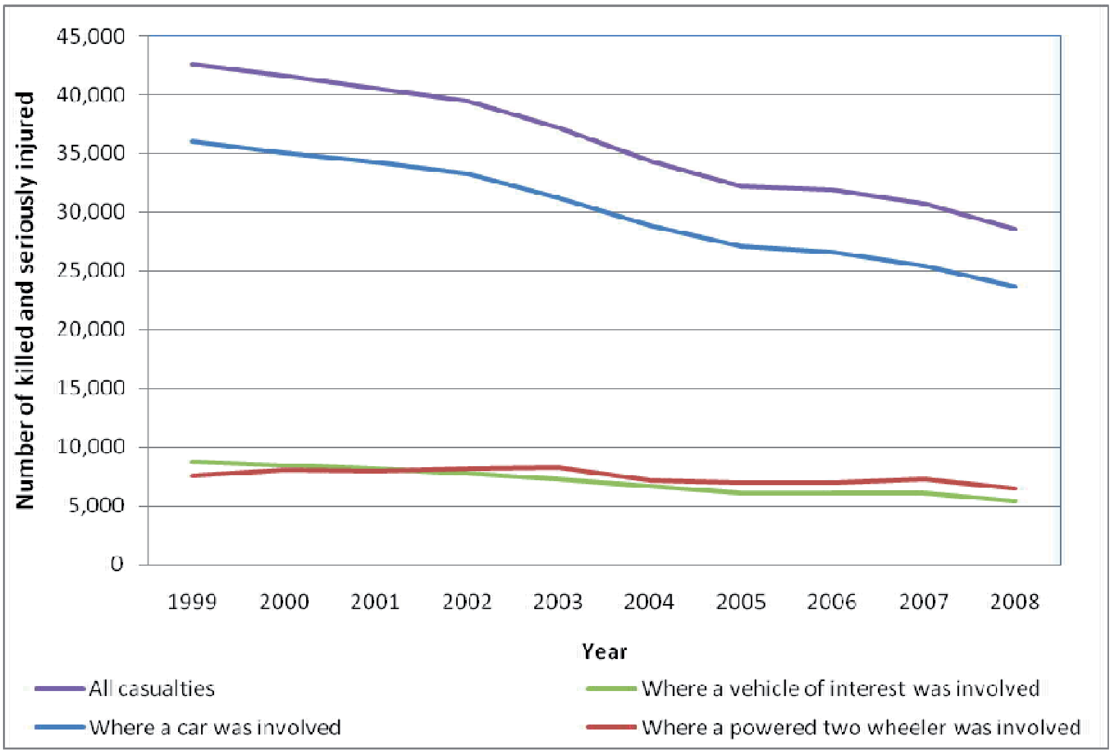


Figure 3. Comparison of trends in number of killed and seriously injured from accidents involving cars, powered two-wheelers and all commercial vehicles (vehicles of interest).

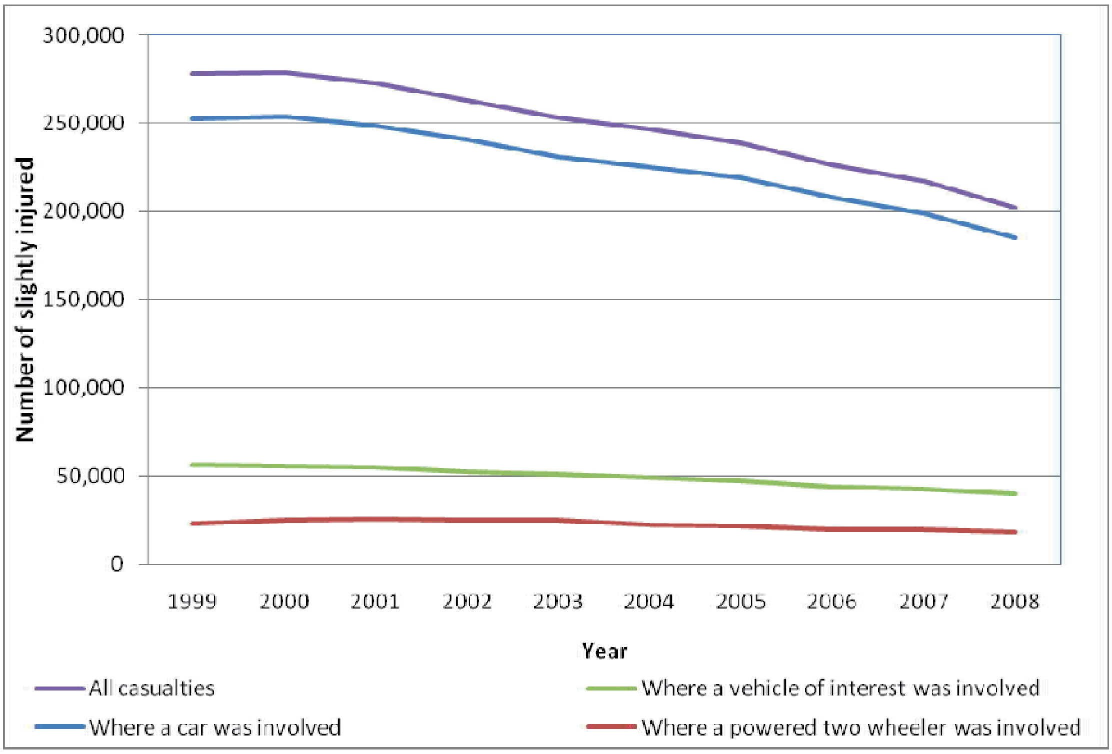


Figure 4. Comparison of trends in number of slightly injured from accidents involving cars, powered two-wheelers and all commercial vehicles (vehicles of interest).

It is clear that passenger cars are involved in the majority of casualties of all severities, which suggests that they represent the highest priority in terms of the absolute casualty reduction potential.

When considering the number of fatalities, those from accidents involving commercial vehicles are consistently higher than the number of fatalities from accidents involving powered two-wheelers. The number of killed and seriously injured from accidents involving commercial vehicles is similar to the number of killed and seriously injured from accidents involving powered two-wheelers, although there is a clear downward trend for the commercial vehicles. This declining trend for commercial vehicles might tend to suggest a lower priority compared with powered two-wheelers where the trend is closer to constant. The number of slight casualties from accidents involving commercial vehicles has also been consistently higher than for accidents involving powered two-wheelers. Overall, the higher number of fatalities from accidents involving commercial vehicle tends to suggest a higher priority relative to powered two wheelers.

2.2 Number of casualties from accidents involving commercial vehicles

Figure 5 and Figure 6 show the trends in the numbers of fatalities and serious casualties from accidents involving each of the VOI that occurred between 1999 and 2008 inclusive.

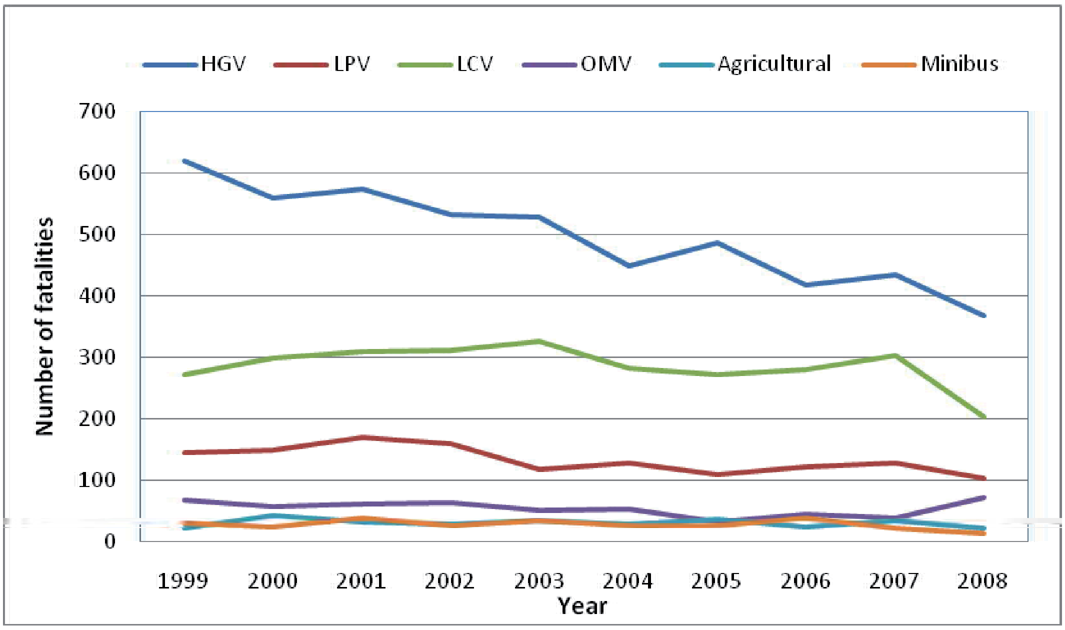


Figure 5. Trends in number of fatalities from accidents involving each vehicle of interest.

The number of fatalities in accidents involving HGVs and LPVs has shown a general downward trend for the period. The number of fatalities from accidents involving LCVs showed an initial increase up to 2003 and has fluctuated since then, until a relatively sharp decrease in 2008. Fatalities from accidents involving agricultural vehicles and minibuses have fluctuated around the same levels up to 2007, but showed a decrease in 2008.

All groups of fatalities, except for those where an OMV was involved, showed a distinct reduction between 2007 and 2008. This may reflect a reduction in the distance travelled by commercial vehicles, and thus their exposure to accident risk, because of the downturn in the economic climate. This hypothesis is investigated further in section 2.4. However, in contrast, fatalities from accidents involving OMVs have increased from 38 in 2007 to 71 in 2008.

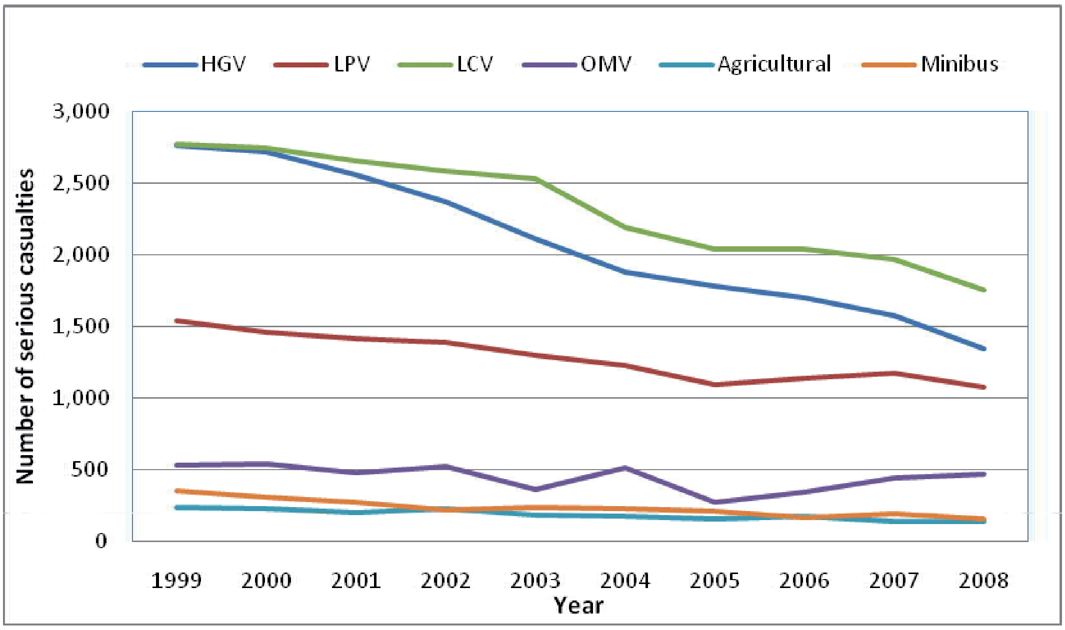


Figure 6. Trends in number of serious casualties from accidents involving each vehicle of interest.

There was a larger reduction in the number of serious casualties from accidents involving HGVs compared to LCVs. Serious casualties from accidents involving all VOI, with the exception of OMVs showed a downward trend. There was an increase in the number of serious casualties from accidents involving OMVs from 2005.

Figure 7 shows the trend in the number of killed and seriously injured (KSI), the sum of the fatalities and serious casualties.

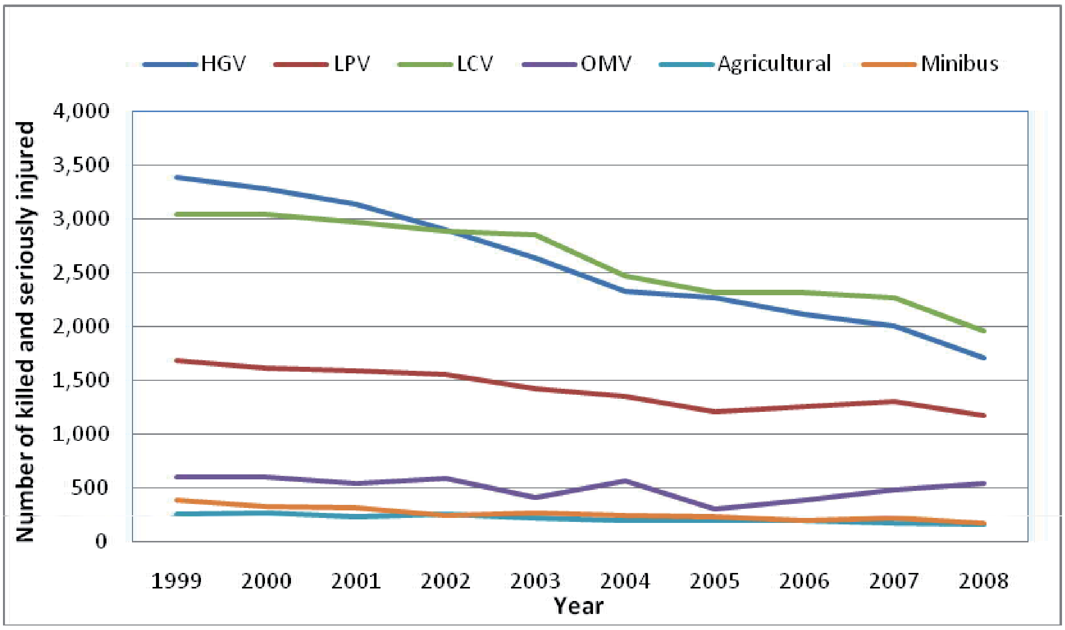


Figure 7. Trends in number of killed and seriously injured casualties from accidents involving each vehicle of interest.

The trends are dominated by the number of serious casualties and the overall trends are similar to those seen for the serious casualties. However, one interesting observation in this data is related to the number of KSI in accidents involving LCVs, which started out lower than those from accidents involving HGV, but has end up higher than for HGVs.

Figure 8 shows the equivalent trends for slight casualties.

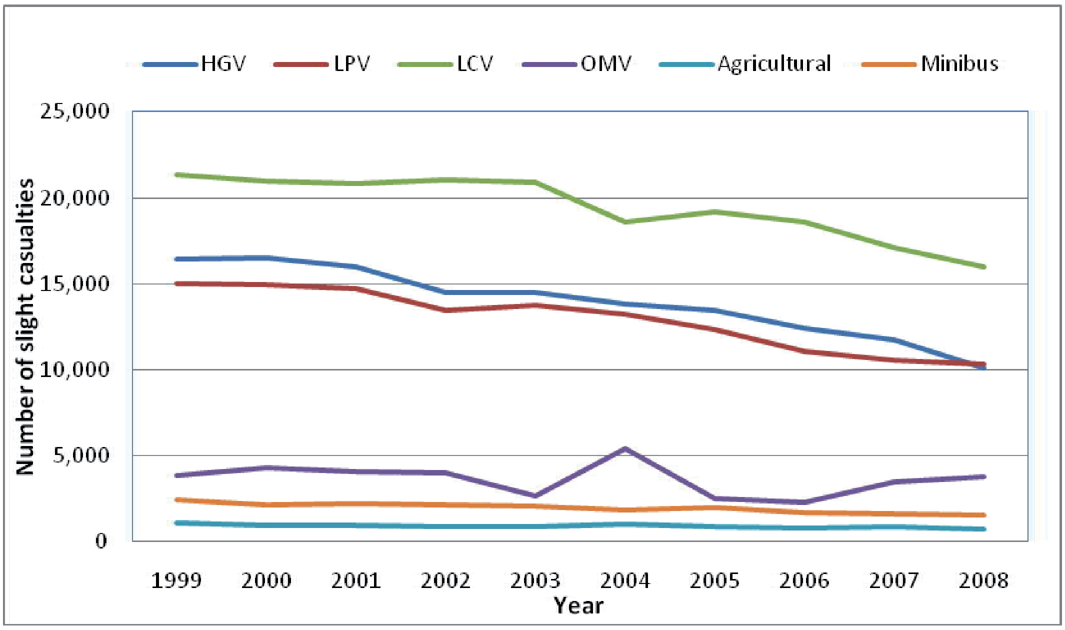


Figure 8. Trends in number of slight casualties from accidents involving each vehicle of interest.

The conclusions are similar; slight casualties have also reduced with the exception of those from accidents involving OMVs.

There are a number of possible explanations for the increase in the number of accidents involving OMVs across all three severities, for example:

- Increasing numbers of OMVs - it is possible that some vehicle types such as quad bikes have increased in popularity or that a growth in recycling has increased the number of refuse collection vehicles;
- Increasing use of OMVs (i.e. distances they travel); or
- Mis-coding of the vehicles in Stats19.

At present these are mostly hypotheses and have not been investigated in depth. However, Robinson *et al* (2009) compared the coding of OMVs in Stats19 and the HVCIS fatal accident database. Although there were slight differences in the definitions of OMV used between the two databases, the analysis identified that 12 of 18 vehicles coded in Stats19 as OMV were actually other types of vehicle, with three vehicles being coded as agricultural vehicles, which prior to 1999 were included as OMVs. However, considering how vehicles coded as OMV in HVCIS are coded in Stats19 revealed that less than half were coded as OMV in Stats19 with most being coded as HGV. This suggests that the OMVs are under-represented in Stats19. This would only explain the increases observed in 2008 if the vehicle type misclassification was suddenly and substantially reduced in 2008.

The figures presented here do not account for any changes in vehicle usage during the period, which is covered in section 2.4.

2.3 Casualty rates for accidents involving all types of motor vehicle

Figure 9 to Figure 12 show the trends in casualty rates of different severities from accidents involving cars, powered two-wheelers and all commercial vehicles[4] (vehicles of interest).

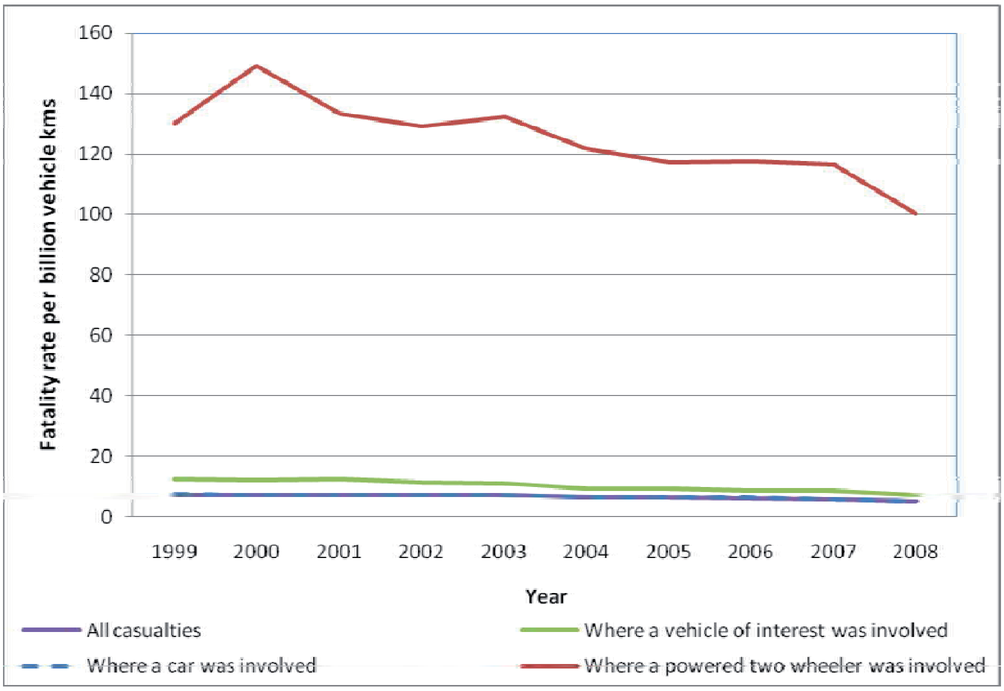


Figure 9. Comparison of trends in fatality rate from accidents involving cars, powered two-wheelers and all commercial vehicles (vehicles of interest).

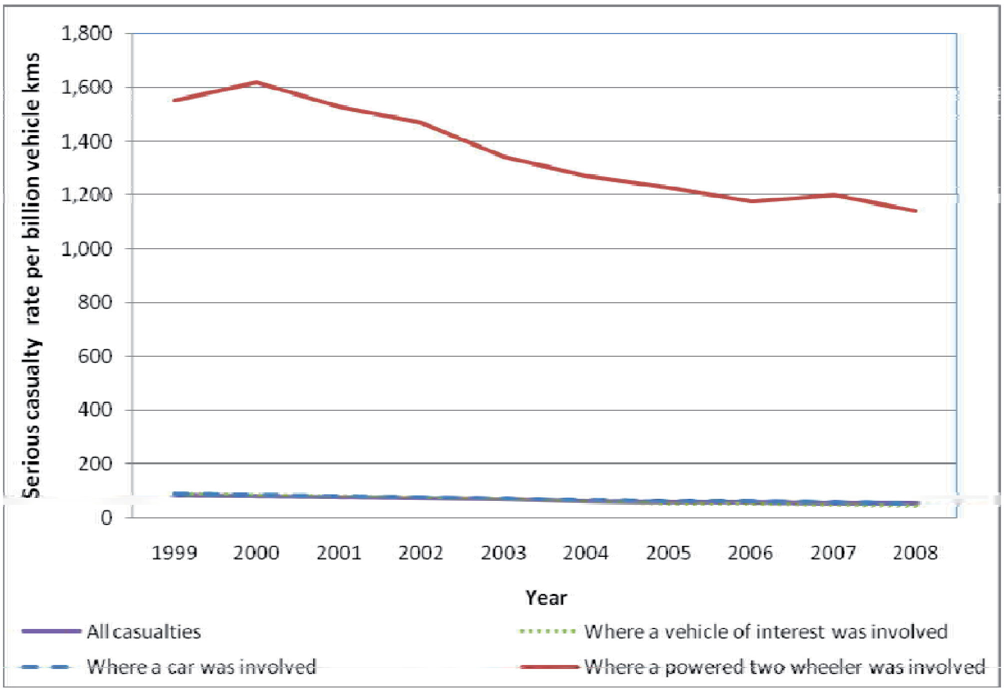


Figure 10. Comparison of trends in serious casualty rate from accidents involving cars, powered two-wheelers and all commercial vehicles (vehicles of interest).

[4] The casualty rate has been calculated using the number of casualties for all vehicles of interest but the exposure data is only available for HGVs, LPVs and LCVs. In reality the casualty rate for all vehicles of interest will be lower than shown.

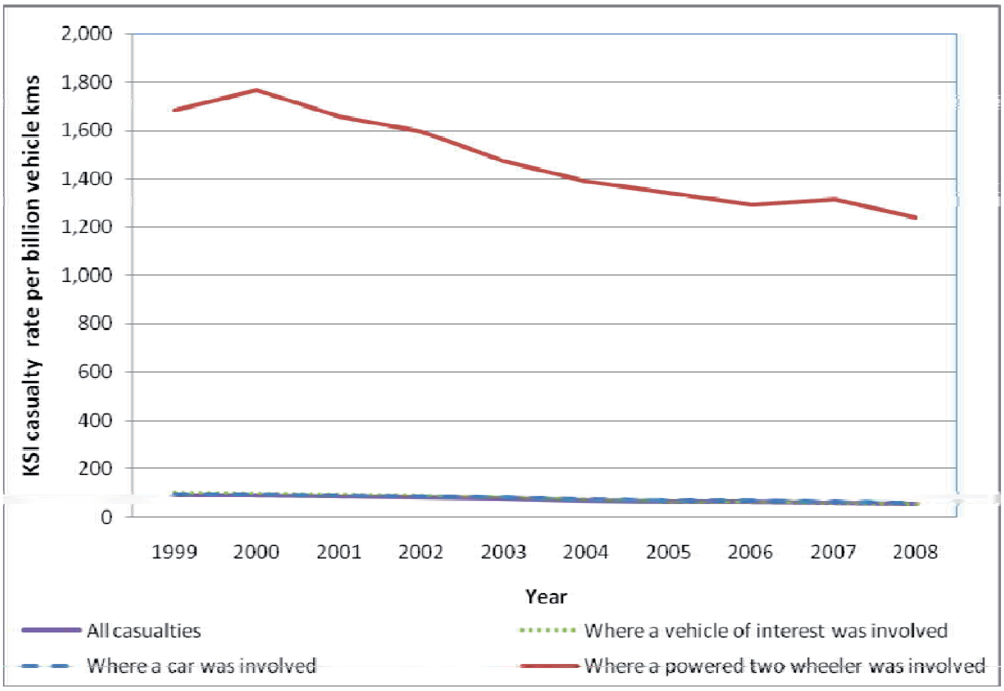


Figure 11. Comparison of trends in KSI casualty rate from accidents involving cars, powered two-wheelers and all commercial vehicles (vehicles of interest).

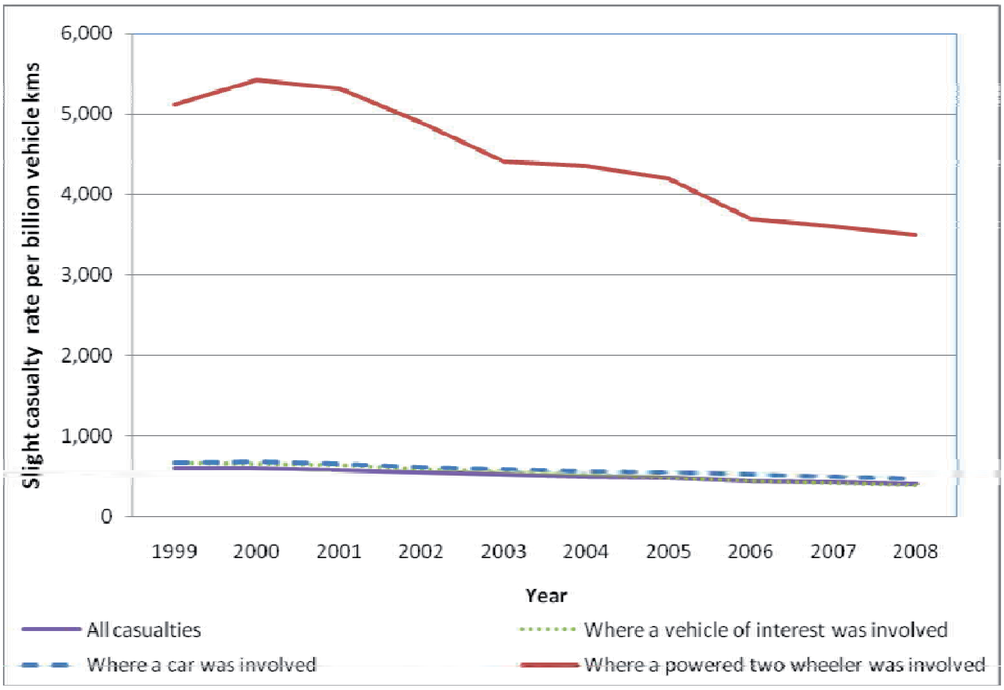


Figure 12. Comparison of trends in slight casualty rate from accidents involving cars, powered two-wheelers and all commercial vehicles (vehicles of interest).

It is clear that powered two wheelers represent by far the largest casualty risk per km driven of any of the vehicle types considered at all injury severities. The risk per km associated with commercial vehicles is very low by comparison, although it is higher than the overall fatality rate and the fatality rate for cars.

2.4 Casualty rates for accidents involving commercial vehicles

Figure 13 and Figure 14 show the fatal and serious casualty rates for accidents involving HGVs, LPVs and LCVs. The exposure data used is the distance travelled by the specific vehicle type. Minibuses, agricultural vehicles and OMVs are not included in the figures because the equivalent exposure data is not available. Note that casualty rate for accidents involving cars has been included for comparison and context.

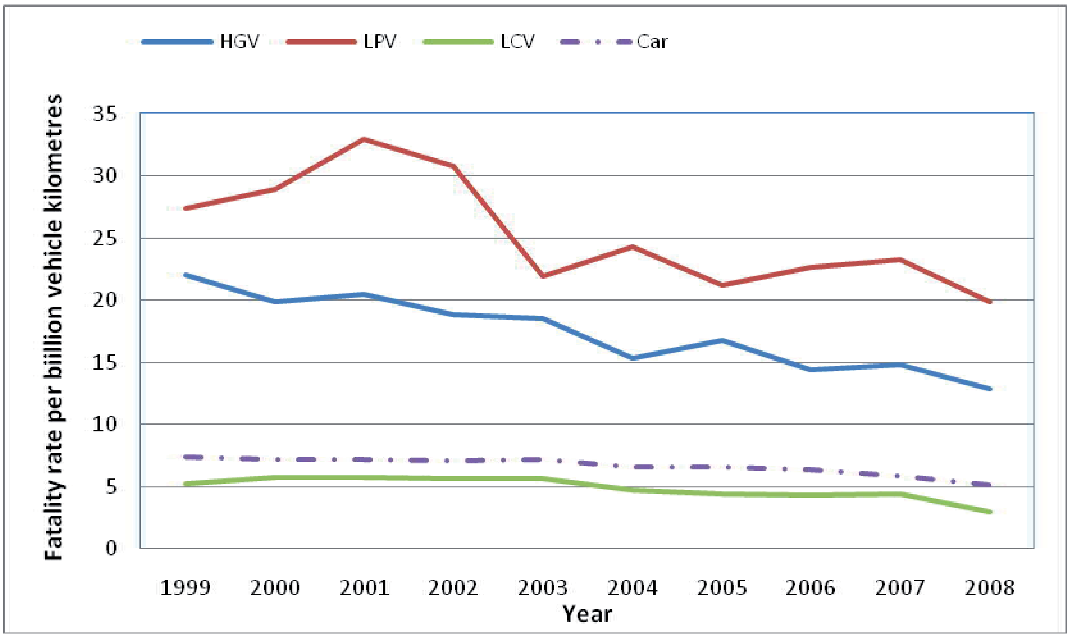


Figure 13. Trend in fatality rates per billion vehicle kilometres.

The reduction in the number of fatalities from 2007 to 2008 could have been explained by considering a potential reduction in vehicle kilometres travelled by these vehicle types during the recession. However the fatality rate also shows a reduction across all three vehicle types, indicating a genuine reduction in the fatality risk associated with each vehicle type. However this is more of a departure from trend for LCVs than for trucks or buses where the change could be within the range of expected annual variation around a longer term trend.

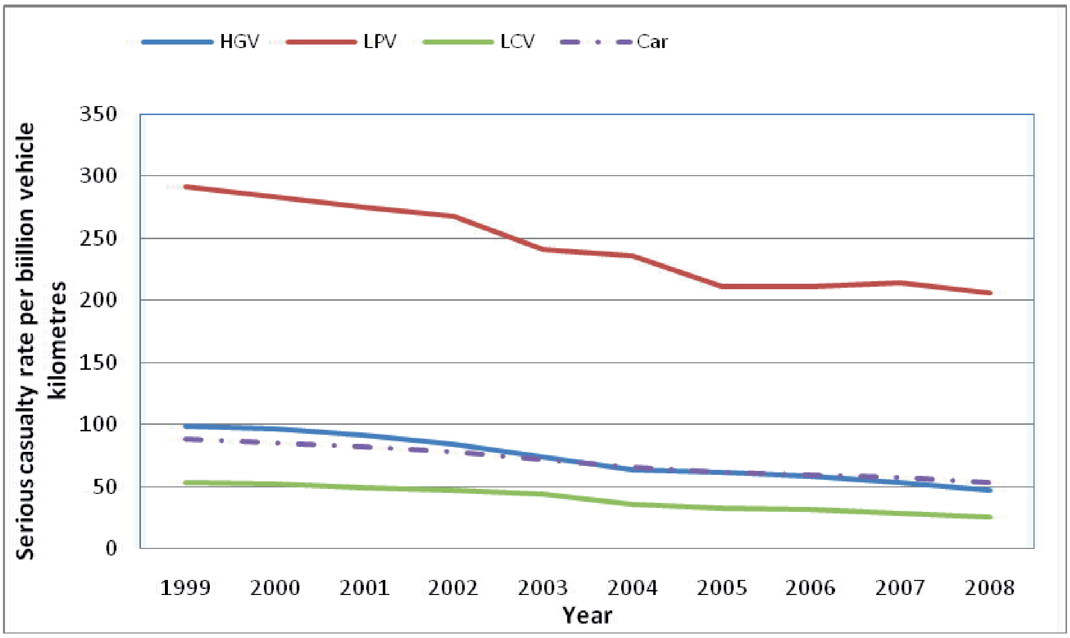


Figure 14. Trend in serious casualty rates per billion vehicle kilometres.

The serious casualty rate has also shown a continued downward trend. However the rate at which it is reducing has decreased across all three vehicle types, particularly for LPVs, which show a distinct plateau. Figure 15 combines the fatal and serious casualty rates into the KSI casualty rates for accidents involving these three vehicle types. Again, these trends are dominated by the number of serious casualties.

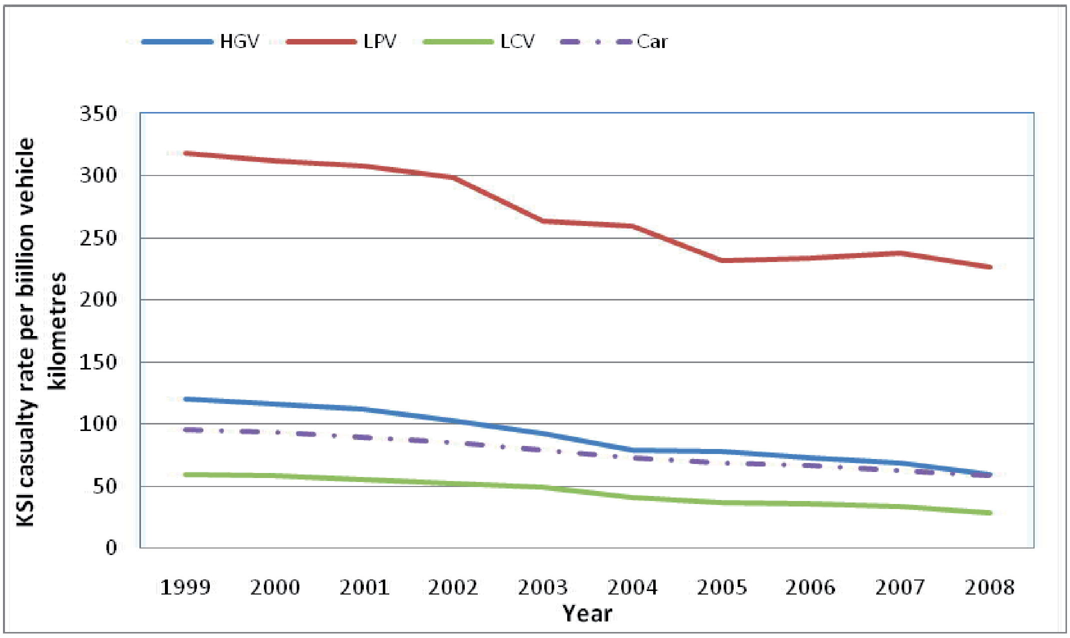


Figure 15. Trend in KSI casualty rates per billion vehicle kilometres.

Figure 16 shows the trends in the slight casualty rates.

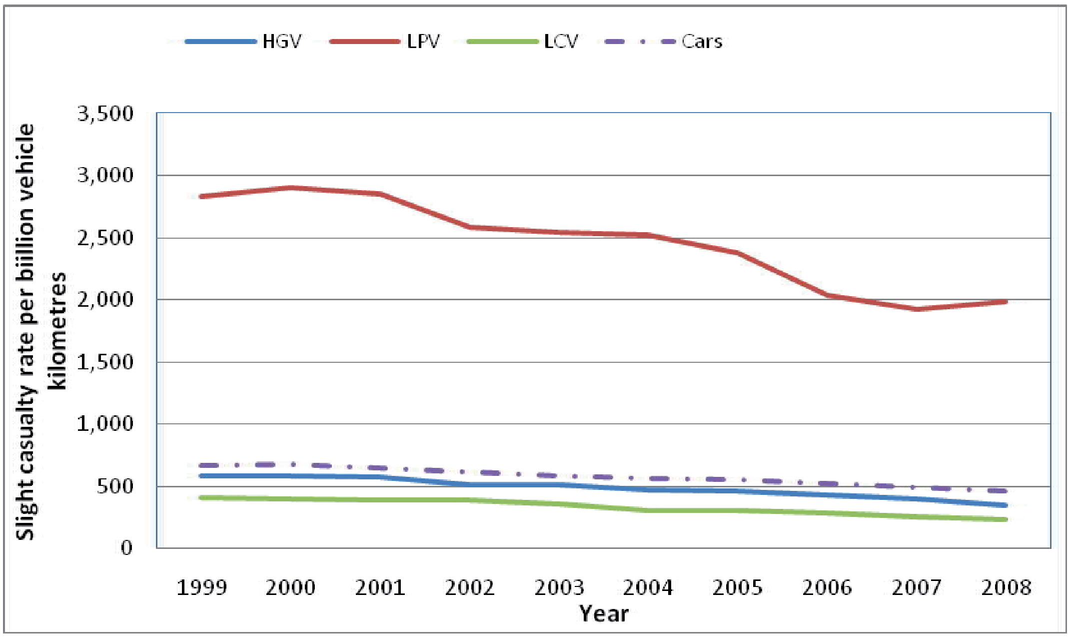


Figure 16. Trend in slight casualty rates per billion vehicle kilometres.

A similar effect to that shown for serious casualties can be seen in the slight casualty rate. The most notable difference is the increase in the slight casualty rate for LPVs from 2007 to 2008.

Overall, the data shows that, although the absolute number of casualties from accidents involving LPVs is generally lower than for HGVs and LCVs, the casualty rate is consistently higher. This is likely to be related to the low number of registered vehicles, resulting in the exposure to risk of an accident for an LPV being low, but high occupancy, which means that when an LPV has an accident the number of casualties is likely to be higher than for other vehicle types. LCVs consistently have a lower casualty rate than HGVs and LPVs, but all three vehicle types are showing an overall reduction in casualty rate at all three casualty severities for the time period shown.

2.5 Relative casualty rates

The most direct way to assess the contribution of specific accident or vehicle types to the overall casualty population is via the relative casualty rate. For example, for LPVs:

$$relative\ \ casualty\ \ rate = \frac{casualties\ \ in\ LPV\ \ accidents\ \ per\ billion\ \ LPV\ \ kilometres}{casualties\ \ in\ all\ accidents\ \ per\ billion\ \ vehicle\ \ kilometres}$$

Figure 17 shows the trends in relative KSI casualty rate for the three commercial vehicle types plus for passenger cars. The latter has been provided for contextual purposes but it should be noted that the rate for cars will always be close to one because most casualties are from accidents involving cars and thus the numbers and trends for "all casualties" will be dominated by the effect of cars.

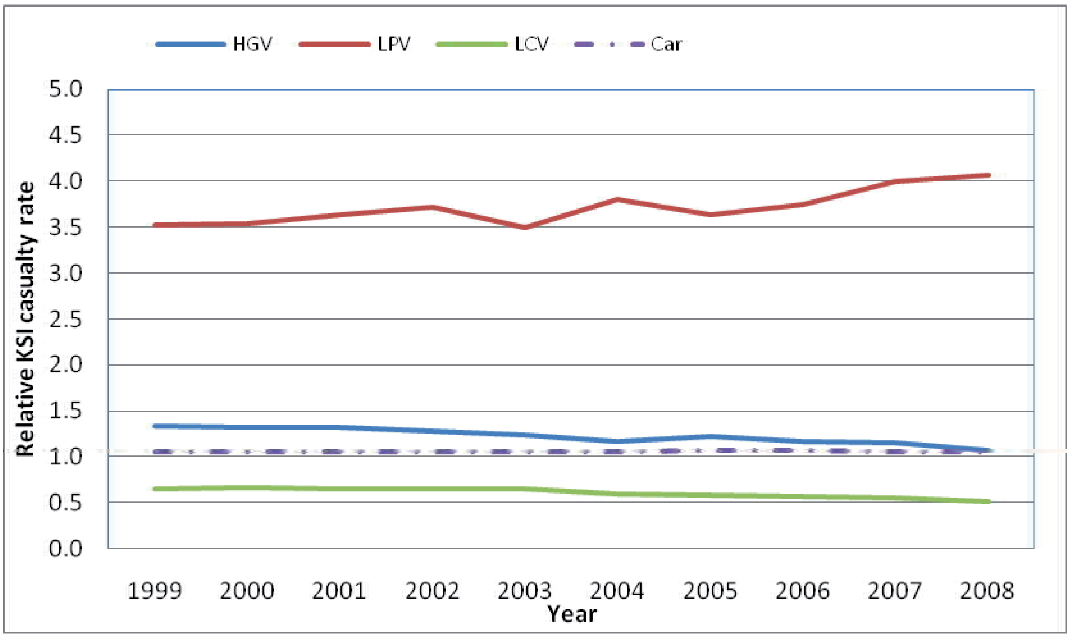


Figure 17. Relative KSI casualty rates for HGVs, LPVs and LCVs.

The value of the relative casualty rate indicates whether a particular type of accident involves more (value in excess of one) or less (value lower than one) casualties per billion vehicle kilometres than the aggregate value for all accident types. The slope of the trend indicates how the specific group of accidents has contributed to the overall target. A horizontal line shows that the accident rate for the specific group of accidents has fallen in line with the overall reduction for all accidents. A downward trend indicates that the accident rate for the specific group has fallen by more than that for all accidents, thus indicating that that group of accidents has strongly contributed to the overall effect. An increasing trend suggests that the group of accidents has held back progress towards the target. Therefore, LCVs are continuing to out-perform the overall vehicle fleet in terms of casualty reduction with a relative KSI casualty rate of less than one and an overall reduction of 20% from 0.65 to 0.52. HGVs are continuing to improve their contribution to the overall accident rate and it is now only very slightly higher than for all vehicles. However, since 2003, the increasing LPV relative casualty rate indicates a decline in the contribution to the overall casualty reductions by LPVs.

Similar trends can be seen for the relative fatality rate, though lower numbers result in greater fluctuation, particularly for LPVs..

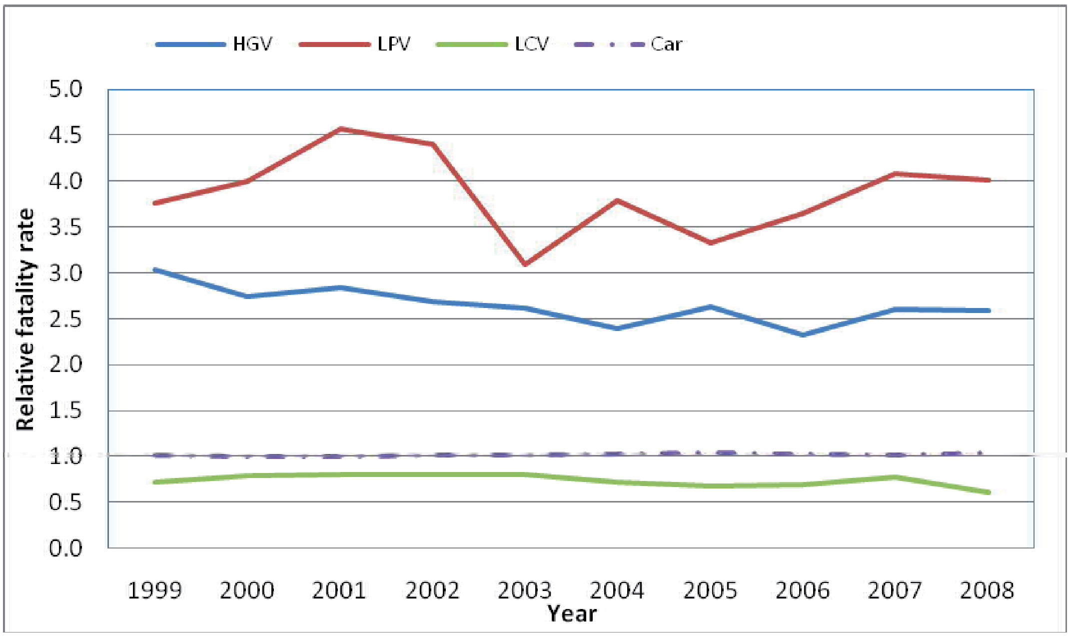


Figure 18: Relative fatality rates for HGVs, LPVs and LCVs.

3 Analysis of casualty groups

Smith *et al* (2007) analysed the national road accident database for Great Britain, Stats19, for the years 2003-2005 inclusive. This involved generating a list of 244[5] casualty groups based on the vehicle of interest, collision partner and impact configuration. This list was ranked in order to identify the largest groups, although not all groups in the list were mutually exclusive[6]. The following section of this report describes how this analysis has been updated with the most recent accident data available and to make the analysis relevant to the current discussions regarding casualty reduction targets.

The ranking of casualty groups can be affected by both the number of casualties and by the severity of the casualties. Casualty reduction targets for 2010 were based on reducing the number of killed and seriously injured and therefore a ranking based on killed and seriously injured was considered most appropriate by Smith *et al* (2007). The ranking reported was based on the casualty prevention values (Table 1) associated with the killed and seriously injured (referred to as KSI cost) because this was a measure of both the total number of casualties and the distribution of the casualties between the two severities. For example, when ranking the casualty groups on the basis of the number of killed and seriously injured, "pedestrians in impacts with LPVs" would rank higher than "pedestrians in impacts with HGVs", (an annual average of 401 compared to 237). However, when using the KSI cost, the ranking of these two casualty groups is reversed, with the HGV-pedestrian group having an annual cost of £408million compared to £391million for the LPV-pedestrian group. This is because although the total number of KSI casualties in the HGV-pedestrian group is lower, the proportion of casualties that are fatally injured is much higher than in the LPV-pedestrian group.

Table 1. Casualty prevention values (DfT, 2009a).

Casualty severity	Casualty prevention value (£)
Fatal	1,683,800
Serious	189,200
Slight	14,600

At the time of writing this report, the casualty reduction targets for 2020 are yet to be published. The consultation document (DfT, 2009b) proposed targets of reducing both the number of fatalities and serious casualties by 33% each, rather than using a combined KSI target. The ranking of casualty groups should aim to be consistent with the latest casualty reduction targets. This would mean that the proposed targets for 2020 would require ranking based on two separate criteria and differences in the ranking produced by each criterion would need to be assessed. The use of KSI cost therefore remains the most appropriated single ranking criteria because it allows both the number of casualties and distribution of the severity of the casualties to be considered. However, to provide information relevant to the proposed 2020 targets, the numbers of fatalities and serious casualties have been presented alongside the KSI cost values.

[5] To minimise the number of casualty groups, the sub-division of casualty groups by impact location was restricted to those where the number of fatalities was greater than ten.

[6] For example, casualty groups based on impact location such as "pedestrians in impacts with front of HGV" are a sub-group of "pedestrians in impacts with HGV".

Table 2 compares the top ten casualty groups for 2006-2008 with those from 2003-2005 ranked by KSI Cost. The number of fatalities and serious casualties are also shown.

Table 2. Ranking of casualty groups using 2003-2005 and 2006-2008 Stats19 data.

	2003-2005[7]		2006-2008			
	Ranked by KSI cost	Annual average KSI cost £M	Ranked by KSI cost	Annual average KSI cost £M	Annual average number of fatalities	Annual average number of serious casualties
1	Car Occupants in impact with HGV	354.3	Car Occupants in impact with HGV	341.2	146.3	501.3
2	Car Occupants in impact with LCV	195.4	Car Occupants in impact with LCV	202.2	74.3	407.0
3	LCV Occupants	185.6	LCV Occupants	171.0	51.0	450.0
4	Pedestrians in impact with HGV	136.1	Pedestrians in impact with HGV	149.9	72.0	151.3
5	Pedestrians in impact with LPV	130.4	Pedestrians in impact with LPV	142.5	47.0	334.7
6	HGV Occupants	127.5	Pedestrians in impact with LCV	125.4	40.3	303.7
7	Car Occupants in impact with HGV (Front - Front)	126.5	HGV Occupants	119.0	38.0	290.7
8	Pedestrians in impact with LCV	121.7	Car Occupants in impact with HGV (Front - Front)	117.9	53.0	151.7
9	LCV Occupants in impact with other vehicle	105.4	LPV Occupants	101.2	12.3	425.3
10	LPV Occupants	89.2	LCV occupants in impacts with another vehicle	96.9	26.0	280.7

Table 2 shows that there was no change in the top five casualty groups between the periods 2003-2005 and 2006-2008. However, examining the number of fatalities and serious casualties suggests that changing the ranking criteria could affect the ranking.

[7] Smith *et al* (2007)

Table 3 compares the ranking of the top 10 casualty groups based on KSI cost, number of fatalities and number of serious injuries, although KSI cost will be the ranking criteria used for the remainder of this report. Complete lists of the casualty groups ranked by all three criteria can be found in Appendix A.

Table 3. Comparison of ranking criteria for 2006-2008 data.

	Ranked by KSI cost	Annual average KSI cost £M	Ranked by number of fatalities	Annual average number of fatalities	Ranked by number of serious casualties	Annual average number of serious casualties
1	Car Occupants in impact with HGV	341.2	Car Occupants in impact with HGV	146.3	Car Occupants in impact with HGV	501.3
2	Car Occupants in impact with LCV	202.2	Car Occupants in impact with LCV	74.3	LCV Occupants	450.0
3	LCV Occupants	171.0	Pedestrians in impact with HGV	72.0	LPV Occupants	425.3
4	Pedestrians in impact with HGV	149.9	Car Occupants in impact with HGV (Front - Front)	53.0	Car Occupants in impact with LCV	407.0
5	Pedestrians in impact with LPV	142.5	LCV Occupants	51.0	Pedestrians in impact with LPV	334.7
6	Pedestrians in impact with LCV	125.4	Pedestrians in impact with **Front** of HGV	50.0	Pedestrians in impact with LCV	303.7
7	HGV Occupants	119.0	Pedestrians in impact with LPV	47.0	HGV Occupants	290.7
8	Car Occupants in impact with HGV (Front - Front)	117.9	Pedestrians in impact with LCV	40.3	LPV occupants where the vehicle had no impact	281.3
9	LPV Occupants	101.2	HGV Occupants	38.0	LCV occupants in impact with another vehicle	280.7
10	LCV occupants in impacts with another vehicle	96.9	Pedestrians in impact with **Front** of LPV	34.3	LPV occupants in single vehicle accidents	275.7

The most striking difference that occurs as a result of the different ranking criteria is for pedestrians in collision with an HGV. Ranked by number of fatalities, this group is third highest priority whereas ranked by the number of serious injuries it is 17th most important. However, the use of KSI cost as a ranking criterion shows this group as fourth most important.

Table 4 shows the top 20 casualty groups for the period 2006-2008 inclusive, ranked by the KSI cost for each group. The change in rank position since the analysis of the 2003-2005 data is also shown.

Table 4. Top 20 casualty groups and change in rank position when ranked by KSI cost.

Rank	Vehicle 1	1st impact of V1	Annual average KSI cost (£M)	Annual average fatalities	Annual average serious	03-05 rank	Change in rank
1	Car occupant in impact with HGV	All impact configurations	341.2	146.3	501.3	1	**0**
2	Car occupant in impact with LCV	All impact configurations	202.2	74.3	407.0	2	**0**
3	LCV occupants	All impact configurations	171.0	51.0	450.0	3	**0**
4	Pedestrian in impact with HGV	All impact configurations	149.9	72.0	151.3	4	**0**
5	Pedestrian in impact with LPV	All impact configurations	142.5	47.0	334.7	5	**0**
6	Pedestrian in impact with LCV	All impact configurations	125.4	40.3	303.7	8	**2**
7	HGV occupant	All impact configurations	119.0	38.0	290.7	6	-1
8	Car occupant in impact with HGV	Front - front	117.9	53.0	151.7	7	-1
9	LPV occupant	All impact configurations	101.2	12.3	425.3	10	**1**
10	LCV occupant	Impact with other vehicle	96.9	26.0	280.7	9	-1
11	TWMV rider in impact with LCV	All impact configurations	96.1	30.0	241.0	13	**2**
12	Pedestrian in impact with HGV	Front of HGV	94.5	50.0	54.7	12	**0**
13	Pedestrian in impact with LPV	Front of LPV	92.5	34.3	183.3	14	**1**
14	Car occupant in impact with LCV	Front - front	83.2	31.0	164.0	11	-3
15	TWMV rider in impact with HGV	All impact configurations	77.6	33.7	110.7	17	**2**
16	LCV occupant	Impact with object off carriageway	73.6	26.0	157.7	15	-1
17	Pedestrian in impact with LCV	Front of LCV	70.2	24.7	151.3	18	**1**
18	LPV occupant	No impact	67.8	8.7	281.3	22	**4**
19	LPV occupant	Single vehicle	67.3	9.0	275.7	24	**5**
20	Car occupant in impact with LPV	All impact configurations	65.1	24.7	124.3	21	**1**

This table shows that the ranking positions in the top 20 have shown only a small amount of variation. The largest change can be seen for LPV occupants (ranked #18 and #19) who have moved up 4 and 5 places into the top 20. Car occupants in head-on collision with an LCV were the group that moved down the ranking the most within the top 20 (3 places).

Changes to the rank position of casualty groups are larger for those groups that appear lower on the list. Table 5 shows the casualty groups in the top 100 (excluding top 20) that have gone up the ranking by more than five places when ranked on KSI cost. The full list of the top 100 groups and their change in rank position can be found in Appendix B.

Table 5. Casualty groups that move up in the ranking by more than five places when ranked on KSI cost.

Rank	Vehicle 1	1st impact of V1	Annual average KSI cost (£M)	Annual average fatalities	Annual average serious	03-05 rank	Change in rank
22	Pedal cyclist in impact with HGV	All impact configurations	59.09	27.0	72.0	30	8
26	OMV occupants	All impact configurations	56.97	18.7	135.0	35	9
31	Car occupant in impact with HGV	Front of HGV to rear of car	43.04	18.7	61.3	36	5
35	TWMV rider in impact with LCV	Front of TWMV to side of LCV	38.29	13.0	86.7	45	10
40	OMV occupant	Impact with other vehicle	32.84	10.7	78.7	50	10
44	Pedestrian in impact with OMV	All impact configurations	25.96	7.7	69.0	54	10
49	Pedal cyclist in impact with HGV	Side - side	21.95	9.7	30.0	70	21
54	TWMV rider in impact with Agricultural	All impact configurations	19.90	8.3	31.0	69	15
55	OMV Occupant in impact with car	All impact configurations	19.75	6.0	51.0	67	12
59	Car occupant in impact with LCV	Front of car to rear of LCV	17.56	5.3	45.3	65	6
60	OMV Occupant	Single vehicle	16.98	5.7	39.3	66	6
61	TWMV rider in impact with OMV	All impact configurations	16.48	5.7	36.7	77	16
63	OMV occupant	Rollover	15.27	6.0	27.3	79	16
68	Pedestrian in impact with OMV	Front of OMV	14.10	4.7	33.0	76	8
71	LPV occupant	Impact with object off carriageway	13.02	1.7	54.0	87	16
72	OMV occupant	Impact with object off carriageway	12.98	4.0	33.0	82	10

Rank	Vehicle 1	1st impact of V1	Annual average KSI cost (£M)	Annual average fatalities	Annual average serious	03-05 rank	Change in rank
73	TWMV rider in impact with HGV	Side - side	12.88	5.7	17.7	81	8
74	Pedal cyclist in impact with HGV	Front of pedal cycle to side of HGV	12.88	6.0	14.7	98	24
77	Pedestrian in impact with Minibus	All impact configurations	12.09	4.3	25.3	90	13
78	Pedestrian in impact with HGV	Rear of HGV	11.64	4.7	20.0	86	8
80	TWMV rider in impact with Agricultural	Front of TWMV to side of Agricultural	11.38	5.3	12.7	97	17
86	Pedal cyclist in impact with HGV	Front of HGV to side of pedal cycle	9.25	4.7	7.3	100	14
90	TWMV rider in impact with LPV	Front of TWMV to side of LPV	7.76	3.3	11.3	107	17
92	Pedal cyclist in impact with LCV	Side - side	7.73	1.7	26.0	105	13
93	TWMV rider in impact with LCV	Front of LCV to side of TWMV	7.60	1.7	25.3	111	18
94	Pedestrian in impact with Minibus	Front of minibus	7.51	3.0	13.0	New Entry	n/a
96	Pedestrian in impact with OMV	Side of OMV	7.15	2.0	20.0	115	19
97	HGV occupant	No impact	7.08	2.3	16.7	113	16

From the analysis, it is clear that the largest casualty group has remained car occupants in collision with HGVs. There have been minimal changes in the top 15 between the two analysis periods. However, looking further down the ranking, the following casualty groups stand out as potential areas of interest:

- Pedal cyclists in impacts with HGVs ranked #49 and#74 are the groups that have shown the largest move up the list.
- Riders of two wheeled motor vehicles (TWMV) in impacts with all vehicles of interest except minibuses.
- OMV occupants and pedestrians in impacts with OMVs appear frequently in this list, which is related to the overall increase in number of casualties from accidents involving OMVs as mentioned in Section 2.2.
- LPV occupants, particularly in single vehicle accidents moved to just inside the top 20.

Pedestrians in impacts with the front of a minibus are a new entry into the ranking, although they are ranked #95 and are likely to be affected by fluctuations in low numbers.

4 Assessment of potential countermeasures

Smith *et al* (2007) reported an assessment of the costs and benefits of potential countermeasure for larger commercial vehicles. This section provides an overview of the methodology used and describes how the analysis was updated with the most recent data and information available.

4.1 Methodology

Figure 19 summarises the methodology used and a brief descriptive overview is provided below.

Step 1. The casualty groups identified from the analysis described in Section 3 were used as an input to a brainstorming session which produced a list of possible countermeasures for reducing the frequency and/or severity of the accidents. The list mainly included engineering countermeasures that could be applied to the vehicles of interest, but enforcement, training and infrastructure changes were also considered.

Step 2. Where possible, the scope of each countermeasure was defined in terms of variables present in the HVCIS fatal accident database. The scope was those fatalities that could potentially have been affected by each countermeasure. Depending on the criteria used to define the scope, there could also be some fatalities for whom it was unknown whether or not they could have been affected by each countermeasure (for example, if the impact location was unknown).

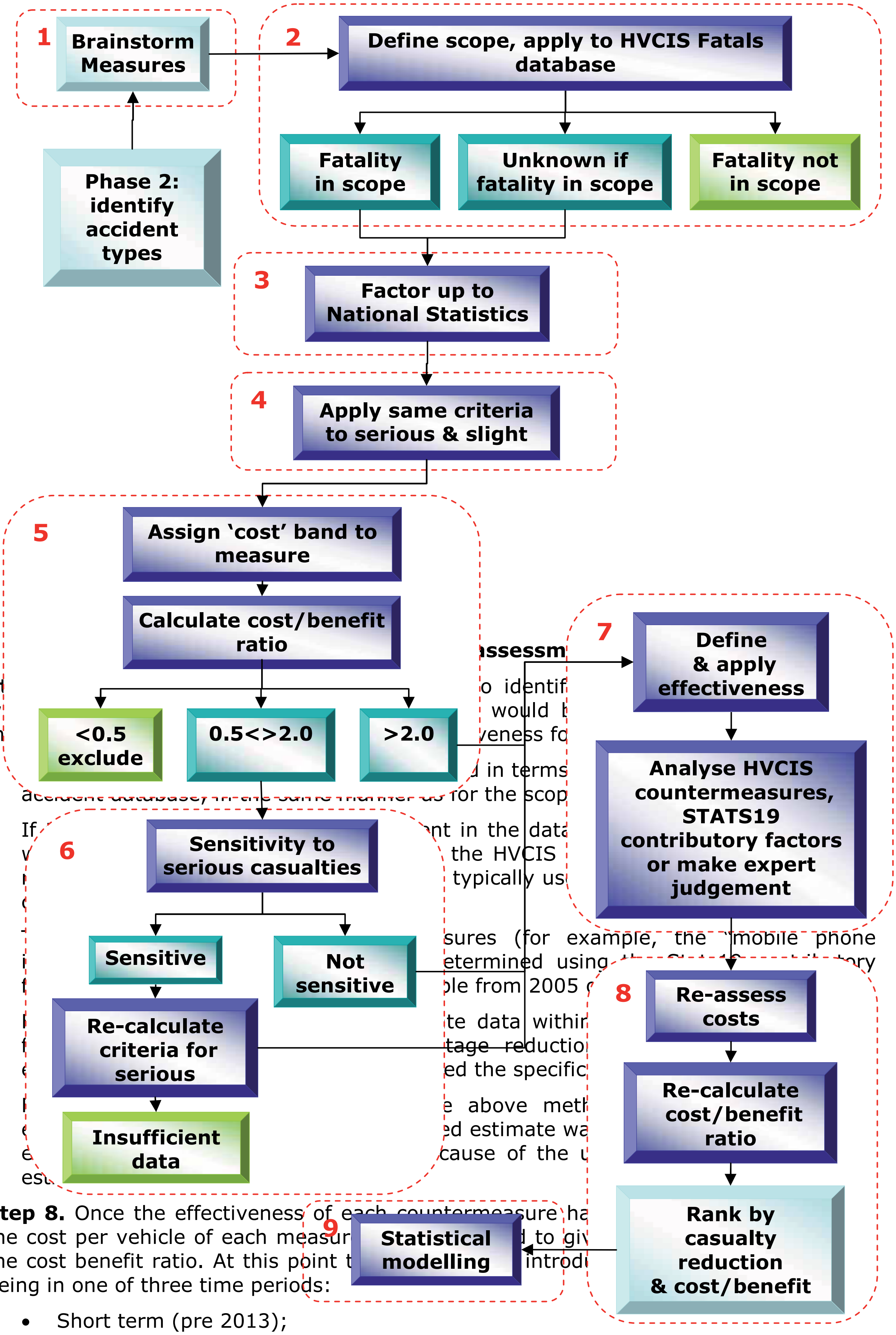
Where it was not possible to define the scope using variables in the HVCIS database, alternative methods were used. These included the use of the subjective case-by-case countermeasures coded routinely in the HVCIS fatal accident database, and also Stats19 contributory factor data.

Step 3. Each fatality in the HVCIS database was allocated a mutually exclusive casualty group, such as “car occupant fatalities in collisions with HGVs”, which enabled the numbers in HVCIS to be scaled up to the national Stats19 accident numbers. Once the numbers had been scaled, the result was an estimate of the number of fatalities per year in Great Britain which could be affected by each countermeasure.

Step 4. The number of serious and slight casualties prevented was initially estimated by applying the same “percentage affected” from the analysis of fatal accidents to the number of serious and slight casualties in Stats19.

Step 5. The financial benefit of preventing these casualties was calculated using the standard casualty prevention values. The cost of applying each measure to the vehicles was initially assigned as a broad category of low (£50 per vehicle), medium (£500 per vehicle) or high (£1,500 per vehicle), so that an initial approximate estimate of the benefit to cost ratio for each countermeasure could be made. The list of countermeasures was reduced to only those which gave a benefit of at least one fatality per year and where the initial benefit-to-cost ratio indicated that there was potential for a cost effective measure bearing in mind the coarse nature of the cost assessment (i.e. benefit-to-cost ratio greater than 0.5).

Step 6. Up until this point, the analysis of the countermeasures had been based entirely on analysis of fatality data. However, it was recognised that some measures could influence serious injuries to a greater or lesser extent than they would for fatalities. To determine whether using the proportions derived from the fatal accident data analysis was a good approximation for serious injuries, the sensitivity to the number of serious casualties was tested. In the cases where the coarse cost-effectiveness of a measure was found to be sensitive to the number of serious casualties, alternative proportions were calculated using an alternative data set, such as Stats19, where the number of serious and slight casualties affected by any particular measure could be estimated more accurately.



Step 8. Once the effectiveness of each countermeasure ha… the cost per vehicle of each measur… …d to giv… the cost benefit ratio. At this point t… introd… being in one of three time periods:

- Short term (pre 2013);
- Medium term (2013-2018); and

- Long term (post 2018).

Within these year groups, the countermeasures were sorted by the KSI casualty prevention values. For the short and medium term lists, the countermeasures with a very low cost benefit (less than 0.5) were removed, leaving three lists of the countermeasures likely to give the greatest benefit in the short, medium and long term. The long term measures were excluded from further consideration because of uncertainty about future costs. While future looking countermeasures are considered to have relatively high costs at present, the extent to which the costs will have fallen by the time that such systems are ready for the market is unknown.

Step 9. Five measures were selected for further analysis which involved re-calculating the benefit-cost ratios ten years after their likely date of introduction. This analysis reflects the changing number of casualties which the countermeasure is intended to affect, the change in vehicle usage and the fleet penetration of the countermeasure.

4.2 Results based on 2003-2005 Stats19 data

The analysis reported by Smith *et al* (2007) selected five countermeasures for further investigation. Table 6 summarises the results from the analysis of these five countermeasures, descriptions of which are provided below.

HGV safer vehicle front (CM88)

This countermeasure would involve providing a "bonnet" or "nosecone" to protect both the occupants and opponents of the HGV. The nosecone could include a crush zone for the protection of the HGV occupants, energy absorbing front underrun protection with increased ride-down distance to protect car occupants and an outer surface designed to improve the kinematics and manage the impacts of vulnerable road users. The frontal design would also improve the direct field of view to the front of the HGV and also have the potential to reduce the drag co-efficient of the vehicle leading to improved fuel economy.

Faster response braking system for HGVs (CM89)

Brake assist systems are designed to improve the ability of a typical driver to exploit the maximum braking performance available to them in emergency situations. The systems can detect when the driver intends emergency braking by measuring the speed at which the brake pedal is applied by the driver. The system then automatically increases the brake pressure to its maximum. Electronically controlled braking systems respond more quickly to emergency brake applications compared with purely pneumatic systems where the air pressure wave takes a finite amount of time to reach the rearmost axle of the vehicle. This countermeasure is intended to ensure that in emergency braking situations the HGV can reach its maximum deceleration within the shortest time possible by utilising all such systems.

Driver alertness monitoring – mitigation for HGVs (CM79b)

In the event of a driver losing alertness or not paying attention to the road ahead during driving, this system applies the brakes of the vehicle to reduce the impact speed or possibly prevent the accident. This system will reduce the number or severity of accidents due to inattention by reducing the speed of the vehicle before the impact occurs. However, there would be risks of unintended consequences such as other vehicles suddenly being confronted by a slow moving or stationary HGV for no apparent reason, depending on the specifics of system implementation.

Low speed vulnerable road user collision warning system for HGVs (CM80a)

Accidents can occur when the driver has been unaware of the presence of a vulnerable road user and has collided with them. Typically, this occurs during low-speed manoeuvring or when moving off from rest at a junction or pedestrian crossing. This system will alert the driver to the presence of any vulnerable road users within close proximity of the HGV. This countermeasure offers protection to pedestrians, pedal cyclists and motorcyclists that are in close proximity to the HGV when it is manoeuvring.

LPV energy absorbing front for pedestrians (CM39)

Fitting an energy absorbing front to the LPV will increase the distance over which the pedestrian can be decelerated allowing the pedestrians to be protected at higher impact speeds than for a standard vehicle. This countermeasure is not effective where the pedestrian has been run over.

For the five selected countermeasures, a more in-depth cost-benefit analysis was undertaken. The method involved:

- Forecasting the target population for each countermeasure based on the existing trends;
- Accounting for inflation and discounting the casualty valuations and system costs to define costs at 2005 prices; and
- Forecasting the number of new registrations and total vehicle fleet based on existing trends.

Table 6 summarises the results from this analysis alongside other key information such as the estimated number of casualties prevented and break-even costs.

Table 6. Summary of results from countermeasure assessment using 2003-2005 Stats19 data.

Counter-measure	KSI benefit-cost ratio calculated over a 10 year evaluation period from the date of implementation			Effects in year 10 after mandatory fitment‡‡‡: Countermeasure KSI casualty prevention value (£M, 2005 prices)			Effects in year 10 after mandatory fitment‡‡‡: Reduction in number of fatalities	Effects in year 10 after mandatory fitment‡‡‡: Reduction in number of serious injuries	Largest casualty groups that could be affected*	Assumed system cost (2005 prices)***			Break even cost (2005 prices)‡‡ Calculated using KSI benefit		
	Min	BE‡	Max	Min	BE‡	Max	BE‡	BE‡		Min	Ave.	Max	Min	BE	Max
HGV Safer vehicle front (CM88)†	0.3	0.7	2.4	20	29	51	19	25	#7 – HGV front to car front (car occ) #12 – HGV front to pedestrian #16 – HGV front to car side (car occ) #29 – HGV occupant in impact with HGV ***#23 – HGV occupant in impact with object off carriageway***** ***#28 – HGV occupant in single vehicle accident*** #36 – HGV front to car rear (car occ)	£303	£530	£758	£271	£401	£763
HGV Faster response braking system (CM89) ††	0.4	0.7	11.0	11	12	30	8	12	#7 – HGV front to car front (car occ) #12 – HGV front to pedestrian #16 – HGV front to car side (car occ) ***#23 – HGV occupant in impact with object off carriageway***** ***#28 – HGV occupant in single vehicle accident*** ***#29 – HGV occupant in impact with HGV*** ***#31 – HGV occupant in rollover*** #36 – HGV front to car rear (car occ)	£40	£218	£396	£169	£169	£471
HGV driver alertness monitoring – mitigation (CM79b)†	0.1	0.4	3.6	2	7	30	5	11	#7 – HGV front to car front (car occ) #12 – HGV front to pedestrian #16 – HGV front to car side (car occ) ***#23 – HGV occupant in impact with object off carriageway***** ***#28 – HGV occupant in single vehicle accident*** ***#29 – HGV occupant in impact with HGV*** ***#31 – HGV occupant in rollover*** #36 – HGV front to car rear (car occ)	£114	£246	£379	£34	£97	£442
HGV low speed VRU collision warning (CM80a)†	0.1	0.2	1.3	4	5	11	3	6	#12 – HGV front to pedestrian #38 – HGV side to pedestrian	£99	£239	£379	£51	£61	£140
LPV pedestrian friendly (energy absorbing) front (CM39)†	1.4	2.1	6.9	3	4	9	1	14	#14 – LPV front to pedestrian	£136	£170	£205	£329	£394	£1,035

Notes relating to Table 6 and Table 7:

** The rank position is from the casualty group ranking list (See appendix B). All relevant casualty groups have been considered in the numerical data but, for reasons of brevity,* ***the relevant group has only been listed if it falls within the top 20 lower level groups*** *(e.g. HGV front to car front rather than HGV to car, and LPV front to pedestrian rather than LPV to pedestrian, HGV occupant in single vehicle accident rather than HGV occupant etc.).*
*** Casualty groups shown in* ***bold italics*** *are not necessarily mutually exclusive.*
**** Average cost of the system in year 10 after implementation, expressed in 2005 prices accounting for inflation and discounted cash flow.*

† Year of implementation 2015
†† Year of implementation 2012

‡ Best estimate of casualty benefit assumed that the proportion of casualties that were known to be within the scope of the measure was applied to those where it was unknown if the casualties were within the scope. The cost used was the average of the upper and lower values for 2005.

‡‡ Equivalent to the cumulative benefits of the measure over the 10 year evaluation period, divided by the cumulative number of new vehicles fitted with the countermeasure in the same period, expressed in 2005 prices including the effects of inflation and discounted cash flow.

‡‡‡ In year 10 after implementation it is estimated that 87.4% of all registered HGVs and 70.0% of all registered LPVs will be fitted with the countermeasure.

While the cost-benefit methodology used for the five countermeasures is aligned with the Government guidelines for cost-benefit analyses8 other methods are used in the field of vehicle safety to assess cost-effectiveness. In order to allow appropriate representation when compared to other analyses of potential safety measures, the data has been used to estimate benefit-cost ratios based on a more frequently applied approach. This is the same approach that was used to filter the full range of countermeasures under consideration; although some of the underlying data (e.g. system costs) was subsequently updated for the remaining analysis.

The second approach estimates the benefit-cost ratio for the "steady-state" period when the entire vehicle fleet has been fitted with the system. The method generally uses existing casualty data and assumes that all vehicles in the fleet were fitted with the measure overnight. The casualty benefits are therefore the benefits that would be seen if the system had been fitted to all vehicles for the period for which most recent data was available (in this case 2006-2008). The associated costs would be the cost of fitting the system to new registrations in the most recent year(s).

In addition to the "steady state" analysis based on 2003-2005 data, the same analysis has been re-run using the forecast casualty numbers for the 10th year after the date of implementation (2022 or 2024 depending on the countermeasure in question). Table 7 compares the benefit-cost ratios using the more frequently applied approach based on 2003-2005 data and the forecast casualty data with the benefit-cost ratios defined in Table 6.

[8] http://www.dft.gov.uk/webtag/

Table 7. Comparison of benefit-cost ratios estimated using different calculation methods.

Countermeasure	KSI "steady-state" benefit-cost ratio based on 2003-2005 casualty data			KSI "steady-state" benefit-cost ratio based on forecast casualty data (2021 or 2024)			KSI benefit-cost ratio calculated over a 10 year evaluation period from the date of implementation			Effects in year 10 after mandatory fitment‡‡‡				
										KSI casualty prevention value for countermeasure (£M, 2005 prices)			Reduction in number of fatalities	Reduction in number of serious injuries
	Min	BE‡	Max	Min	BE‡	Max	Min	BE‡	Max	Min	BE‡‡	Max	BE‡	BE‡
HGV Safer vehicle front (CM88)†	1.0	2.0	6.6	0.5	1.0	3.1	0.3	0.7	2.4	20	29	51	19	25
HGV Faster response braking system (CM89) ††	0.9	1.6	22.1	0.6	1.0	14.7	0.4	0.7	11.0	11	12	30	8	12
HGV driver alertness monitoring – mitigation (CM79b)†	0.2	1.0	9.5	0.1	0.6	4.8	0.1	0.4	3.6	2	7	30	5	11
HGV low speed VRU collision warning (CM80a)†	0.3	0.5	2.9	0.2	0.4	2.0	0.1	0.2	1.3	4	5	11	3	6
LPV pedestrian friendly (energy absorbing) front (CM39)†	4.8	6.8	18.7	3.0	4.3	12.8	1.4	2.1	6.9	3	4	9	1	14

4.3 Updating the countermeasure assessment

The countermeasure analysis was updated to reflect changes in the casualty population, add new measures not previously assessed and to update the definition of some of the countermeasures that were previously assessed in light of new research published since the previous report. The analysis was undertaken in two stages, firstly updating the casualty population and associated valuations only, and secondly updating the countermeasures and their definitions where this was considered relevant.

4.3.1 Stage 1 - updating casualty numbers and valuations

The first stage in updating the countermeasure analysis involved replacing the 2003-2005 Stats19 data with the data for 2006-2008 and updating the casualty prevention valuations to the values shown in Table 8. This allowed the ranking of the countermeasures to be compared, based solely on the change in the number of casualties and their valuations. The countermeasures were ranked based on the KSI Cost as described in Section 3.

Table 8. Casualty prevention valuations, 2008 prices (DfT, 2009a).

Casualty severity	Casualty prevention value
Fatal	£1,683,800
Serious	£189,200
Slight	£14,600

Table 9 compares the top 20 countermeasures ranked by KSI cost from the analysis by Smith *et al* (2007) and the top 20 countermeasures for 2006-2008 ranked by an initial estimate of KSI cost. The comparison shows only the effect of updating the casualty data from 2003-2005 to 2006-2008 and casualty prevention values from 2005 to 2008, with the countermeasure definitions remaining unchanged.

Table 9. Comparison of top 20 countermeasures ranked by initial estimate of KSI cost for 2003-2005 vs. 2006-2008.

2003-2005 annual average			2006-2008 annual average		
Countermeasure	**Vehicle type**	**KSI cost**	**Countermeasure**	**Vehicle type**	**KSI cost**
Safer vehicle front	HGV	£109M	Safer vehicle front	HGV	£109M
Segregate vehicle types by in cab information systems	HGV	£63M	Segregate vehicle types by in cab information systems	HGV	£67M
Improved driver training	HGV	£47M	Improved driver training	HGV	£43M
Faster response braking system	HGV	£42M	Faster response braking system	HGV	£38M
Improved driver training	LCV	£37M	Segregate vehicle types by in cab information systems	LCV	£37M
Segregate vehicle types by in cab information systems	LCV	£34M	Improved driver training	LCV	£35M
Inter-vehicle communication system	HGV	£33M	Vulnerable road user sensors - avoidance	HGV	£34M
Driver alertness monitoring - warning	HGV	£32M	Prevent run over from front of vehicle – change kinematics (e.g. nosecone)	LPV	£32M
Driver alertness monitoring - avoidance	HGV	£32M	Safer vehicle front	LPV	£32M
Prevent run over from front of vehicle – change kinematics (e.g. nosecone)	LPV	£31M	Vulnerable road user sensors - mitigation	HGV	£30M
Seatbelt enforcement	HGV	£30M	Lane following	HGV	£28M
Safer vehicle front	LPV	£30M	Driver alertness monitoring - avoidance	HGV	£27M
Collision avoidance - front to rear	HGV	£30M	Driver alertness monitoring - warning	HGV	£27M
Seatbelt enforcement	LCV	£30M	Seatbelt enforcement	LCV	£27M
Lane following	HGV	£29M	Improved forward visibility	HGV	£26M
Collision avoidance – vulnerable road users	HGV	£28M	Prevent run over from front of vehicle – change kinematics (e.g. nosecone)	HGV	£23M
Collision mitigation braking system - front to rear	HGV	£26M	Prevent run over from front of vehicle – reduced ground clearance	HGV	£23M
Vulnerable road user sensors - mitigation	HGV	£25M	Fit and use 3-point seatbelt	LCV	£21M
Improve forward visibility	HGV	£24M	Segregate vehicle types by in cab information systems	LPV	£21M
Driver alertness monitoring – warning	LCV	£23M	Extended energy absorbing front underrun protection	HGV	£20M

The top four ranked countermeasure have remained the same, which is consistent with the small changes to the rank order of the largest casualty groups. The most notable difference in the ranking is the higher position of the vulnerable road user sensor countermeasures, reflecting the increasing importance of vulnerable road users in the casualty group ranking. Not all of the five countermeasures selected by Smith *et al* (2007) appear in the 2003-2005 top 20; this is because the selection criteria applied resulted in lower ranked countermeasures being chosen.

4.3.2 Stage 2 - review and update of countermeasure definitions

Definitions, including system costs, were reviewed for countermeasures that met the following selection criteria:

- Were in the five selected countermeasures from the analysis based on 2003-2005 data;
- Were likely to be in the five countermeasures selected based on updated casualty data (using selection criteria the same as that used by Smith *et al* (2007);
- Recent/current research was available that could refine the previous definition; or
- The countermeasure influences casualty groups where there was uncertainty of the benefits estimated from the 2003-2005 data because of recent changes in legislation (front underrun protection, forward field of view etc).

In addition to updating the countermeasures that had previously been used, new countermeasures were also added. The countermeasure definitions that were updated or added are listed in Table 10.

The updated definitions used for the analysis are shown in Appendix C along with the definitions for all countermeasures mentioned in this report. The complete list of original definitions can be found in Smith *et al* (2007).

Table 10. List of updated countermeasure definitions.

Countermeasure	Reason for update
Front underrun protection (front-front)	New information relating to effectiveness
Energy absorbing FUP (front-front)	New information relating to effectiveness
Extended energy absorbing FUP (front-front)	New information relating to effectiveness
Improved rigid rear underrun protection (RUP)	New information relating to effectiveness and cost
Energy absorbing RUP	New information relating to effectiveness
Energy absorbing front for pedestrians	New HVCIS field to refine scope, new information about effectiveness, selected for further consideration in previous analysis
Prevent run over – change kinematics	New HVCIS field to refine scope, new information about effectiveness
Prevent run over – reduce ground clearance	Potentially in 2009 top 5, new HVCIS field to refine scope
Improve forward visibility	Update effectiveness using HVCIS countermeasures, improve possibility of effect of class VI mirrors being included
Improve side visibility	Update effectiveness using HVCIS countermeasures improve possibility of effect of class V mirrors being included
Improve rear visibility	To allow up to date assessment of all round visibility if required
Lane departure warning	Update scope and effectiveness to be consistent with research from the EC
Driver alertness monitoring - warning	Potentially affected by changes to the mitigation system
Driver alertness monitoring - mitigation	Selected for further consideration in previous analysis
Driver alertness monitoring – avoidance	Potentially affected by changes to the mitigation system
Vulnerable road user sensors - warning	Selected for further consideration in previous analysis
Vulnerable road user sensors - mitigation	Potentially affected by changes to the warning system
Vulnerable road user sensors - avoidance	Potentially affected by changes to the warning system
Safer vehicle front	Selected for further consideration in previous analysis
Faster response braking system	Selected for further consideration in previous analysis
Head-up display	New
Lane change assistance	New
Overtake assistance	New
Tyre pressure monitoring	New
Advanced front lighting systems	New

4.3.3 *Stage 3 - repeat the countermeasure analysis*

The countermeasure analysis was repeated with the latest accident data (States19 2006-2008 and HVCIS phase II[9]) and the updated countermeasure definitions. To ensure consistency throughout this analysis, the selection of five countermeasures for further analysis has been based on a list that has been ranked by the potential benefit of the countermeasures in terms of KSI cost. Table 11 shows the top 20 ranked countermeasures where the effectiveness had been defined[10]. A more extensive list is included in Appendix D.

Table 11. Ranking of countermeasures based on best estimate KSI cost.

Rank	VOI	Countermeasure	2006-2008 annual average best estimate KSI cost (£M)
1	HGV	Driver alertness monitoring - avoidance	184.7
2	HGV	Vulnerable road user sensor - avoidance	175.3
3	HGV	Vulnerable road user sensor - mitigation	129.7
4	HGV	Safer vehicle front[11]	107.3
5	HGV	Segregate vehicle types by in-cab information systems	79.4
6	HGV	Faster response braking system[12]	72.3
7	HGV	Vulnerable road user sensor - warning	71.7
8	HGV	Improved driver training	57.5
9	HGV	Brake assist (utilising maximum braking)	49.7
10	LPV	Vulnerable road user sensor - avoidance	49.0
11	LPV	Safer vehicle front	45.7
12	LCV	Improved driver training	45.6
13	LCV	Segregate vehicle types by in-cab information systems	44.1
14	HGV	Improved forward visibility	43.8
15	LPV	Driver alertness monitoring - avoidance	43.4
16	HGV	Driver alertness monitoring - warning	39.0
17	HGV	Inter-vehicle communication system	38.4
18	LPV	Vulnerable road user sensor - mitigation	36.3
19	HGV	Rear collision system - avoidance	35.7
20	LCV	Faster response braking system	34.9

[9] HVCIS phase II is a sample of fatal accidents occurring between 1997 and 2008
[10] Some countermeasures (e.g. advanced front lighting systems) only defined at scope level
[11] Incorporating protection for car occupants, pedestrians, cyclists, HGV/LPV occupants and improved field of view
[12] Incorporating Electronic Braking System (EBS) and Brake Assist (BAS)

Smith *et al* (2007) established a number of criteria used for selecting the five countermeasures for further analysis. To enhance the objectivity of the assessment, these criteria were reviewed and updated as follows:

- **Select five countermeasures that individually and cumulatively cover as many of the top ten casualty groups as possible** – This was important to maximise potential benefits and to ensure that the countermeasures selected did not all influence the same casualty groups (the benefits would not be additive) and remains a valid selection criterion.
- **Select countermeasures that could be implemented through vehicle construction standards –** The broad range of countermeasures assessed included education and enforcement countermeasures. These countermeasures provided context for those that can be implemented through vehicle construction standards and the results may be of interest to other stakeholders with different policy portfolios. However, the main focus of the research was related to vehicle construction and therefore this criterion remains valid.
- **Exclude countermeasures fitted to LCVs** – the reasoning behind this exclusion was that the relative casualty rates for LCVs showed that these vehicles had a relative casualty rate lower than that for the overall vehicle fleet and was showing a downward trend. The latest accident data shows that this is still the case. However, prior to the recession, the fatality rate for accidents involving LCVs stopped falling and showed an increase from 2005 to 2006. With a shifting focus towards fatalities from KSI and the number of fatalities from accidents involving LCVs exceeding 250 per year (with the exception of 2008) it could be argued that this exclusion is no longer appropriate.
- **Exclude countermeasures which are not likely to be implemented in the short or medium term** - Uncertainty about potential future costs of longer term countermeasure resulted in uncertainty in the benefit-cost ratios. This uncertainty over costs would affect the quality of the statistical modelling and remains a valid criterion for the exclusion of a measure.
- **Exclude countermeasures that have been implemented in full or in part by recent or forthcoming legislation** – the effect of recent legislation such as front underrun protection and class VI mirrors had not filtered into the HVCIS fatal accident database. Therefore there was a high probability that the benefits estimated for countermeasures that influence the casualty groups affected by these changes may have been over-estimated. The HVCIS fatal accident database now contains accidents up to 2007. It is clear that a larger proportion of vehicles are fitted with front underrun protection, however the number of vehicles equipped with class VI mirrors is still very low (although if these mirrors are effective, then vehicles fitted with them should not be seen in accidents involving forward field of view). The effect of these past changes are less relevant when selecting the countermeasures for this analysis than for the previous analysis, however fitment of electronic stability control (ESC), lane departure warning (LDW) and automatic emergency braking systems (AEBS) will influence the selection process.
- **Exclude countermeasures that are a sub-system of an already selected measure –** For example, the countermeasure "safer HGV fronts" is a composite countermeasure that includes the benefits of "extended energy-absorbing front underrun protection", "improved forward field of view" and others. If such a composite countermeasure is selected for further analysis then the sub-system measures should not be because it would represent a duplication of effort and risks double counting of potential benefits. However, this should not be taken to mean that there would be no benefit from implementing only the sub-system measure.

- **Exclude countermeasures which rely on the use of a seatbelt –** The effectiveness of many countermeasures aimed at protecting the occupant of the vehicle of interest rely on the occupant wearing a seatbelt. The effectiveness of the system defined during the analysis should, therefore, include seat-belt use as one of the criteria. However, a large proportion of fatally injured VOI occupants in the HVCIS fatal accident database were not wearing their seatbelt. Therefore, if this criterion was applied in the analysis, the effectiveness for the countermeasure would in many cases be 0%. To enable a more meaningful analysis to be carried out, the seat-belt use criterion was removed from the definition of effectiveness. This allowed the assessment of the potential benefits that could be achieved **IF** all occupants of the VOI were wearing their seatbelt. This would only be realistic if implemented alongside a measure that at least got close to ensuring 100% seatbelt use for the VOI. However, the approach is considered to be justified because it helps to highlight the additional measures that could be enabled if seat belt wearing rates were improved.
- **Exclude countermeasures where the initial best estimate benefit-cost ratio is less than one –** The "steady state" benefit cost ratio using current accident data provides the most optimistic benefit cost ratio of the three methods described. If this optimistic benefit cost ratio is less than one, then the further analysis is unlikely to yield a positive conclusion.

The countermeasures that were considered to be short or medium term were ranked by the best estimate of KSI prevention value (£M) and the five countermeasures selected are highlighted in Table 12.

Table 12. Selection of five countermeasures.

Rank	VOI	Countermeasure	Annual average KSI cost (£M)			Best estimate casualties prevented (annual average)		Comments
			Min	BE	Max	Fatal	Serious	
1	HGV	Vulnerable road user sensor – mitigation	122.0	129.7	132.0	42	382	Best estimate BCR less than 1
2	**HGV**	**Safer vehicle front[13]**	**59.1**	**107.3**	**368.2**	**35**	**316**	**Selected**
3	**HGV**	**Faster response braking system[14]**	**29.0**	**72.3**	**654.9**	**24**	**213**	**Selected**
4	**HGV**	**Vulnerable road user sensor – warning[15]**	**71.7**	**71.7**	**71.7**	**23**	**211**	**Selected**
5	HGV	Improved driver training	29.9	57.5	235.1	17	153	Not implemented through vehicle construction standards
6	HGV	Brake Assist (utilise maximum braking)	40.8	49.7	234.2	16	146	Sub-system of faster response braking system
7	**LPV**	**Safer vehicle front[13]**	**30.4**	**45.7**	**85.0**	**15**	**134**	**Selected**
8	LCV	Improved driver training	23.7	45.6	186.1	13	121	Not implemented through vehicle construction standards
9	HGV	Improved forward visibility[15]	43.8	43.8	43.8	13	117	Benefit may be overestimated, sub-system of safer vehicle front
10	**HGV**	**Driver alertness monitoring – warning**	**9.6**	**43.4**	**50.7**	**12**	**104**	**Selected**

[13] Incorporating protection for car occupants, pedestrians, cyclists, HGV/LPV occupants and improved field of view
[14] Incorporating Electronic Braking System (EBS) and Brake Assist (BAS)
[15] The casualty benefit is estimated in two parts, the scope and the effectiveness. The scope of the countermeasure is generated using a number of criteria and where any one criteria has unknown values this produces a range in the scope. In this case, there were no unknown values and the scope was a single value, and when combined with a single value of effectiveness, this generated a single value for the benefit estimate.

The five countermeasures selected from the updated analysis were:

HGV safer vehicle front (CM88) - which would involve providing a "bonnet" or "nosecone" to protect both the occupants and opponents of the HGV. The nosecone could include a crush zone for the protection of the HGV occupants, energy absorbing front underrun protection with increased ride-down distance to protect car occupants and an outer surface designed to improve the kinematics and manage the impacts of vulnerable road users. The frontal design would also improve the direct field of view to the front of the HGV and also have the potential to reduce the drag co-efficient of the vehicle leading to improved fuel economy. This countermeasure is intended to offer protection to the occupants of the vehicle to which it is fitted and other vehicle occupants, pedestrians and cyclists that are in collision with the vehicle to which is fitted.

Faster response braking system for HGVs (CM89) - Brake assist systems are designed to improve the ability of a typical driver to exploit the maximum braking performance available to them in emergency situations. The systems can detect when the driver intends emergency braking by measuring the speed at which the brake pedal is applied by the driver. The system then automatically increases the brake pressure to its maximum. Electronically controlled braking systems respond more quickly to emergency brake applications compared with purely pneumatic systems where the air pressure wave takes a finite amount of time to reach the rearmost axle of the vehicle. This countermeasure is intended to ensure that in emergency braking situations the HGV can reach its maximum deceleration within the shortest time possible by utilising all such systems. This countermeasure could offer protection to all types of road user casualties.

Low speed vulnerable road user collision warning system for HGVs (CM80a) - Accidents can occur when the driver has been unaware of the presence of a vulnerable road user and has collided with them. Typically, this occurs during low-speed manoeuvring or when moving off from rest at a junction or pedestrian crossing. This system will alert the driver to the presence of any vulnerable road users within close proximity of the HGV. This countermeasure offers protection to pedestrians, pedal cyclists and motorcyclists that are in close proximity to the HGV when it is manoeuvring.

LPV safer vehicle front (CM88) – This countermeasure is the same as that described for HGVs, although practical implementation may be influenced by differences in vehicle design.

Driver alertness monitoring – warning for HGVs (CM79a) - In the event of a driver losing alertness or not paying attention to the road ahead during driving, this system provides a warning to the driver. The warning is intended to make the driver aware of the situation and allow them to take appropriate action such as making a rest stop at an appropriate location. This system could offer protection to casualties from all road user groups.

The main differences between the five selected countermeasures above and those selected by Smith *et al* (2007) are the "safer LPV front" and the "driver alertness monitoring system". The "safer LPV front" had not been selected previously because the selection criteria used had excluded it based on the fact it had already been selected for HGVs. The "driver alertness system" selected previously was the mitigation system, whereas the warning system has been selected in Table 12. Smith *et al* (2007) identified that a "driver alertness" system had the potential to offer substantial benefits. The "avoidance" system was not selected because it was considered to be long term, leaving a choice between a warning and a mitigation system. The choice of a mitigation system was not based on the objective data but was intended to allow further investigation of a system with a different user interface (a warning system had already been selected for vulnerable road user sensors).

Based on the enhanced selection criteria described above, this approach was no longer appropriate and the "warning" system was selected because of its' higher ranking than the "mitigation" system.

The five selected countermeasures were evaluated further using the three cost-benefit methods described in Section 4.2 and in more detail by Smith *et al* (2007).The three methods were:

- Evaluation over a ten year implementation period using forecast casualty data, casualty valuations and fleet penetration;
- Steady-state evaluation using forecast casualty data; and
- Steady-state evaluation using the existing casualty data.

Table 13 summarises the results from the analysis over the ten year implementation period.

Table 14 compares the results from the three methods.

Table 13. Summary of updated countermeasure assessment (2006-2008 Stats19 data).

Counter-measure	KSI benefit-cost ratio calculated over a 10 year evaluation period from the date of implementation			Effects in year 10 after mandatory fitment‡‡‡: Countermeasure KSI casualty prevention value (£M, 2008 prices)			Effects in year 10 after mandatory fitment‡‡‡: Reduction in number of fatalities	Effects in year 10 after mandatory fitment‡‡‡: Reduction in number of serious injuries	Largest casualty groups that could be affected*	Assumed System cost (£, 2008 prices)***			Break Even Cost (£ 2008 prices)‡‡ Calculated using KSI benefit		
	Min	**BE‡**	**Max**	**Min**	**BE‡**	**Max**	**BE‡**	**BE‡**		**Min**	**Ave.**	**Max**	**Min**	**BE**	**Max**
Safer HGV front†	0.2	0.8	2.1	8	23	35	14	22	#8 – HGV front to car front (car occ) #12 – HGV front to pedestrian #25 – HGV front to car side (car occ) **#27 – HGV occupant in impact with other vehicle**** ***#28 – HGV occupant in impact with object off carriageway***** ***#30 – HGV occupant in single vehicle accident***** #31 – HGV front to car rear (car occ)	317	554	792	148	449	705
Faster response braking system for HGV††	0.3	1.4	11.3	8	22	31	12	25	#8 – HGV front to car front (car occ) #12 – HGV front to pedestrian #25 – HGV front to car side (car occ) ***#27 – HGV occupant in impact with other vehicle***** ***#28 – HGV occupant in impact with object off carriageway***** ***#30 – HGV occupant in single vehicle accident***** #31 – HGV front to car rear (car occ) ***#34 – HGV occupant in rollover*****	41	224	408	123	335	505
HGV low speed VRU collision warning†	0.2	0.2	0.4	17	17	17	10	18	#12 – HGV front to pedestrian #37 – HGV side to pedestrian	633	1,108	1,583	281	281	281
HGV driver alertness monitoring – warning†	0.1	0.5	1.8	6	16	24	9	22	#8 – HGV front to car front (car occ) #12 – HGV front to pedestrian #25 – HGV front to car side (car occ) **#27 – HGV occupant in impact with other vehicle**** ***#28 – HGV occupant in impact with object off carriageway***** ***#30 – HGV occupant in single vehicle accident***** #31 – HGV front to car rear (car occ)	238	515	792	102	295	461
Safer LPV front†	1.1	2.9	7.2	8	14	19	7	25	#13 – LPV front to pedestrian ***#18 – LPV occupant where vehicle had no impact***** ***#19 – LPV occupant in single vehicle accident*****	317	554	792	914	1,723	2,451

Table 14. Comparison of benefit-cost ratios estimated using different calculation methods.

Countermeasure	KSI "steady-state" benefit-cost ratio based on 2006-2008 casualty data			KSI "steady-state" benefit-cost ratio based on forecast casualty data (2022 or 2024)			KSI benefit-cost ratio calculated over a 10 year evaluation period from the date of implementation			Effects in year 10 after mandatory fitment‡‡‡				
										KSI casualty prevention value for countermeasure (£M, 2008 prices)			Reduction in number of fatalities	Reduction in number of serious injuries
	Min	BE‡	Max	Min	BE‡	Max	Min	BE‡	Max	Min	BE‡‡	Max	BE‡	BE‡
Safer HGV front (CM88)†	0.6	2.3	5.7	0.3	1.3	3.4	0.2	0.8	2.1	8	23	35	14	22
Faster response braking system for HGVs (CM89) ††	0.9	3.7	24.4	0.7	3.0	22.7	0.3	1.4	11.3	8	22	31	12	25
HGV low speed VRU collision warning (CM80a)†	0.2	0.3	0.6	0.3	0.5	0.9	0.2	0.2	0.4	17	17	17	10	18
HGV driver alertness monitoring – warning (CM79a)†	0.3	1.2	3.7	0.3	1.0	3.2	0.1	0.5	1.8	6	16	24	9	22
Safer LPV front (CM88)†	4.4	10.9	25.3	2.4	6.0	19.4	1.1	2.9	7.2	8	14	19	7	25

Notes relating to Table 13 and Table 14:
:
** The rank position is from casualty group ranking list (See appendix B). All relevant casualty groups have been considered in the numerical data but, for reasons of brevity,* ***the relevant group has only been listed if it falls within the top 20 lower level groups*** *(e.g. HGV front to car front rather than HGV to car, and LPV front to pedestrian rather than LPV to pedestrian, HGV occupant in single vehicle accident rather than HGV occupant etc.) it is possible that the countermeasure could affect a group that is not listed.*
*** Casualty groups shown in* ***bold italics*** *are not necessarily mutually exclusive.*
**** Average cost of the system in year 10 after implementation, expressed in 2005 prices accounting for inflation and discounted cash flow.*
† Year of implementation 2015
†† Year of implementation 2013

‡ Best estimate of casualty benefit assumed that the proportion of casualties that were known to be within the scope of the measure was applied to those where it was unknown if the casualties were within the scope. The cost used was the average of the upper and lower values for 2008.

‡‡ Equivalent to the cumulative benefits of the measure over the 10 year evaluation period, divided by the cumulative number of new vehicles fitted with the countermeasure in the same period, expressed in 2008 prices including the effects of inflation and discounted cash flow.

‡‡‡ In year 10 after implementation it is estimated that 87.4% of all registered HGVs and 70.0% of all registered LPVs will be fitted with the countermeasure.

Based on the cost benefit method that is aligned to Government guidelines, only two of the five selected countermeasures have a best estimate BCR greater than one. However all but the VRU sensor warning system have a range of BCRs that span one using this methodology, indicating at least a chance of a positive return on investment. Using the "steady state" approach, either with forecast or existing casualty data, produces a best estimate BCR greater than one for all of the countermeasures except the VRU sensor warning system. The low BCR can be attributed to the cost used for the VRU warning system, which is the highest of the five countermeasures. Producing a lower cost system that has a similar performance level, would result in a much improved BCR and may well be possible as the technology develops. If the number of VRU casualties increases in future, this countermeasure would also become more likely to have a BCR greater than one.

When ranked by best estimate of KSI cost, the rank order of the countermeasures has remained similar to that reported in Smith *et al* (2007). Although the driver alertness system is now a warning system rather than a mitigation system and has swapped places with the VRU warning system, both have similar estimates of KSI cost. The LPV countermeasure is ranked fifth for both the 2006 and 2009 analyses, despite being a different countermeasure. This reflects the lower number of casualties from accidents involving LPVs when compared to HGVs. However when considering the BCR, the LPV measures appear to offer the potential for the highest return on investment because of the lower number of vehicles to which the countermeasure will need to be fitted.

5 Sector specific analysis

So far, the analysis presented in this report has considered the overall future safety priorities for large commercial vehicles. This section of the report provides an overview of priorities for each of the vehicle sectors individually, within the overall context of the analysis presented so far.

The ranking of casualty groups and countermeasures is taken from the most recent analysis using 2006-2008 Stats19 data. No filters, such as those applied to select the five countermeasures for further analysis, have been applied to the list of countermeasures. This means that long term countermeasures appear in the lists shown in the following tables. It should be noted that some of these countermeasures are conceptual and/or aspirational at this stage. The tables show the overall top five casualty groups or countermeasures[16], followed by the next ten casualty groups or next five countermeasures for the vehicle of interest. Additional information has been included, which has been taken from various dissemination activities[17] relating to the study reported by Smith *et al* (2007) which includes analysis of phase 1 of the Heavy Vehicle Crash Injury Study[18].

5.1 HGVs

Table 15 shows the most important casualty groups for HGVs when ranked by KSI cost.

Table 15. Top ranked (by KSI cost, 2006-2008 data) HGV related casualty groups, compared to overall top five ranked casualty groups.

Rank	Casualty group	KSI cost (£M)	Number of fatalities	Number of serious casualties	03-05 rank	Change in rank
1	Car occupants in impacts with HGV – All impact configurations	341.2	146	501	1	0
2	Car occupants in impacts with LCV – All impact configurations	202.2	74	407	2	0
3	LCV occupants – All impact configurations	171.0	51	450	3	0
4	Pedestrians in impacts with HGV – All sides	149.9	72	151	4	0
5	Pedestrians in impacts with LPV – All sides	142.5	47	335	5	0
7	HGV occupants – All impact configurations	119.0	38	291	6	-1
8	Car occupants in impacts with HGV – Front to Front	117.9	53	152	7	-1
12	Pedestrians in impacts with HGV – Front of HGV	94.5	50	55	12	0
15	Two-wheeled motor vehicle riders in impacts with HGV – All	77.6	34	111	17	2

[16] Those which are not relevant to the sector under consideration are greyed out
[17] UNECE GRSG Informal Group on Regulation 66 (June 2007) , ESV Conference 2007 (June 2007), Institute of Agricultural Engineers Agricultural Transport Conference (March 2008), Posters prepared for the DEKRA Safety of Commercial Vehicles Symposium (October 2008),
[18] HVCIS phase 1 is a sample of fatal accidents occurring between 1997 and 2002 inclusive

Rank	Casualty group	KSI cost (£M)	Number of fatalities	Number of serious casualties	03-05 rank	Change in rank
	impact configurations					
22	Pedal cyclists in impacts with HGV – All impact configurations	59.1	27	72	30	8
24	Car occupants in impacts with HGV – Front of car to rear of HGV	57.9	25	87	26	2
25	Car occupants in impacts with HGV – Front of HGV to side of car	57.5	27	61	16	-9
27	HGV occupants – impact with other vehicle	52.0	16	135	19	-8
28	HGV occupants – impact with object off carriageway	47.6	16	112	23	-5
30	HGV occupants – single vehicle accidents	44.8	14	115	28	-2

It can be seen that casualty groups involving HGVs are amongst the highest ranked groups overall. Car occupants, particularly in front to front collisions are the highest ranked group that could be influenced by one specific countermeasure.

The analysis by Smith *et al* (2007) based on Stats19 data from 2003 to 2005 and phase 1 of the HVCIS fatal accident database showed that;

Where a fatally or seriously injured HGV occupant was in an impact with another vehicle, the opponent vehicle was most frequently an HGV:

- From Stats19:
    - Front to rear impacts account for approximately 66% of fatalities and 55% of KSI casualties where the casualty was in the HGV with the frontal impact (bullet vehicle).
    - Head-on collisions are the second most frequent, 19% of fatalities and 17% of KSI casualties.
- Analysis of HGV front to HGV rear collisions in the HVCIS Fatals database showed that:
    - Approximately 60% of struck HGVs were stationary at time of impact and median closing speed between vehicles was 65km/h.
    - Lack of attention or fatigue was considered to be a contributory factor for 96% of the drivers of the bullet vehicle.

For accidents where the HGV occupant was injured in a single vehicle rollover:

- Analysis of Stats19 showed that:
    - The majority of rollover accidents (96% of fatal and 68% of serious) also include impacts with objects off the carriageway such as bridges/trees/crash barriers.
- From the HVCIS fatals database:

- Where seatbelt use was known (8 fatalities, 30%), none of the fatalities were wearing the seatbelt provided;
- 12 fatalities were fully ejected and 4 were partially ejected from the HGV cab;
- The average travel speed in the rollover accidents was 85km/h, close to the maximum permitted speed; and
- 56% of the rollovers occurred on a motorway slip road or bend.

Table 16 shows the top countermeasures when ranked by KSI cost.

Table 16. Top ranked (by KSI cost, 2006-2008 data) countermeasures for HGVs compared to overall top ranked countermeasures.

Rank	Countermeasure	Best estimate of benefit		
		KSI cost (£M)	Number of fatalities	Number of serious casualties
1	HGV - Driver alertness monitoring – avoidance	184.7	54	492
2	HGV - Vulnerable road user sensor - avoidance	175.3	52	467
3	HGV - Vulnerable road user sensor – mitigation	129.7	42	382
4	HGV - Safer vehicle front[19]	107.3	35	316
5	HGV - Segregate vehicle types by in-cab information systems	79.4	23	212
6	HGV – Faster response braking system	72.3	24	213
7	HGV - Vulnerable road user sensor – warning	71.7	23	211
8	HGV – Improved driver training	57.5	17	153
9	HGV – Brake assist	49.7	16	146
14	HGV – Improve forward visibility	43.8	13	117

The top five countermeasures overall are all applied to HGVs. The next five highest ranked countermeasures for HGVs almost complete the top ten overall. Each of the countermeasures included in the list are intended to influence number of different casualty groups, with some (e.g. driver alertness monitoring, improved driver training or brake assist) intended to influence accidents involving HGVs regardless of the casualty type injured. Many of the countermeasures listed are intended to solely offer protection to vulnerable road users (VRU sensors, improved forward visibility) or to provide protection to vulnerable road users in conjunction with other types of casualty such as car occupants and HGV occupants (safer vehicle front).

[19] Incorporating protection for car occupants, pedestrians, cyclists, HGV/LPV occupants and improved field of view

5.2 LCVs

The top ranked casualty groups associated with LCVs are shown in Table 17.

Table 17. Top ranked (by KSI cost, 2006-2008 data) LCV related casualty groups, compared to overall top five ranked casualty groups.

Rank	Casualty group	KSI cost (£M)	Number of fatalities	Number of serious casualties	03-05 rank	Change in rank
1	Car occupants in impacts with HGV – All impact configurations	341.2	146	501	1	0
2	Car occupants in impacts with LCV – All impact configurations	202.2	74	407	2	0
3	LCV occupants – All impact configurations	171.0	51	450	3	0
4	Pedestrians in impacts with HGV – All sides	149.9	72	151	4	0
5	Pedestrians in impacts with LPV – All sides	142.5	47	335	5	0
6	Pedestrians in impacts with LCV – All sides	125.4	40	304	8	2
10	LCV occupants in impacts with other vehicles	96.9	26	281	9	-1
11	TWMV riders in impacts with LCVs – All impact configurations	96.1	30	241	13	2
14	Car occupants in impacts with LCV – Front to front	83.2	31	164	11	-3
16	LCV occupants - Impacts with objects off the carriageway	73.6	26	158	15	-1
17	Pedestrians in impacts with LCV – Front of LCV	70.2	25	151	18	1
21	LCV occupants - Single vehicle accidents	59.4	21	127	20	-1
23	Car occupants in impacts with LCV – Front of LCV to side of car	58.7	26	76	25	2
29	LCV occupants – Impacts with cars	47.6	10	165	27	-2
32	LCV occupants - Rollover	42.8	16	84	34	1

As seen for HGVs, casualty groups relating to LCVs are in the overall top five, with car occupants in collision with LCVs the highest ranked LCV group. Although for LCVs, the occupants themselves rank higher than pedestrians.

Analysis of the 2003-2005 Stats19 database showed that:

- LCV occupant fatalities most frequently arise from impacts with HGVs (30%). Impacts with cars and objects off the carriageway such as bridges/trees/crash barriers are the next most frequent (both 16%) cause of fatalities; and
- The most frequent cause of serious injury to LCV occupants arise from impacts with cars (35%) followed by impacts with HGVs (14%).

For impacts with HGVs where the LCV occupant was injured, the Stats19 data (2003-2005) showed:

- Head on collisions were most frequent for LCV occupant fatalities (46%), followed by front LCV-rear HGV collisions (23%); and
- For KSI casualties the distribution of collision types was more evenly distributed with head-on and front-rear both accounting for approximately 28%.

The analysis of the HVCIS fatal accident database (phase 1) showed that:

- Post impact load movement was recorded for six fatalities (15%), however, the load movement only contributed to injury severity for one of the fatalities;
- Only 10 (27%) of the 37 seatbelts fitted were used;
- 5 of the fatalities were ejected (13%); and
- The majority of LCV occupants died from multiple injuries.

Table 18 shows the top ranked countermeasures for LCVs compared to the overall top five countermeasures.

Table 18. Top ranked (by KSI cost, 2006-2008 data) countermeasures for LCVs compared to overall top ranked countermeasures.

Rank	Countermeasure	Best estimate of benefit		
		KSI cost (£M)	Number of fatalities	Number of serious casualties
1	HGV - Driver alertness monitoring – avoidance	184.7	55	492
2	HGV - Vulnerable road user sensor - avoidance	175.3	52	467
3	HGV - Vulnerable road user sensor – mitigation	129.7	42	382
4	HGV - Safer vehicle front[20]	107.3	35	316
5	HGV - Segregate vehicle types by in-cab information systems	79.4	23	212
12	LCV – Improved driver training	45.6	13	121
13	LCV - Segregate vehicle types by in-cab information systems	44.1	13	118
20	LCV – Faster response braking system	34.9	11	103
21	LCV – Seatbelt enforcement	34.3	11	101
25	LCV – Driver alertness monitoring - warning	28.9	9	77

[20] Incorporating protection for car occupants, pedestrians, cyclists, HGV/LPV occupants and improved field of view

Four of the top five LCV countermeasures are intended to offer protection to a wide range of casualty groups. Unlike the HGVs, the only countermeasure intended to influence a specific casualty group is intended to protect the LCV occupants rather than any of the opponents. There is minimal overlap with the HGV specific countermeasures

5.3 LPVs

Table 19 shows the top ranked casualty groups associated with LPVs.

Table 19. Top ranked (by KSI cost, 2006-2008 data) LPV related casualty groups, compared to overall top five ranked casualty groups.

Rank	Casualty group	KSI cost (£M)	Number of fatalities	Number of serious casualties	03-05 rank	Change in rank
1	Car occupants in impacts with HGV – All impact configurations	341.2	146	501	1	0
2	Car occupants in impacts with LCV – All impact configurations	202.2	74	407	2	0
3	LCV occupants – All impact configurations	171.0	51	450	3	0
4	Pedestrians in impacts with HGV – All sides	149.9	72	151	4	0
5	Pedestrians in impacts with LPV – All sides	142.5	47	335	5	0
9	LPV occupants – All impact configurations	101.2	12	425	10	1
13	Pedestrians in impacts with LPV – Front of LPV	92.5	34	183	14	1
18	LPV occupants – No impact	67.8	9	281	22	4
19	LPV occupants – Single vehicle	67.3	9	276	24	5
20	Car occupants in impacts with LPVs – All impact configurations	65.1	25	124	21	1
33	Pedestrians in impacts with LPV – Side of LPV	40.2	10	120	35	1
38	Car occupants in impacts with LPVs – Front to front	34.7	15	53	42	3
51	TWMV riders in impacts with LPVs – All impact configurations	21.1	8	37	55	4
57	LPV occupants – Impacts with other vehicles	18.1	2	78	51	-6
58	Pedal cyclists in impacts with LPVs – All impact configurations	17.8	5	50	63	5

Pedestrians and LPV occupants are the highest ranked casualty groups associated with LPVs.

For pedestrian casualties, the analysis of Stats19 for 2003-2005 showed that:

- 63% of pedestrian KSI in collision with LPVs had a first point of impact of the front of the LPV.
- Most frequent manoeuvre for the LPV was "going ahead other" accounting for 70% of the KSI pedestrians. Starting was the next most frequent followed by, stopping and turning left.

The HVCIS analysis (phase 1) provided further details such as:

- 33% of pedestrians in collisions with buses were considered to not be paying attention;
- 18% of the pedestrians were under the influence of alcohol (either alone or in conjunction with some other behavioural factor);
- The median impact speed for collisions between pedestrians and the front of LPVs was approximately 30km/h; and
- The most frequent cause of death was head injuries.

Although LPV occupants rank highly in the list, rollover is not the most frequent injury mechanism. Rollover is ranked #107 overall. Higher priorities for LPV occupants are single vehicle accidents (which include rollover) and also accidents where the LPV has no external impact (for example where an occupant falls over as the LPV brakes suddenly). Table 20 compares the top ranked countermeasures for LPV to the overall top five.

Table 20. Top ranked (by KSI cost, 2006-2008 data) countermeasures for LPVs compared to overall top ranked countermeasures.

Rank	Countermeasure	Best estimate of benefit		
		KSI cost (£M)	Number of fatalities	Number of serious casualties
1	HGV - Driver alertness monitoring – avoidance	184.7	54	492
2	HGV - Vulnerable road user sensor - avoidance	175.3	52	467
3	HGV - Vulnerable road user sensor – mitigation	129.7	42	382
4	HGV - Safer vehicle front[21]	107.3	35	316
5	HGV - Segregate vehicle types by in-cab information systems	79.4	23	212
10	LPV - Vulnerable road user sensor - avoidance	49.0[22]	14	131
11	LPV - Safer vehicle front[23]	45.7	15	134
15	LPV - Driver alertness monitoring – avoidance	43.4	13	116
18	LPV - Vulnerable road user sensor – mitigation	36.3	12	107
24	LPV - Faster response braking system	29.9	10	88

[21] Incorporating protection for car occupants, pedestrians, cyclists, HGV/LPV occupants and improved field of view

[22] The KSI cost is higher than a countermeasure with a higher number of fatalities and serious casualties prevented because this countermeasures avoids the accident rather than mitigating the outcome as for the lower ranked countermeasure.

[23] Incorporating protection for car occupants, pedestrians, cyclists, HGV/LPV occupants and improved field of view

Again, the highest ranked countermeasures are intended to influence multiple casualty groups, although three of the five include protection of pedestrians.

5.4 Minibuses

The top ranked casualty groups associated with minibuses are shown in Table 21

Table 21. Top ranked (by KSI cost, 2006-2008 data) Minibus related casualty groups, compared to overall top five ranked casualty groups.

Rank	Casualty group	KSI cost (£M)	Number of fatalities	Number of serious casualties	03-05 rank	Change in rank
1	Car occupants in impacts with HGV – All impact configurations	341.2	146	501	1	0
2	Car occupants in impacts with LCV – All impact configurations	202.2	74	407	2	0
3	LCV occupants – All impact configurations	171.0	51	450	3	0
4	Pedestrians in impacts with HGV – All sides	149.9	72	151	4	0
5	Pedestrians in impacts with LPV – All sides	412.5	47	335	5	0
47	Minibus occupants – All	22.3	6	64	37	**-10**
62	Car occupants in impacts with minibuses – All impact configurations	15.5	5	38	53	**-9**
70	Minibus occupants – Impacts with other vehicles	13.1	4	37	52	**-18**
77	Pedestrians in impacts with minibuses – All sides	12.1	4	25	90	**13**
89	Car occupants in impacts with minibuses – Front to front	7.8	3	18	89	**0**
94	Pedestrians in impacts with minibuses – Front of minibus	7.5	3	13	New	**N/A**
98	Minibus occupants – Impacts with cars	7.0	1	25	71	**-27**
102	Minibus occupants – Single vehicle	6.8	2	21	83	**-19**
107	Minibus occupants – Impacts with objects off carriageway	5.8	1	22	74	**-33**
120	Minibus occupants – Rollover	4.7	1	13	73	**-47**

The highest ranked casualty group for minibuses is the occupants of the minibuses themselves. These minibus occupants are more frequently killed and seriously injured in impacts with other vehicles, rather than single vehicle or rollover accidents. However, the following analysis of the HVCIS fatal accident database describes some characteristics of minibus rollover accidents:

- 10 minibus occupant fatalities 1997-2002:
  - 50% involve rollover;
  - 3 of 5 fatalities in a rollover were at least partially ejected;
  - For 1 of 5 fatalities in a rollover, the rollover was the most injurious event in the collision; and
  - 4 of 5 also involved substantial collisions with other vehicles/fixed objects.

This analysis indicates that protection of minibus occupants in rollover accidents needs to consider impacts with other fixed objects or vehicles and the prevention of ejection.

Table 22 shows the top ranked countermeasures associated with minibuses.

Table 22. Top ranked (by KSI cost, 2006-2008 data) countermeasures for minibuses compared to overall top ranked countermeasures.

Rank	Countermeasure	Best estimate of benefit		
		KSI cost (£M)	Number of fatalities	Number of serious casualties
1	HGV - Driver alertness monitoring – avoidance	184.7	54	492
2	HGV - Vulnerable road user sensor - avoidance	175.3	52	467
3	HGV - Vulnerable road user sensor – mitigation	129.7	42	382
4	HGV - Safer vehicle front[24]	107.3	35	316
5	HGV - Segregate vehicle types by in-cab information systems	79.4	23	212
72	Minibus – Improve side impact crashworthiness	8.4	3	25
93	Minibus – Improve car to minibus compatibility	5.4	2	16
94	Minibus - Driver alertness monitoring – avoidance	5.4	2	14
95	Minibus – Seatbelt enforcement	5.2	2	15
123	Minibus – Apply pedestrian protection Directive	3.3	1	10

The top five countermeasures for minibuses are rather different to those seen for the other vehicle types so far. The majority of the countermeasures are intended to influence specific groups of casualties, car occupants, minibus occupants, pedestrians. The only countermeasure to address multiple casualty groups is the driver alertness monitoring.

5.5 Agricultural vehicles

Table 23 shows the top ranked casualty groups for Agricultural vehicles.

[24] Incorporating protection for car occupants, pedestrians, cyclists, HGV/LPV occupants and improved field of view

Table 23. Top ranked (by KSI cost, 2006-2008 data) agricultural vehicle related casualty groups, compared to overall top five ranked casualty groups.

Rank	Casualty group	KSI cost (£M)	Number of fatalities	Number of serious casualties	03-05 rank	Change in rank
1	Car occupants in impacts with HGV – All impact configurations	341.2	146	501	1	0
2	Car occupants in impacts with LCV – All impact configurations	202.2	74	407	2	0
3	LCV occupants – All impact configurations	171.0	51	450	3	0
4	Pedestrians in impacts with HGV – All sides	149.9	72	151	4	0
5	Pedestrians in impacts with LPV – All sides	142.5	47	335	5	0
46	Car occupants in impacts with agricultural vehicles – All impact configurations	22.9	8	50	48	**2**
54	TWMV riders in impacts with agricultural vehicles – All impact configurations	19.9	8	31	69	**15**
80	TWMV riders in impacts with agricultural vehicles – Front of TWMV to side of agricultural vehicle	11.4	5	13	97	**17**
87	Agricultural vehicle occupants	8.5	3	18	72	**-15**
99	Car occupants in impacts with agricultural vehicles – Front of car to side of agricultural vehicle	6.9	3	13	101	**-2**
103	Car occupants in impacts with agricultural vehicles – Front to front	6.4	2	13	102	**-1**
115	Car occupants in impacts with agricultural vehicles – Front of car to rear of agricultural vehicle	5.1	2	9	96	**-19**
125	Agricultural vehicle occupants - Rollover	4.4	2	6	109	**-16**
127	Agricultural vehicle occupants – Impact with object off carriageway	4.3	2	5	103	**-24**
130	Agricultural vehicle occupants – Impacts with other vehicles	4.0	1	12	112	**-18**

From the HVCIS fatal accident database, the following information relating to the two most frequently KSI casualty groups involving agricultural vehicles:

- Car occupant casualties:

  - The behaviour of three of nine agricultural vehicle drivers and seven of nine car drivers was considered contributory to the cause of the accidents;
  - Where belt use known (8) all car occupants were wearing a seatbelt; and
  - Eight of nine accidents occurred on roads with speed limit of 60mile/h or more.
- TWMV riders:
  - Seven of nine accidents involved the TWMV going ahead other or overtaking and the agricultural vehicle turning right;
  - The behaviour of two of eight agricultural vehicle drivers and seven of eight TWMV riders was considered contributory to the cause of the accidents; and
  - Seven of eight accidents occurred on roads with speed limit of 60mile/h or more.

In addition, the following information was available about five accidents where the agricultural vehicle occupants were fatally injured:

- Three accidents involved rollover, one occupant was ejected, one accident also involved impact with HGV;
- Three of five fatalities were ejected from the cab;
- Seatbelt use was known for three of five fatalities, all were unbelted; and
- The behaviour of four of the drivers of the agricultural vehicles was considered contributory to the cause of the accidents.

Table 24 shows the top ranked countermeasures for agricultural vehicles compared to the overall top five ranked countermeasures.

Table 24. Top ranked (by KSI cost, 2006-2008 data) countermeasures for agricultural vehicles compared to overall top ranked countermeasures.

Rank	Countermeasure	Best estimate of benefit		
		KSI cost (£M)	Number of fatalities	Number of serious casualties
1	HGV - Driver alertness monitoring – avoidance	184.7	54	492
2	HGV - Vulnerable road user sensor - avoidance	175.3	52	467
3	HGV - Vulnerable road user sensor – mitigation	129.7	42	382
4	HGV - Safer vehicle front[25]	107.3	35	316
5	HGV - Segregate vehicle types by in-cab information systems	79.4	23	212
37	Agricultural - Vulnerable road user sensor - avoidance	16.8	5	45
45	Agricultural – De-restrict speed of agricultural vehicles[26]	14.5	4	39
55	Agricultural - Vulnerable road user sensor – mitigation	12.4	4	37
83	Agricultural - Vulnerable road user sensor – warning	6.9	2	20
102	Agricultural - Segregate vehicle types by in-cab information systems	4.6	1	12

The highest ranked countermeasures are all intended to influence multiple casualty groups. The vulnerable road user sensors are ranked highly because they are intended to influence accidents where the agricultural vehicle turning right and collides with an overtaking TWMV. However, the VRU sensors are more intended for accidents where the larger vehicle is turning across the path of a slower moving VRU, such as HGVs turning left and colliding with pedal cycles. Further investigation of the likely effectiveness of such a system in this higher speed accident type would be required. However, other potential countermeasures that are effective at influencing the right turning agricultural vehicle accident are also likely to offer benefits.

5.6 Other motor vehicles

Table 25 shows the top ranked casualty groups for OMVs.

[25] Incorporating protection for car occupants, pedestrians, cyclists, HGV/LPV occupants and improved field of view

[26] Potential dis-benefits were not investigated

Table 25. Top ranked (by KSI cost, 2006-2008 data) OMV related casualty groups, compared to overall top five ranked casualty groups.

Rank	Casualty group	KSI cost (£M)	Number of fatalities	Number of serious casualties	03-05 rank	Change in rank
1	Car occupants in impacts with HGV – All impact configurations	341.2	146	501	1	0
2	Car occupants in impacts with LCV – All impact configurations	202.2	74	407	2	0
3	LCV occupants – All impact configurations	171.0	51	450	3	0
4	Pedestrians in impacts with HGV – All sides	149.9	72	151	4	0
5	Pedestrians in impacts with LPV – All sides	412.5	47	335	5	0
26	OMV occupants – All	57.0	19	135	35	**9**
40	OMV occupants – Impacts with other vehicles	32.8	11	79	50	**10**
44	Pedestrians in impacts with OMVs – All sides	26.0	8	69	54	**10**
53	Car occupants in impacts with OMVs – All impact configurations	20.8	6	57	46	**-7**
65	OMV occupants – Impacts with cars	19.8	6	51	67	**12**
60	OMV occupants – Single vehicle	17.0	6	39	66	**6**
61	TWMV riders in impacts with OMVs – All impact configurations	16.5	6	37	77	**16**
63	OMV occupants – Rollover	15.3	6	27	79	**16**
68	Pedestrians in impacts with OMVs – Front of OMV	14.1	5	33	76	**8**
72	OMV occupants -Impacts with objects off the carriageway	13.0	4	33	82	**10**

The increase in the overall number of casualties from accidents involving OMVs are reflected by the OMV related casualty groups rising up the ranking list. The ranking of the casualty groups is dominated by the OMV occupants, with more than twice the KSI cost of a non-OMV occupant casualty group. No specific analysis of OMV accident has been undertaken for dissemination purposes, but analysis of phase 1 of the HVCIS fatal accident database (Smith *et al,* 2007) showed the types of OMV involved in fatal accidents.

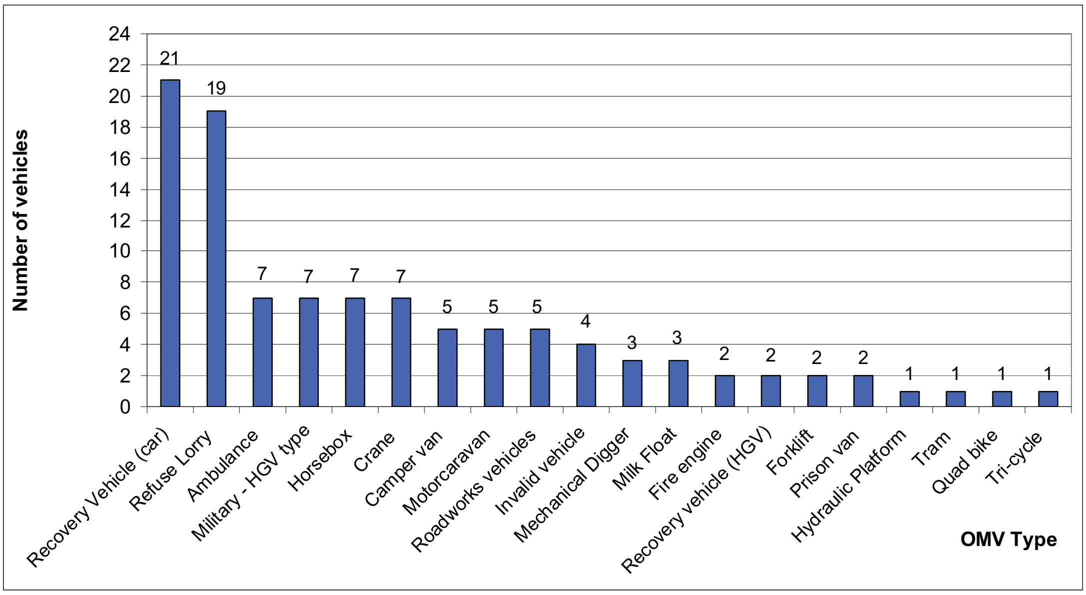


Figure 20. Types of OMV involved in HVCIS fatal accidents between 1997 and 2002 (Smith *et al*, 2007).

For this sample of fatal accidents involving OMVS, recovery vehicles and refuse collection vehicles are the vehicle type most frequently involved.

Table 26 shows the top ranked countermeasures associated with OMVs. The analysis has dealt with OMVs as an overall group, however, this vehicle category includes a wide range of vehicle types, from motorised wheelchairs to mobile cranes. The variety of vehicle designs included in this group means it can be very difficult to identify appropriate countermeasures that would influence this whole group of vehicles.

Table 26. Top ranked (by KSI cost, 2006-2008 data) countermeasures for OMVs compared to overall top ranked countermeasures.

Rank	Countermeasure	Best estimate of benefit		
		KSI cost (£M)	Number of fatalities	Number of serious casualties
1	HGV - Driver alertness monitoring – avoidance	184.7	54	492
2	HGV - Vulnerable road user sensor - avoidance	175.3	52	467
3	HGV - Vulnerable road user sensor – mitigation	129.7	42	382
4	HGV - Safer vehicle front[27]	107.3	35	316
5	HGV - Segregate vehicle types by in-cab information systems	79.4	23	212
49	OMV – Seatbelt enforcement	13.3	4	39
61	OMV – Improved driver training	11.0	3	29
80	OMV- Front airbag[28]	7.4	2	22
86	OMV - Segregate vehicle types by in-cab information systems	6.4	2	17
90	OMV – Extend scope of current drivers hours to include such vehicles	6.2	2	16

The top five OMV countermeasures are either intended to avoid accidents, influencing a range of different casualty groups, or to mitigate the injuries sustained to the occupants of the OMVs.

[27] Incorporating protection for car occupants, pedestrians, cyclists, HGV/LPV occupants and improved field of view
[28] Would need to be accompanied by measures to increase seatbelt use to 100% to realise these estimated benefits

6 Discussion

In general, during the last decade, there has been an overall reduction in the number of casualties from accidents involving commercial vehicles, with the exception of Other Motor Vehicles (OMVs) such as refuse vehicles, mobile cranes and fire engines. Accidents involving OMVs are relatively few in number and over the time period analysed showed an initial downward trend with some fluctuation. However, in recent years there has been a notable increase in the number of casualties from accidents involving OMVs. The reason for this increase is currently unclear and would require further investigation. However, the OMV category comprises a wide range of different vehicle designs, from motorised wheelchairs to mobile cranes, which can weigh more than a hundred tonnes. It is, therefore, likely to be difficult to implement countermeasures that are appropriate for all vehicles within this category, and a more targeted approach may be required.

Casualties from accidents involving Heavy Goods Vehicles (HGVs), Light Commercial Vehicles (LCVs) and Large Passenger Vehicles (LPVs) remain the most frequent large vehicle accidents. However, when considering the casualty rates associated with these vehicle types, it can be seen that although there are a large number of casualties from accidents involving LCVs and the number of fatalities has remained relatively constant, this has been accompanied by an increase in the distance travelled by these vehicles. As a result, the LCV killed and seriously injured (KSI) casualty rate is lower than, and has fallen at a higher rate than, the overall KSI casualty rate for all vehicle types. In general this has been achieved with a lower regulatory burden than for other vehicle types, which suggests that the industry is currently managing the safety performance of LCVs relatively well. Additional Government intervention may, therefore, be less of a priority for LCVs than for other vehicle types of interest.

The KSI casualty rate for HGVs is higher than the overall casualty rate, but has been reducing at a faster rate than the overall casualty rate and it is currently only marginally higher than the overall KSI casualty rate. In comparison, the KSI casualty rate for LPVs is approximately four times the KSI casualty rate for all vehicle types. Since 2003, the KSI casualty rate has increased more than the overall casualty rate which may suggest that LPVs are the highest priority vehicle type of interest. However, when considering the total number of fatalities or serious injuries, then HGVs would be the higher priority.

As mentioned in section 3, there are a number of different ways of ranking the list of casualty groups that were identified. Regardless of the ranking criteria (KSI Cost, number of fatalities or number of serious injuries) car occupants in impacts with HGVs is top of the list. When ranking by number of fatalities, the majority of the top ten groups are either car occupants or pedestrians, whereas a ranking by number of serious casualties moves the focus towards occupants of the VOI and pedestrians. If future casualty reduction targets focus on both fatalities and serious injuries, then this analysis suggests that countermeasures that are effective at protecting car occupants and pedestrians are the highest priority.

A wide range of countermeasures were evaluated for all six vehicles of interest and five were selected, on the basis of the KSI casualty prevention value and a range of other objective criteria, as the highest priorities for commercial vehicle safety standards. KSI prevention value was used to rank the countermeasures, but they could have been ranked by any number of criteria, as used for the ranking of casualty groups (best estimate of the KSI cost, fatalities or serious casualties prevented). However, the analysis showed that the criteria used to rank the countermeasures had less influence on the selection of the five countermeasures than it did on the ranking of the casualty groups.

The five countermeasures selected were:

- Safer HGV fronts;
- Faster response braking systems for HGVs;
- Sensors to detect and warn of the presence of vulnerable road users around an HGV, particularly while it is manoeuvring;
- Driver alertness warning systems for HGVs; and
- Safer LPV fronts.

These countermeasures were subjected to a more detailed cost benefit analysis in accordance with Government guidelines. This suggested that all but the low speed VRU warning system had the potential to produce a benefit cost ratio (BCR) greater than one, but significant uncertainty remained and the BCR could also be less than one for all measures except the safer LPV front.

The five countermeasures were also evaluated using cost benefit methods that were more comparable to those typically used to assess the potential impacts of vehicle safety measures. This found that the methods used had a considerable effect on the predicted BCR. The more commonly used methods tended to predict much higher BCRs, with all five measures having potential for a BCR greater than one except the low speed vulnerable road user warning system. This system could achieve a BCR in excess of one if the costs could be substantially reduced or the implementation targeted at vehicles with high exposure to vulnerable road users.

The method aligned with the Government guidelines relies on extrapolating current trends in accident data, which are reducing strongly. However, it is likely that in order to maintain this reduction the continued introduction of safety interventions will be required. Using this assumption means that the predicted effect of a measure will be based on an assumption that other measures will be implemented at a rate comparable to the recent past. This may, therefore under-estimate the BCR.

The more frequently used "steady state" method assumes that all vehicles could have been fitted with the new measure last year. Thus, this completely ignores the effects of other safety measures that have already been implemented but have not yet fully penetrated the market. This is likely to produce an over-estimate of the benefits. It is likely that reality will lie somewhere between the two and the results must be considered in this light, particularly when comparing the effects predicted for these measures with those of other safety measures competing for budget and regulatory resources. In the longer term there may be a need to consider which cost benefit methods are most appropriate for the evaluation of vehicle safety measures, and to standardise on one method to simplify the process that is used to assess and prioritise vehicle safety measures.

Car occupants in head-on (front-front) collisions with HGVs remain the highest ranked of the low-level casualty groups (i.e. those groups that are defined by a specific impact location) based on KSI cost and number of fatalities. Since the analysis by Smith *et al* (2007), the number of fatalities in this casualty group has reduced. However, if the recent mandatory fitment of FUP to trucks from 2003 (except where exemptions were granted) had been effective, a greater reduction in the number of casualties might have been expected. Although in 2008, it is likely that less than half the HGV fleet were actually equipped with FUP.

Previous analysis (Smith *et al,* 2007) using a single retrospective method, found no evidence that FUP had reduced the likelihood of car occupants being killed or seriously injured in head-on collisions with trucks. However, the number of newer vehicles, likely to be fitted with FUP, included in the sample was very small and the analysis was limited in its ability to correctly identify FUP fitment. Further investigation was recommended and has been undertaken as part of this research. This has included repeating the previous analysis using new data, undertaking an alternative retrospective statistical analysis and an in-depth analysis of accident mechanisms and causes. Neither statistical technique has shown any convincing evidence of FUP having the intended casualty reduction effect and in some cases the data suggests a counter-productive effect. FUP genuinely not having the desired effect is one of a range of possible explanations for these findings, others include:

- the low statistical power of the analysis; a result of the low number of vehicles equipped with FUP;
- the possibility that the effect of FUP has been masked by the difficulty in identifying FUP equipped vehicles in the accident data; or
- the possibility that the effect of FUP has been masked by other differences between equipped and non-equipped vehicles, for example vehicle usage.

The analysis of in-depth accident data found no changes over time to the speed (delta V) at which collisions occurred and concluded that this was unlikely to be a factor that could potentially act to mask the effect of FUP. It may be that a much more comprehensive and wide ranging analysis, based on data from multiple EU countries would help to identify the effect, if any, of FUP and to isolate it more rigorously from other confounding factors. More details of the updated analysis can be found in Appendix E.

If rigid front underrun protection has not been as effective as it had been predicted to be, then the most important commercial vehicle casualty group will not reduce in size as quickly as expected. This could also affect the relative priorities of future countermeasures. For example, part of the benefit of the safer HGV front is based on a more advanced development of rigid front underrun, incorporating energy absorption to help increase the collision speeds that are survivable for car occupants. Given that the casualty group that front underrun protection is intended to influence is the largest for all commercial vehicles, it could be argued that understanding whether or not FUP has had the intended effect and, if not why not, could be as high a priority as any of those new countermeasures identified by the analysis.

7 Conclusions

From the analysis presented in this report, it can be concluded that:

- In general, there has been a continued reduction in the number of casualties from accidents involving large commercial vehicles, although the number of fatal and serious casualties from accidents involving Other Motor Vehicles has increased in recent years.
- If further consideration is to be given to the reasons behind the increase in OMV accidents then a more detailed study and further monitoring of these accidents may be necessary. This could help to inform the future countermeasures that might be appropriate for OMVs.
- When considering the total number of fatalities from accidents involving the vehicles of interest, heavy goods vehicles appear to be the main priority. However, large passenger vehicles have a killed and seriously injured casualty rate that is three to four times higher than the overall casualty rate for all vehicle types and is reducing more slowly than the overall casualty rate.
- The safety performance of light commercial vehicles is currently exceeding that of the overall vehicle fleet, with a killed and seriously injured casualty rate that is lower than the overall rate and reducing more quickly than the overall rate.
- Car occupants in collisions with heavy goods vehicles remain the highest ranked casualty group, regardless of ranking criteria. When considering cost associated with the killed and seriously injured (KSI cost) and fatalities, head-on collisions between cars and heavy goods vehicles are the highest ranked individual casualty group that a single countermeasure is likely to influence.
- Analysis of the effectiveness of front underrun protection has found no evidence to suggest that the mandatory fitment of front underrun protection to new vehicle types from 2003 has had the effect on the casualties that had been expected. On the contrary, there is some evidence to suggest there has been an increase in the severity of head-on collisions between cars and heavy goods vehicles. It is important to understand the effectiveness of current front underrun protection because head-on collisions between cars and trucks remains the most important casualty group in commercial vehicle safety and because it could affect the estimated benefits of other countermeasures presented in this report. In particular, the effectiveness of the countermeasure "safer HGV front" assumed that current FUP was effective, if this is not the case, then the design for a safer vehicle front will have to compensate for any deficiencies in existing FUP.
- If it is considered appropriate to better understand the reasons why FUP does not appear to be as effective as had been expected the following steps could be taken:
    - Establish alternative means of identifying the vehicles fitted with FUP in the analysis.
    - Repeat the retrospective analysis as FUP continues to penetrate the vehicle fleet.
    - Undertake a detailed analysis of head-on collisions between cars and HGVs to better identify the characteristics of such accidents.
    - Refer the current analysis to an appropriate European scientific committee (e.g. EEVC Working Group 14) for consideration.
    - Promote ideas for collaborative research within the European research arena.
- Countermeasures that are intended to offer protection to multiple casualty groups are most likely to deliver cost-effective casualty benefits.

- The criteria used to rank the countermeasures (best estimate of the KSI cost, fatalities or serious casualties prevented) had less influence on the selection of the five countermeasures than it did on the ranking of the casualty groups.
- Five countermeasures that could be implemented through commercial vehicle safety standards were selected for a more detailed cost-benefit analysis:
    - Safer fronts for heavy goods vehicles;
    - Faster response braking systems for heavy goods vehicles;
    - Low speed vulnerable road user warning systems for heavy goods vehicles;
    - Driver alertness warning systems for heavy goods vehicles; and
    - Safer fronts for large passenger vehicles.
- Analysis of the costs and benefits over a ten year evaluation period, accounting for inflation, forecasting the casualty figures based on existing data and forecasting how the vehicle fleet will change, indicated that the faster response braking system for heavy goods vehicles and safer front for large passenger vehicles are most likely to provide a positive return on investment. The range in benefit cost ratio for the safer front for heavy goods vehicles and the driver alertness system spanned one, although the best estimate was less than one. The vulnerable road user sensor had a range for the benefit cost ratio of less than one.
- However, when calculating benefit-cost ratios using a method more commonly deployed in the assessment of vehicle safety measures, all but the low speed vulnerable road user warning system had best estimate benefit-cost ratios greater than one, and all five were more favourable. Such a method is one that is based on the benefits that would have been accrued if in the last year all vehicles in the fleet had been fitted with the countermeasure.
- It may be considered appropriate in the longer term to identify the most appropriate cost-benefit methodologies for the evaluation of vehicle safety measures, and possibly standardise on one method.
- Future priorities can be influenced by the ranking criteria, and changes in the accident data and the information available about the countermeasures. Periodic updates of the analysis would ensure that future priorities remain aligned with current knowledge and accident trends.

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Appendix A Ranking of casualty groups

Table 27, Table 28, and Table 29, show the ranking of casualty groups by annual average KSI cost, fatalities and serious casualties. Note that not all casualty groups are mutually exclusive.

Table 27. Ranking of casualty groups by KSI cost (2006-2008).

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average KSI cost (£M)
1	HGV	Car occupant	All	341.2
2	LCV	Car occupant	All	202.2
3	LCV	VOI occupant	All	171.0
4	HGV	Pedestrian	All	149.9
5	LPV	Pedestrian	All	142.5
6	LCV	Pedestrian	All	125.4
7	HGV	VOI occupant	All	119.0
8	HGV	Car occupant	Front to front	117.9
9	LPV	VOI occupant	All	101.2
10	LCV	VOI occupant	Impact with other vehicle	96.9
11	LCV	TWMV[29] rider	All	96.1
12	HGV	Pedestrian	Front of HGV	94.5
13	LPV	Pedestrian	Front of LPV	92.5
14	LCV	Car occupant	Front to front	83.2
15	HGV	TWMV rider	All	77.6
16	LCV	VOI occupant	Impact with object off carriageway	73.6
17	LCV	Pedestrian	Front of LCV	70.2
18	LPV	VOI occupant	No impact	67.8
19	LPV	VOI occupant	Single vehicle	67.3
20	LPV	Car occupant	All	65.1
21	LCV	VOI occupant	Single vehicle	59.4
22	HGV	Pedal cyclist	All	59.1
23	LCV	Car occupant	Front of LCV to side of car	58.7
24	HGV	Car occupant	Front of car to rear of HGV	57.9
25	HGV	Car occupant	Front of HGV to side of car	57.5
26	OMV	VOI occupant	All	57.0
27	HGV	VOI occupant	Impact with other vehicle	52.0
28	HGV	VOI occupant	Impact with object off carriageway	47.6
29	LCV	VOI occupant	Impact with car	47.6
30	HGV	VOI occupant	Single vehicle	44.8
31	HGV	Car occupant	Front of HGV to rear of car	43.0
32	LCV	VOI occupant	Rollover	42.8
33	LPV	Pedestrian	Side of LPV	40.2

[29] Two wheeled motor vehicle

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average KSI cost (£M)
34	HGV	VOI occupant	Rollover	39.1
35	LCV	TWMV rider	Front of TWMV to side of LCV	38.3
36	LCV	Pedal cyclist	All	38.1
37	HGV	Pedestrian	Side of HGV	35.1
38	LPV	Car occupant	Front to front	34.7
39	HGV	LCV occupant	All	33.8
40	OMV	VOI occupant	Impact with other vehicle	32.8
41	HGV	Car occupant	Side to side	32.6
42	LCV	Pedestrian	Side of LCV	32.2
43	HGV	VOI occupant	Impact with another HGV	31.9
44	OMV	Pedestrian	All	26.0
45	HGV	Car occupant	Front of car to side of HGV	24.8
46	Agricultural	Car occupant	All	22.9
47	Minibus	VOI occupant	All	22.3
48	HGV	TWMV rider	Front of TWMV to side of HGV	22.1
49	HGV	Pedal cyclist	Side to side	22.0
50	LCV	TWMV rider	Front to front	21.7
51	LPV	TWMV rider	All	21.1
52	HGV	TWMV rider	Front to front	20.9
53	OMV	Car occupant	All	20.8
54	Agricultural	TWMV rider	All	19.9
55	OMV	VOI occupant	Impact with car	19.8
56	LCV	Pedestrian	Rear of LCV	18.5
57	LPV	VOI occupant	Impact with other vehicle	18.1
58	LPV	Pedal cyclist	All	17.8
59	LCV	Car occupant	Front of car to rear of LCV	17.6
60	OMV	VOI occupant	Single vehicle	17.0
61	OMV	TWMV rider	All	16.5
62	Minibus	Car occupant	All	15.5
63	OMV	VOI occupant	Rollover	15.3
64	LPV	Car occupant	Front of LPV to side of car	15.2
65	LCV	VOI occupant	Impact with object on carriageway	15.1
66	HGV	VOI occupant	Impact with object on carriageway	14.7
67	HGV	VOI occupant	Impact with car	14.3
68	OMV	Pedestrian	Front of OMV	14.1
69	LCV	Car occupant	Front of car to side of LCV	13.6
70	Minibus	VOI occupant	Impact with other vehicle	13.1
71	LPV	VOI occupant	Impact with object off carriageway	13.0
72	OMV	VOI occupant	Impact with object off carriageway	13.0
73	HGV	TWMV rider	Side to side	12.9

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average KSI cost (£M)
74	HGV	Pedal cyclist	Front of pedal cycle to side of HGV	12.9
75	LCV	TWMV rider	Front of TWMV to rear of LCV	12.6
76	LCV	Car occupant	Front of LCV to rear of car	12.4
77	Minibus	Pedestrian	All	12.1
78	HGV	Pedestrian	Rear of HGV	11.6
79	LCV	TWMV rider	Side to side	11.6
80	Agricultural	TWMV rider	Front of TWMV to side of agricultural vehicle	11.4
81	HGV	LCV occupant	Front of LCV to rear of HGV	11.3
82	HGV	TWMV rider	Front of TWMV to rear of HGV	10.7
83	LCV	Car occupant	Side to side	10.4
84	HGV	LCV occupant	Front to front	10.3
85	OMV	Car occupant	Front to front	9.9
86	HGV	Pedal cyclist	Front of HGV to side of pedal cycle	9.2
87	Agricultural	VOI occupant	All	8.5
88	LCV	Pedal cyclist	Front of pedal cycle to side of LCV	8.2
89	Minibus	Car occupant	Front to front	7.8
90	LPV	TWMV rider	Front of TWMV to side of LPV	7.8
91	HGV	Pedal cyclist	Front of HGV to rear of pedal cycle	7.7
92	LCV	Pedal cyclist	Side to side	7.7
93	LCV	TWMV rider	Front of LCV to side of TWMV	7.6
94	Minibus	Pedestrian	Front of minibus	7.5
95	LPV	TWMV rider	Front to front	7.4
96	OMV	Pedestrian	Side of OMV	7.2
97	HGV	VOI occupant	No impact	7.1
98	Minibus	VOI occupant	Impact with car	7.0
99	Agricultural	Car occupant	Front of car to side of agricultural vehicle	6.9
100	LCV	VOI occupant	No impact	6.9
101	HGV	TWMV rider	Front of HGV to side of TWMV	6.9
102	Minibus	VOI occupant	Single vehicle	6.8
103	Agricultural	Car occupant	Front to front	6.4
104	HGV	OMV occupant	All	6.2
105	OMV	VOI occupant	Impact with HGV	6.2
106	LPV	VOI occupant	Rollover	5.8
107	Minibus	VOI occupant	Impact with object off carriageway	5.8
108	LPV	Car occupant	Front of car to side of LPV	5.8
109	OMV	TWMV rider	Front to front	5.6
110	LCV	Pedal cyclist	Front of LCV to side of pedal cycle	5.6
111	OMV	Car occupant	Front of OMV to side of car	5.5
112	OMV	Pedal cyclist	All	5.3
113	HGV	LCV occupant	Front of HGV to rear of LCV	5.3

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average KSI cost (£M)
114	OMV	VOI occupant	No impact	5.2
115	Agricultural	Car occupant	Front of car to rear of agricultural vehicle	5.1
116	LCV	Pedal cyclist	Front to front	5.1
117	OMV	TWMV rider	Front of TWMV to side of OMV	4.9
118	LCV	Pedal cyclist	Front of LCV to rear of pedal cycle	4.8
119	OMV	VOI occupant	Impact with object on carriageway	4.7
120	Minibus	VOI occupant	Rollover	4.7
121	LPV	Pedal cyclist	Side to side	4.6
122	Minibus	TWMV rider	All	4.5
123	Minibus	Car occupant	Front of minibus to side of car	4.5
124	HGV	Minibus occupant	All	4.4
125	Agricultural	VOI occupant	Rollover	4.4
126	Minibus	VOI occupant	Impact with HGV	4.4
127	Agricultural	VOI occupant	Impact with object off carriageway	4.3
128	LPV	Pedal cyclist	Front of LPV to side of pedal cycle	4.1
129	LPV	LCV occupant	All	4.1
130	Agricultural	VOI occupant	Impact with other vehicle	4.0
131	LCV	Pedal cyclist	Front of pedal cycle to rear of LCV	3.9
132	LPV	VOI occupant	Impact with object on carriageway	3.8
133	LPV	Pedal cyclist	Front of pedal cycle to side of LPV	3.8
134	LCV	HGV occupant	All	3.8
135	Minibus	Pedestrian	Side of minibus	3.5
136	Agricultural	Pedestrian	All	3.4
137	LPV	Car occupant	Side to side	3.3
138	Agricultural	VOI occupant	Single vehicle	3.3
139	LPV	Car occupant	Front of LPV to rear of car	3.1
140	OMV	Pedestrian	Rear of OMV	3.1
141	HGV	LCV occupant	Front of HGV to side of LCV	3.0
142	Agricultural	Pedal cyclist	All	3.0
143	HGV	Pedal cyclist	Front to front	2.9
144	Minibus	VOI occupant	No impact	2.8
145	Agricultural	TWMV rider	Side to side	2.8
146	Agricultural	TWMV rider	Front to front	2.6
147	LPV	Car occupant	Front of car to rear of LPV	2.6
148	HGV	LPV occupant	All	2.6
149	HGV	Pedal cyclist	Front of pedal cycle to rear of HGV	2.4
150	LPV	Pedal cyclist	Front to front	2.3
151	HGV	TWMV rider	Front of HGV to rear of TWMV	2.1
152	HGV	Agricultural occupant	All	2.1
153	HGV	LCV occupant	Front of LCV to side of HGV	2.0

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average KSI cost (£M)
154	Agricultural	Car occupant	Side to side	2.0
155	Agricultural	VOI occupant	No impact	2.0
156	HGV	Car occupant	Side of car to rear of HGV	1.9
157	LPV	TWMV rider	Front of TWMV to rear of LPV	1.9
158	LCV	Car occupant	Side of car to rear of LCV	1.9
159	Agricultural	Car occupant	Front of agricultural vehicle to side of car	1.9
160	LPV	TWMV rider	Side to side	1.9
161	OMV	Car occupant	Front of car to rear of OMV	1.8
162	LCV	Pedal cyclist	Side of LCV to rear of pedal cycle	1.8
163	OMV	TWMV rider	Front of TWMV to rear of OMV	1.8
164	LCV	TWMV rider	Front of LCV to rear of TWMV	1.7
165	HGV	Car occupant	Side of HGV to rear of car	1.7
166	LPV	Pedestrian	Rear of LPV	1.6
167	Agricultural	TWMV rider	Front of TWMV to rear of agricultural vehicle	1.6
168	Agricultural	LCV occupant	All	1.6
169	HGV	LCV occupant	Side to side	1.5
170	OMV	TWMV rider	Front of OMV to side of TWMV	1.5
171	LPV	TWMV rider	Front of LPV to side of TWMV	1.4
172	LCV	Car occupant	Rear to rear	1.4
173	LPV	Pedal cyclist	Front of LPV to rear of pedal cycle	1.4
174	LCV	OMV occupant	All	1.4
175	OMV	Car occupant	Front of car to side of OMV	1.3
176	OMV	TWMV rider	Side to side	1.3
177	LCV	LPV occupant	All	1.2
178	HGV	TWMV rider	Side of TWMV to rear of HGV	1.2
179	LCV	Minibus occupant	All	1.0
180	HGV	Pedal cyclist	Side of HGV to rear of pedal cycle	0.9
181	OMV	LCV occupant	All	0.9
182	Minibus	Pedal cyclist	All	0.9
183	Minibus	Car occupant	Side to side	0.9
184	Minibus	Car occupant	Front of car to rear of minibus	0.8
185	Minibus	VOI occupant	Impact with object on carriageway	0.8
186	HGV	Car occupant	Rear to rear	0.8
187	Minibus	Pedestrian	Rear of minibus	0.8
188	OMV	Car occupant	Side to side	0.8
189	Agricultural	TWMV rider	Front of agricultural vehicle to side of TWMV	0.8
190	LPV	Pedal cyclist	Front of pedal cycle to rear of LPV	0.7
191	Minibus	Car occupant	Front of car to side of minibus	0.7
192	Agricultural	HGV occupant	All	0.7
193	Agricultural	VOI occupant	Impact with object on carriageway	0.7

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average KSI cost (£M)
194	LCV	TWMV rider	Side of TWMV to rear of LCV	0.6
195	OMV	Car occupant	Front of OMV to rear of car	0.6
196	HGV	Pedal cyclist	Rear to rear	0.6
197	LPV	Pedal cyclist	Side of LPV to rear of pedal cycle	0.6
198	OMV	Car occupant	Rear to rear	0.6
199	LPV	OMV occupant	All	0.6
200	Minibus	Car occupant	Front of minibus to rear of car	0.6
201	LPV	Minibus occupant	All	0.6
202	Minibus	HGV occupant	All	0.6
203	LPV	HGV occupant	All	0.4
204	LPV	TWMV rider	Front of LPV to rear of TWMV	0.3
205	LCV	Pedal cyclist	Side of pedal cycle to rear of LCV	0.3
206	OMV	TWMV rider	Front of OMV to rear of TWMV	0.3
207	HGV	LCV occupant	Rear to rear	0.3
208	HGV	TWMV rider	Rear to rear	0.2
209	HGV	TWMV rider	Side of HGV to rear of TWMV	0.2
210	LCV	Car occupant	Side of LCV to rear of car	0.2
211	LCV	Agricultural occupant	All	0.2
212	Minibus	LCV occupant	All	0.2
213	OMV	Car occupant	Side of car to rear of OMV	0.2
214	OMV	HGV occupant	All	0.2
215	Agricultural	Car occupant	Front of agricultural vehicle to rear of car	0.2
216	LPV	Car occupant	Rear to rear	0.1
217	LCV	TWMV rider	Side of LCV to rear of TWMV	0.1
218	OMV	TWMV rider	Side of TWMV to rear of OMV	0.1
219	Agricultural	Car occupant	Side of car to rear of agricultural vehicle	0.1
220	HGV	LCV occupant	Side of LCV to rear of HGV	0.1
221	LPV	Car occupant	Side of car to rear of LPV	0.1
222	LPV	TWMV rider	Side of LPV to rear of TWMV	0.1
223	LPV	Pedal cyclist	Side of pedal cycle to rear of LPV	0.1
224	LPV	Agricultural occupant	All	0.1
225	LCV	TWMV rider	Rear to rear	0.1
226	LCV	Pedal cyclist	Rear to rear	0.1
227	Minibus	LPV occupant	All	0.1
228	OMV	LPV occupant	All	0.1
229	Agricultural	Car occupant	Rear to rear	0.1
230	Agricultural	TWMV rider	Rear to rear	0.1
231	Agricultural	Minibus occupant	All	0.1
232	Agricultural	OMV occupant	All	0.1
233	HGV	Pedal cyclist	Side of pedal cycle to rear of HGV	0.0

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average KSI cost (£M)
234	HGV	LCV occupant	Side of HGV to rear of LCV	0.0
235	LPV	Car occupant	Side of HGV to rear of car	0.0
236	LPV	TWMV rider	Rear to rear	0.0
237	LPV	TWMV rider	Side of TWMV to rear of LPV	0.0
238	LPV	Pedal cyclist	Rear to rear	0.0
239	Minibus	Car occupant	Rear to rear	0.0
240	Minibus	Car occupant	Side of car to rear of minibus	0.0
241	Minibus	Car occupant	Side of minibus to rear of car	0.0
242	Minibus	OMV occupant	All	0.0
243	Minibus	Agricultural occupant	All	0.0
244	OMV	Car occupant	Side of OMV to rear of car	0.0
245	OMV	TWMV rider	Rear to rear	0.0
246	OMV	TWMV rider	Side of OMV to rear of TWMV	0.0
247	OMV	Minibus occupant	All	0.0
248	OMV	Agricultural occupant	All	0.0
249	Agricultural	Car occupant	Side of agricultural vehicle to rear of car	0.0
250	Agricultural	TWMV rider	Front of agricultural vehicle to rear of TWMV	0.0
251	Agricultural	TWMV rider	Side of TWMV to rear of agricultural vehicle	0.0
252	Agricultural	TWMV rider	Side of agricultural vehicle to rear of TWMV	0.0
253	Agricultural	LPV occupant	All	0.0

Table 28. Ranking of casualty groups by number of fatalities (2006-2008).

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of fatalities
1	HGV	Car occupant	All	146.3
2	LCV	Car occupant	All	74.3
3	HGV	Pedestrian	All	72.0
4	HGV	Car occupant	Front to front	53.0
5	LCV	VOI occupant	All	51.0
6	HGV	Pedestrian	Front of HGV	50.0
7	LPV	Pedestrian	All	47.0
8	LCV	Pedestrian	All	40.3
9	HGV	VOI occupant	All	38.0
10	LPV	Pedestrian	Front of LPV	34.3
11	HGV	TWMV rider	All	33.7
12	LCV	Car occupant	Front to front	31.0
13	LCV	TWMV rider	All	30.0
14	HGV	Car occupant	Front of HGV to side of car	27.3
15	HGV	Pedal cyclist	All	27.0
16	LCV	Car occupant	Front of LCV to side of car	26.3
17	LCV	VOI occupant	Impact with other vehicle	26.0
18	LCV	VOI occupant	Impact with object off carriageway	26.0
19	HGV	Car occupant	Front of car to rear of HGV	24.7
20	LPV	Car occupant	All	24.7
21	LCV	Pedestrian	Front of LCV	24.7
22	LCV	VOI occupant	Single vehicle	21.0
23	HGV	Car occupant	Front of HGV to rear of car	18.7
24	OMV	VOI occupant	All	18.7
25	LCV	VOI occupant	Rollover	16.0
26	HGV	VOI occupant	Impact with other vehicle	15.7
27	HGV	VOI occupant	Impact with object off carriageway	15.7
28	LPV	Car occupant	Front to front	14.7
29	HGV	Pedestrian	Side of HGV	14.0
30	HGV	VOI occupant	Single vehicle	13.7
31	LCV	TWMV rider	Front of TWMV to side of LCV	13.0
32	HGV	LCV occupant	All	12.7
33	LPV	VOI occupant	All	12.3
34	HGV	Car occupant	Side to side	12.0
35	HGV	VOI occupant	Rollover	11.3
36	HGV	VOI occupant	Impact with another HGV	11.0
37	OMV	VOI occupant	Impact with other vehicle	10.7
38	LPV	Pedestrian	Side of LPV	10.3

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of fatalities
39	HGV	TWMV rider	Front to front	10.0
40	HGV	TWMV rider	Front of TWMV to side of HGV	9.7
41	HGV	Pedal cyclist	Side to side	9.7
42	LCV	VOI occupant	Impact with car	9.7
43	LCV	Pedestrian	Side of LCV	9.0
44	LPV	VOI occupant	Single vehicle	9.0
45	LCV	TWMV rider	Front to front	8.7
46	LPV	VOI occupant	No impact	8.7
47	LPV	TWMV rider	All	8.3
48	LCV	Pedal cyclist	All	8.3
49	Agricultural	TWMV rider	All	8.3
50	HGV	Car occupant	Front of car to side of HGV	8.0
51	Agricultural	Car occupant	All	8.0
52	OMV	Pedestrian	All	7.7
53	LPV	Car occupant	Front of LPV to side of car	6.3
54	HGV	Pedal cyclist	Front of pedal cycle to side of HGV	6.0
55	LCV	Pedestrian	Rear of LCV	6.0
56	OMV	Car occupant	All	6.0
57	OMV	VOI occupant	Impact with car	6.0
58	OMV	VOI occupant	Rollover	6.0
59	Minibus	VOI occupant	All	6.0
60	HGV	TWMV rider	Side to side	5.7
61	OMV	TWMV rider	All	5.7
62	OMV	VOI occupant	Single vehicle	5.7
63	LCV	Car occupant	Front of car to rear of LCV	5.3
64	Agricultural	TWMV rider	Front of TWMV to side of agricultural vehicle	5.3
65	HGV	VOI occupant	Impact with object on carriageway	5.3
66	LPV	Pedal cyclist	All	5.0
67	Minibus	Car occupant	All	5.0
68	HGV	Pedestrian	Rear of HGV	4.7
69	HGV	Pedal cyclist	Front of HGV to side of pedal cycle	4.7
70	OMV	Pedestrian	Front of OMV	4.7
71	HGV	LCV occupant	Front to front	4.3
72	HGV	LCV occupant	Front of LCV to rear of HGV	4.3
73	Minibus	Pedestrian	All	4.3
74	LCV	VOI occupant	Impact with object on carriageway	4.3
75	HGV	TWMV rider	Front of TWMV to rear of HGV	4.0
76	HGV	Pedal cyclist	Front of HGV to rear of pedal cycle	4.0
77	OMV	VOI occupant	Impact with object off carriageway	4.0

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of fatalities
78	OMV	Car occupant	Front to front	3.7
79	Minibus	VOI occupant	Impact with other vehicle	3.7
80	HGV	TWMV rider	Front of HGV to side of TWMV	3.3
81	LPV	TWMV rider	Front to front	3.3
82	LPV	TWMV rider	Front of TWMV to side of LPV	3.3
83	LCV	Car occupant	Side to side	3.3
84	LCV	TWMV rider	Front of TWMV to rear of LCV	3.3
85	HGV	VOI occupant	Impact with car	3.3
86	LCV	Car occupant	Front of LCV to rear of car	3.0
87	Minibus	Pedestrian	Front of minibus	3.0
88	Agricultural	VOI occupant	All	3.0
89	HGV	OMV occupant	All	2.7
90	LCV	Car occupant	Front of car to side of LCV	2.7
91	Minibus	Car occupant	Front to front	2.7
92	OMV	TWMV rider	Front to front	2.7
93	Agricultural	Car occupant	Front of car to side of agricultural	2.7
94	LCV	VOI occupant	No impact	2.7
95	OMV	VOI occupant	Impact with HGV	2.7
96	LCV	TWMV rider	Side to side	2.3
97	Agricultural	Car occupant	Front to front	2.3
98	HGV	VOI occupant	No impact	2.3
99	HGV	LCV occupant	Front of HGV to rear of LCV	2.0
100	HGV	Minibus occupant	All	2.0
101	LCV	Pedal cyclist	Front of LCV to rear of pedal cycle	2.0
102	Minibus	Car occupant	Front of minibus to side of car	2.0
103	OMV	Pedestrian	Side of OMV	2.0
104	OMV	Car occupant	Front of OMV to side of car	2.0
105	Agricultural	Car occupant	Front of car to rear of agricultural vehicle	2.0
106	LPV	VOI occupant	Impact with other vehicle	2.0
107	OMV	VOI occupant	No impact	2.0
108	Agricultural	VOI occupant	Rollover	2.0
109	Agricultural	VOI occupant	Impact with object off carriageway	2.0
110	Minibus	VOI occupant	Impact with HGV	2.0
111	LPV	Pedal cyclist	Front of LPV to side of pedal cycle	1.7
112	LPV	LCV occupant	All	1.7
113	LCV	TWMV rider	Front of LCV to TWMV	1.7
114	LCV	Pedal cyclist	Side to side	1.7
115	LPV	VOI occupant	Impact with object off carriageway	1.7
116	Minibus	VOI occupant	Single vehicle	1.7

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of fatalities
117	HGV	LCV occupant	Front of HGV to side of LCV	1.3
118	LPV	Car occupant	Front of car to side of LPV	1.3
119	LCV	Pedal cyclist	Front of pedal cycle to rear of LCV	1.3
120	Minibus	TWMV rider	All	1.3
121	OMV	TWMV rider	Front of TWMV to side of OMV	1.3
122	Agricultural	Pedestrian	All	1.3
123	Agricultural	Pedal cyclist	All	1.3
124	LPV	VOI occupant	Rollover	1.3
125	OMV	VOI occupant	Impact with object on carriageway	1.3
126	Agricultural	VOI occupant	Single vehicle	1.3
127	Minibus	VOI occupant	Impact with car	1.3
128	Minibus	VOI occupant	Rollover	1.3
129	HGV	Pedal cyclist	Front to front	1.0
130	HGV	Pedal cyclist	Front of pedal cycle to rear of HGV	1.0
131	LPV	Car occupant	Front of LPV to rear of car	1.0
132	LPV	Car occupant	Side to side	1.0
133	LPV	Pedal cyclist	Front of pedal cycle to side of LPV	1.0
134	LPV	Pedal cyclist	Side to side	1.0
135	LCV	Pedal cyclist	Front to front	1.0
136	LCV	Pedal cyclist	Front of LCV to side of pedal cycle	1.0
137	LCV	HGV occupant	All	1.0
138	Minibus	Pedestrian	Side of minibus	1.0
139	OMV	Pedestrian	Rear of OMV	1.0
140	OMV	Pedal cyclist	All	1.0
141	Agricultural	TWMV rider	Front to front	1.0
142	Agricultural	TWMV rider	Side to side	1.0
143	Agricultural	VOI occupant	No impact	1.0
144	Agricultural	VOI occupant	Impact with other vehicle	1.0
145	Minibus	VOI occupant	No impact	1.0
146	Minibus	VOI occupant	Impact with object off carriageway	1.0
147	HGV	Car occupant	Side of car to rear of HGV	0.7
148	HGV	Car occupant	Side of HGV to rear of car	0.7
149	HGV	TWMV rider	Front of HGV to rear of TWMV	0.7
150	HGV	LPV occupant	All	0.7
151	HGV	Agricultural occupant	All	0.7
152	LPV	TWMV rider	Front of LPV to side of TWMV	0.7
153	LPV	TWMV rider	Front of TWMV to rear of LPV	0.7
154	LPV	Pedal cyclist	Front to front	0.7
155	LCV	Car occupant	Rear to rear	0.7

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of fatalities
156	LCV	Car occupant	Side of car to rear of LCV	0.7
157	LCV	Pedal cyclist	Front of pedal cycle to side of LCV	0.7
158	LCV	Pedal cyclist	Side of LCV to rear of pedal cycle	0.7
159	OMV	TWMV rider	Front of OMV to side of TWMV	0.7
160	Agricultural	Car occupant	Front of agricultural vehicle to side of car	0.7
161	HGV	Car occupant	Rear to rear	0.3
162	HGV	TWMV rider	Side of TWMV to rear of HGV	0.3
163	HGV	Pedal cyclist	Rear to rear	0.3
164	HGV	Pedal cyclist	Side of HGV to rear of pedal cycle	0.3
165	HGV	LCV occupant	Front of LCV to side of HGV	0.3
166	HGV	LCV occupant	Side to side	0.3
167	LPV	Pedestrian	Rear of LPV	0.3
168	LPV	Car occupant	Front of car to rear of LPV	0.3
169	LPV	TWMV rider	Side to side	0.3
170	LPV	Pedal cyclist	Front of LPV to rear of pedal cycle	0.3
171	LPV	Pedal cyclist	Side of LPV to rear of pedal cycle	0.3
172	LPV	Minibus occupant	All	0.3
173	LCV	TWMV rider	Front of LCV to rear of TWMV	0.3
174	LCV	OMV occupant	All	0.3
175	Minibus	Car occupant	Side to side	0.3
176	Minibus	Pedestrian	Rear of minibus	0.3
177	Minibus	HGV occupant	All	0.3
178	OMV	Car occupant	Rear to rear	0.3
179	OMV	TWMV rider	Front of TWMV to rear of OMV	0.3
180	OMV	TWMV rider	Side to side	0.3
181	OMV	LCV occupant	All	0.3
182	Agricultural	Car occupant	Side to side	0.3
183	Agricultural	TWMV rider	Front of agricultural vehicle to side of TWMV	0.3
184	Agricultural	TWMV rider	Front of TWMV to rear of agricultural vehicle	0.3
185	Agricultural	LCV occupant	All	0.3
186	LPV	VOI occupant	Impact with object on carriageway	0.3
187	Agricultural	VOI occupant	Impact with object on carriageway	0.3
188	HGV	TWMV rider	Rear to rear	0.0
189	HGV	TWMV rider	Side of HGV to rear of TWMV	0.0
190	HGV	Pedal cyclist	Side of pedal cycle to rear of HGV	0.0
191	HGV	LCV occupant	Rear to rear	0.0
192	HGV	LCV occupant	Side of LCV to rear of HGV	0.0
193	HGV	LCV occupant	Side of HGV to rear of LCV	0.0
194	LPV	Car occupant	Rear to rear	0.0

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of fatalities
195	LPV	Car occupant	Side of car to rear of LPV	0.0
196	LPV	Car occupant	Side of LPV to rear of car	0.0
197	LPV	TWMV rider	Front of LPV to rear of TWMV	0.0
198	LPV	TWMV rider	Rear to rear	0.0
199	LPV	TWMV rider	Side of TWMV to rear of LPV	0.0
200	LPV	TWMV rider	Side of LPV to rear of TWMV	0.0
201	LPV	Pedal cyclist	Front of pedal cycle to rear of LPV	0.0
202	LPV	Pedal cyclist	Rear to rear	0.0
203	LPV	Pedal cyclist	Side of pedal cycle to rear of LPV	0.0
204	LPV	HGV occupant	All	0.0
205	LPV	OMV occupant	All	0.0
206	LPV	Agricultural occupant	All	0.0
207	LCV	Car occupant	Side of LCV to rear of car	0.0
208	LCV	TWMV rider	Rear to rear	0.0
209	LCV	TWMV rider	Side of TWMV to rear of LCV	0.0
210	LCV	TWMV rider	Side of LCV to rear of TWMV	0.0
211	LCV	Pedal cyclist	Rear to rear	0.0
212	LCV	Pedal cyclist	Side of pedal cycle to rear of LCV	0.0
213	LCV	LPV occupant	All	0.0
214	LCV	Minibus occupant	All	0.0
215	LCV	Agricultural occupant	All	0.0
216	Minibus	Car occupant	Front of minibus to rear of car	0.0
217	Minibus	Car occupant	Front of car to rear of minibus	0.0
218	Minibus	Car occupant	Rear to rear	0.0
219	Minibus	Car occupant	Side of car to rear of minibus	0.0
220	Minibus	Car occupant	Front of car to side of minibus	0.0
221	Minibus	Car occupant	Side of minibus to rear of car	0.0
222	Minibus	LPV occupant	All	0.0
223	Minibus	LCV occupant	All	0.0
224	Minibus	Pedal cyclist	All	0.0
225	Minibus	OMV occupant	All	0.0
226	Minibus	Agricultural occupant	All	0.0
227	OMV	Car occupant	Front of OMV to rear of car	0.0
228	OMV	Car occupant	Front of car to rear of OMV	0.0
229	OMV	Car occupant	Side of car to rear of OMV	0.0
230	OMV	Car occupant	Front of car to side of OMV	0.0
231	OMV	Car occupant	Side of OMV to rear of car	0.0
232	OMV	Car occupant	Side to side	0.0
233	OMV	TWMV rider	Front of OMV to rear of TWMV	0.0

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of fatalities
234	OMV	TWMV rider	Rear to rear	0.0
235	OMV	TWMV rider	Side of TWMV to rear of OMV	0.0
236	OMV	TWMV rider	Side of OMV to rear of TWMV	0.0
237	OMV	HGV occupant	All	0.0
238	OMV	LPV occupant	All	0.0
239	OMV	Minibus occupant	All	0.0
240	OMV	Agricultural occupant	All	0.0
241	Agricultural	Car occupant	Front of agricultural vehicle to rear of car	0.0
242	Agricultural	Car occupant	Rear to rear	0.0
243	Agricultural	Car occupant	Side of car to rear of agricultural vehicle	0.0
244	Agricultural	Car occupant	Side of agricultural vehicle to rear of car	0.0
245	Agricultural	TWMV rider	Front of agricultural vehicle to rear of TWMV	0.0
246	Agricultural	TWMV rider	Rear to rear	0.0
247	Agricultural	TWMV rider	Side of TWMV to rear of agricultural vehicle	0.0
248	Agricultural	TWMV rider	Side of agricultural vehicle to rear of TWMV	0.0
249	Agricultural	HGV occupant	All	0.0
250	Agricultural	LPV occupant	All	0.0
251	Agricultural	Minibus occupant	All	0.0
252	Agricultural	OMV occupant	All	0.0
253	Minibus	VOI occupant	Impact with object on carriageway	0.0

Table 29. Ranking of casualty groups by number of serious casualties (2006-2008).

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of serious casualties
1	HGV	Car occupant	All	501.3
2	LCV	VOI occupant	All	450.0
3	LPV	VOI occupant	All	425.3
4	LCV	Car occupant	All	407.0
5	LPV	Pedestrian	All	334.7
6	LCV	Pedestrian	All	303.7
7	HGV	VOI occupant	All	290.7
8	LPV	VOI occupant	No impact	281.3
9	LCV	VOI occupant	Impact with other vehicle	280.7
10	LPV	VOI occupant	Single vehicle	275.7
11	LCV	TWMV rider	All	241.0
12	LPV	Pedestrian	Front of LPV	183.3
13	LCV	VOI occupant	Impact with car	165.3
14	LCV	Car occupant	Front to front	164.0
15	LCV	VOI occupant	Impact with object off carriageway	157.7
16	HGV	Car occupant	Front to front	151.7
17	HGV	Pedestrian	All	151.3
18	LCV	Pedestrian	Front of LCV	151.3
19	HGV	VOI occupant	Impact with other vehicle	135.3
20	OMV	VOI occupant	All	135.0
21	LCV	VOI occupant	Single vehicle	127.0
22	LCV	Pedal cyclist	All	127.0
23	LPV	Car occupant	All	124.3
24	LPV	Pedestrian	Side of LPV	120.3
25	HGV	VOI occupant	Single vehicle	115.3
26	HGV	VOI occupant	Impact with object off carriageway	112.3
27	HGV	TWMV rider	All	110.7
28	HGV	VOI occupant	Rollover	106.0
29	LCV	Pedestrian	Side of LCV	90.0
30	HGV	Car occupant	Front of car to rear of HGV	86.7
31	LCV	TWMV rider	Front of TWMV to side of LCV	86.7
32	LCV	VOI occupant	Rollover	83.7
33	OMV	VOI occupant	Impact with other vehicle	78.7
34	LPV	VOI occupant	Impact with other vehicle	77.7
35	LCV	Car occupant	Front of LCV to side of car	75.7
36	HGV	Pedal cyclist	All	72.0
37	HGV	VOI occupant	Impact with another HGV	70.7

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of serious casualties
38	OMV	Pedestrian	All	69.0
39	HGV	LCV occupant	All	65.7
40	HGV	Car occupant	Side to side	65.7
41	Minibus	VOI occupant	All	64.3
42	HGV	Car occupant	Front of HGV to rear of car	61.3
43	HGV	Pedestrian	Side of HGV	61.0
44	HGV	Car occupant	Front of HGV to side of car	60.7
45	HGV	Car occupant	Front of car to side of HGV	59.7
46	OMV	Car occupant	All	56.7
47	HGV	Pedestrian	Front of HGV	54.7
48	LPV	VOI occupant	Impact with object off carriageway	54.0
49	LPV	Car occupant	Front to front	53.0
50	OMV	VOI occupant	Impact with car	51.0
51	Agricultural	Car occupant	All	50.0
52	LPV	Pedal cyclist	All	49.7
53	LCV	Car occupant	Front of car to side of LCV	48.0
54	HGV	VOI occupant	Impact with car	45.7
55	LCV	Car occupant	Front of car to rear of LCV	45.3
56	LCV	Pedestrian	Rear of LCV	44.3
57	LCV	VOI occupant	Impact with object on carriageway	41.0
58	LCV	TWMV rider	Side to side	40.7
59	OMV	VOI occupant	Single vehicle	39.3
60	LCV	Car occupant	Front of LCV to rear of car	39.0
61	LCV	TWMV rider	Front to front	37.7
62	Minibus	Car occupant	All	37.7
63	LCV	Pedal cyclist	Front of pedal cycle to side of LCV	37.7
64	LPV	TWMV rider	All	37.3
65	LCV	TWMV rider	Front of TWMV to rear of LCV	37.0
66	OMV	TWMV rider	All	36.7
67	Minibus	VOI occupant	Impact with other vehicle	36.7
68	OMV	Pedestrian	Front of OMV	33.0
69	OMV	VOI occupant	Impact with object off carriageway	33.0
70	HGV	TWMV rider	Front of TWMV to side of HGV	31.0
71	Agricultural	TWMV rider	All	31.0
72	HGV	VOI occupant	Impact with object on carriageway	30.3
73	HGV	Pedal cyclist	Side to side	30.0
74	OMV	VOI occupant	Rollover	27.3
75	LCV	Pedal cyclist	Side to side	26.0
76	Minibus	Pedestrian	All	25.3

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of serious casualties
77	LCV	Car occupant	Side to side	25.3
78	LCV	TWMV rider	Front of LCV to side of TWMV	25.3
79	Minibus	VOI occupant	Impact with car	25.0
80	LPV	Car occupant	Front of LPV to side of car	24.0
81	Minibus	VOI occupant	Impact with object off carriageway	21.7
82	HGV	TWMV rider	Front to front	21.3
83	HGV	LCV occupant	Front of LCV to rear of HGV	21.0
84	HGV	TWMV rider	Front of TWMV to rear of HGV	21.0
85	Minibus	VOI occupant	Single vehicle	21.0
86	LCV	Pedal cyclist	Front of LCV to side of pedal cycle	20.7
87	HGV	Pedestrian	Rear of HGV	20.0
88	OMV	Pedestrian	Side of OMV	20.0
89	OMV	Car occupant	Front to front	19.7
90	LPV	VOI occupant	Rollover	19.0
91	OMV	Pedal cyclist	All	19.0
92	LPV	Car occupant	Front of car to side of LPV	18.7
93	Agricultural	VOI occupant	All	18.0
94	LCV	Pedal cyclist	Front to front	18.0
95	HGV	TWMV rider	Side to side	17.7
96	Minibus	Car occupant	Front to front	17.7
97	LPV	VOI occupant	Impact with object on carriageway	17.3
98	HGV	VOI occupant	No impact	16.7
99	HGV	LCV occupant	Front to front	15.7
100	LPV	Pedal cyclist	Side to side	15.7
101	HGV	Pedal cyclist	Front of pedal cycle to side of HGV	14.7
102	OMV	TWMV rider	Front of TWMV to side of OMV	14.0
103	Minibus	Pedestrian	Front of minibus	13.0
104	Agricultural	Car occupant	Front of car to side of agricultural vehicle	13.0
105	LCV	VOI occupant	No impact	13.0
106	Agricultural	Car occupant	Front to front	13.0
107	OMV	VOI occupant	Impact with object on carriageway	13.0
108	Minibus	VOI occupant	Rollover	13.0
109	Agricultural	TWMV rider	Front of TWMV to side of agricultural vehicle	12.7
110	Minibus	TWMV rider	All	12.0
111	Agricultural	VOI occupant	Impact with other vehicle	12.0
112	LPV	TWMV rider	Front of TWMV to side of LPV	11.3
113	OMV	Car occupant	Front of OMV to side of car	11.3
114	LPV	Pedal cyclist	Front of pedal cycle to side of LPV	11.0
115	LCV	HGV occupant	All	11.0

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of serious casualties
116	LPV	Car occupant	Front of car to rear of LPV	10.7
117	HGV	LCV occupant	Front of HGV to rear of LCV	10.0
118	LPV	TWMV rider	Front to front	9.7
119	OMV	VOI occupant	No impact	9.7
120	Minibus	Pedestrian	Side of minibus	9.7
121	OMV	Car occupant	Front of car to rear of OMV	9.7
122	Agricultural	Car occupant	Front of car to rear of agricultural vehicle	9.3
123	HGV	OMV occupant	All	9.0
124	OMV	VOI occupant	Impact with HGV	9.0
125	LCV	Pedal cyclist	Front of pedal cycle to rear of LCV	9.0
126	LPV	Car occupant	Side to side	8.7
127	LCV	Pedal cyclist	Front of LCV to rear of pedal cycle	7.7
128	LPV	Car occupant	Front of LPV to rear of car	7.7
129	HGV	LPV occupant	All	7.7
130	HGV	LCV occupant	Front of LCV to side of HGV	7.7
131	Agricultural	Car occupant	Side to side	7.7
132	HGV	Pedal cyclist	Front of HGV to side of pedal cycle	7.3
133	OMV	Pedestrian	Rear of OMV	7.3
134	LPV	TWMV rider	Side to side	7.0
135	HGV	TWMV rider	Front of HGV to side of TWMV	6.7
136	LPV	Pedal cyclist	Front of LPV to side of pedal cycle	6.7
137	LPV	LCV occupant	All	6.7
138	HGV	Pedal cyclist	Front to front	6.7
139	OMV	Car occupant	Front of car to side of OMV	6.7
140	LPV	Pedal cyclist	Front to front	6.3
141	OMV	TWMV rider	Front of TWMV to rear of OMV	6.3
142	LCV	LPV occupant	All	6.3
143	OMV	TWMV rider	Front to front	6.0
144	Minibus	Car occupant	Front of minibus to side of car	6.0
145	Agricultural	Pedestrian	All	6.0
146	Minibus	VOI occupant	No impact	6.0
147	LCV	TWMV rider	Front	6.0
148	HGV	Minibus occupant	All	5.7
149	Agricultural	VOI occupant	Rollover	5.7
150	Minibus	VOI occupant	Impact with HGV	5.7
151	Agricultural	TWMV rider	Side to side	5.7
152	HGV	Pedal cyclist	Front of HGV to rear of pedal cycle	5.3
153	Agricultural	VOI occupant	Single vehicle	5.3
154	LPV	Pedestrian	Rear of LPV	5.3

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of serious casualties
155	Agricultural	TWMV rider	Front of TWMV to rear of agricultural vehicle	5.3
156	Agricultural	LCV occupant	All	5.3
157	LCV	Minibus occupant	All	5.3
158	Agricultural	TWMV rider	Front to front	5.0
159	HGV	TWMV rider	Front of HGV to rear of TWMV	5.0
160	HGV	Agricultural occupant	All	5.0
161	HGV	LCV occupant	Side to side	5.0
162	Agricultural	VOI occupant	Impact with object off carriageway	4.7
163	Minibus	Pedal cyclist	All	4.7
164	HGV	Car occupant	Side of car to rear of HGV	4.3
165	LPV	TWMV rider	Front of TWMV to rear of LPV	4.3
166	LCV	Car occupant	Side of car to rear of LCV	4.3
167	Agricultural	Car occupant	Front of agricultural vehicle to side of car	4.3
168	LPV	Pedal cyclist	Front of LPV to rear of pedal cycle	4.3
169	LCV	OMV occupant	All	4.3
170	Minibus	Car occupant	Front of car to rear of minibus	4.3
171	Minibus	VOI occupant	Impact with object on carriageway	4.3
172	HGV	LCV occupant	Front of HGV to side of LCV	4.0
173	Agricultural	Pedal cyclist	All	4.0
174	OMV	Car occupant	Side to side	4.0
175	HGV	Pedal cyclist	Front of pedal cycle to rear of HGV	3.7
176	LCV	Pedal cyclist	Side of LCV to rear of pedal cycle	3.7
177	OMV	TWMV rider	Side to side	3.7
178	LPV	Pedal cyclist	Front of pedal cycle to rear of LPV	3.7
179	Minibus	Car occupant	Front of car to side of minibus	3.7
180	Agricultural	HGV occupant	All	3.7
181	HGV	TWMV rider	Side of TWMV to rear of HGV	3.3
182	LCV	TWMV rider	Side of TWMV to rear of LCV	3.3
183	OMV	Car occupant	Front of OMV to rear of car	3.3
184	HGV	Car occupant	Side of HGV to rear of car	3.0
185	LPV	OMV occupant	All	3.0
186	Minibus	Car occupant	Front of minibus to rear of car	3.0
187	OMV	TWMV rider	Front of OMV to side of TWMV	2.0
188	HGV	Pedal cyclist	Side of HGV to rear of pedal cycle	2.0
189	OMV	LCV occupant	All	2.0
190	LPV	HGV occupant	All	2.0
191	Agricultural	VOI occupant	No impact	1.7
192	LPV	TWMV rider	Front of LPV to side of TWMV	1.7
193	LCV	Car occupant	Rear to rear	1.7

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of serious casualties
194	Minibus	Car occupant	Side to side	1.7
195	LPV	TWMV rider	Front of LPV to rear of TWMV	1.7
196	LCV	Pedal cyclist	Side of pedal cycle to rear of LCV	1.7
197	OMV	TWMV rider	Front of OMV to rear of TWMV	1.7
198	HGV	Car occupant	Rear to rear	1.3
199	Minibus	Pedestrian	Rear of minibus	1.3
200	HGV	LCV occupant	Rear to rear	1.3
201	Agricultural	TWMV rider	Front of agricultural vehicle to side of TWMV	1.0
202	HGV	TWMV rider	Rear to rear	1.0
203	HGV	TWMV rider	Side of HGV to rear of TWMV	1.0
204	LCV	Car occupant	Side of LCV to rear of car	1.0
205	LCV	Agricultural occupant	All	1.0
206	Minibus	LCV occupant	All	1.0
207	OMV	Car occupant	Side of car to rear of OMV	1.0
208	OMV	HGV occupant	All	1.0
209	Agricultural	Car occupant	Front of agricultural vehicle to rear of car	1.0
210	Agricultural	VOI occupant	Impact with object on carriageway	0.7
211	LPV	Car occupant	Rear to rear	0.7
212	LCV	TWMV rider	Side of LCV to rear of TWMV	0.7
213	OMV	TWMV rider	Side of TWMV to rear of OMV	0.7
214	Agricultural	Car occupant	Side of car to rear of agricultural vehicle	0.7
215	HGV	Pedal cyclist	Rear to rear	0.3
216	LPV	Pedal cyclist	Side of LPV to rear of pedal cycle	0.3
217	OMV	Car occupant	Rear to rear	0.3
218	HGV	LCV occupant	Side of LCV to rear of HGV	0.3
219	LPV	Car occupant	Side of car to rear of LPV	0.3
220	LPV	TWMV rider	Side of LPV to rear of TWMV	0.3
221	LPV	Pedal cyclist	Side of pedal cycle to rear of LPV	0.3
222	LPV	Agricultural occupant	All	0.3
223	LCV	TWMV rider	Rear to rear	0.3
224	LCV	Pedal cyclist	Rear to rear	0.3
225	Minibus	LPV occupant	All	0.3
226	OMV	LPV occupant	All	0.3
227	Agricultural	Car occupant	Rear to rear	0.3
228	Agricultural	TWMV rider	Rear to rear	0.3
229	Agricultural	Minibus occupant	All	0.3
230	Agricultural	OMV occupant	All	0.3
231	LPV	Minibus occupant	All	0.0
232	Minibus	HGV occupant	All	0.0

Rank	Vehicle of interest	Casualty type	Impact configuration	Annual average number of serious casualties
233	HGV	Pedal cyclist	Side of pedal cycle to rear of HGV	0.0
234	HGV	LCV occupant	Side of HGV to rear of LCV	0.0
235	LPV	Car occupant	Side of LPV to rear of car	0.0
236	LPV	TWMV rider	Rear to rear	0.0
237	LPV	TWMV rider	Side of TWMV to rear of LPV	0.0
238	LPV	Pedal cyclist	Rear to rear	0.0
239	Minibus	Car occupant	Rear to rear	0.0
240	Minibus	Car occupant	Side of car to rear of minibus	0.0
241	Minibus	Car occupant	Side of minibus to rear of car	0.0
242	Minibus	OMV occupant	All	0.0
243	Minibus	Agricultural occupant	All	0.0
244	OMV	Car occupant	Side of OMV to rear of car	0.0
245	OMV	TWMV rider	Rear to rear	0.0
246	OMV	TWMV rider	Side of OMV to rear of TWMV	0.0
247	OMV	Minibus occupant	All	0.0
248	OMV	Agricultural occupant	All	0.0
249	Agricultural	Car occupant	Side of agricultural vehicle to rear of car	0.0
250	Agricultural	TWMV rider	Front of agricultural vehicle to rear of TWMV	0.0
251	Agricultural	TWMV rider	Side of TWMV to rear of agricultural vehicle	0.0
252	Agricultural	TWMV rider	Side of agricultural vehicle to rear of TWMV	0.0
253	Agricultural	LPV occupant	All	0.0

Appendix B Top 100 casualty groups – change in rank position between 2003-2005 and 2006-2008

Rank	1st impact of V1	Annual average KSI cost	Annual average fatalities	Annual average serious casualties	Ranking change
1	Car occupants in impacts with HGV – all impact configurations	£341,248,333	146.3	501.3	0
2	Car occupants in impacts with LCV – all impact configurations	£202,166,867	74.3	407.0	0
3	LCV occupants – all impact configurations	£171,013,800	51.0	450.0	0
4	Pedestrians in impacts with HGVs – all sides	£149,865,867	72.0	151.3	0
5	Pedestrians in impacts with LPVs – all sides	£142,457,533	47.0	334.7	0
6	Pedestrians in impacts with LCVs – all sides	£125,367,000	40.3	303.7	2
7	HGV occupants – all impact configurations	£118,978,533	38.0	290.7	-1
8	Car occupants in impacts with HGV – front to front	£117,936,733	53.0	151.7	-1
9	LPV occupants – all impact configurations	£101,239,933	12.3	425.3	1
10	LCV occupants - impacts with other vehicles	£96,880,933	26.0	280.7	-1
11	Riders of TWMV[30] in impacts with LCVs – all impact configurations	£96,111,200	30.0	241.0	2
12	Pedestrians in impacts with front of HGVs	£94,532,933	50.0	54.7	0
13	Pedestrians in impacts with front of LPVs	£92,497,133	34.3	183.3	1
14	Car occupants in impacts with LCV – front to front	£83,226,600	31.0	164.0	-3
15	Riders of TWMV[30] in impacts with HGVs – all impact configurations	£77,626,067	33.7	110.7	2
16	LCV occupants - impact with object off carriageway	£73,609,333	26.0	157.7	-1
17	Pedestrians in impacts with front of LCVs	£70,166,000	24.7	151.3	1
18	LPV occupants in accidents involving no external impact	£67,821,200	8.7	281.3	4
19	LPV occupants in single vehicle accidents	£67,310,333	9.0	275.7	5
20	Car occupants in impacts with LPV – all impact configurations	£65,057,600	24.7	124.3	1
21	LCV occupants in single vehicle accidents	£59,388,200	21.0	127.0	-1
22	Pedal cyclists in impacts with HGV – all impact configurations	£59,085,000	27.0	72.0	8
23	Car occupants in impacts with LCV – front of LCV and side of car	£58,656,200	26.3	75.7	2
24	Car occupants in impacts with HGV – front of car to rear of HGV	£57,931,067	24.7	86.7	2
25	Car occupants in impacts with HGV – front of HGV to side of car	£57,502,000	27.3	60.7	-9
26	OMV occupants – all impact configurations	£56,972,933	18.7	135.0	9

[30] TWMV – Two wheeled motor vehicle

Rank	1st impact of V1	Annual average KSI cost	Annual average fatalities	Annual average serious casualties	Ranking change
27	HGV occupants in impacts with other vehicles	£51,984,600	15.7	135.3	-8
28	HGV occupants – impact with object off carriageway	£47,633,000	15.7	112.3	-5
29	LCV occupants in impacts with cars	£47,557,800	9.7	165.3	-2
30	HGV occupants in single vehicle accidents	£44,833,000	13.7	115.3	-2
31	Car occupants in impacts with HGV – front of HGV to rear of car	£43,035,200	18.7	61.3	5
32	LCV occupants – rollover	£42,770,533	16.0	83.7	1
33	Pedestrians in impacts with side of LPVs	£40,166,333	10.3	120.3	1
34	HGV occupants – rollover	£39,138,267	11.3	106.0	-3
35	Riders of TWMV[30] in impacts with LCVs – front of TWMV to side of LCV	£38,286,733	13.0	86.7	10
36	Pedal cyclists in impacts with LCV – all impact configurations	£38,060,067	8.3	127.0	4
37	Pedestrians in impacts with side of HGVs	£35,114,400	14.0	61.0	1
38	Car occupants in impacts with LPV – front to front	£34,723,333	14.7	53.0	3
39	LCV occupants in impacts with HGV – all impact configurations	£33,752,267	12.7	65.7	-7
40	OMV occupants in impacts with other vehicles – all impact configurations	£32,844,267	10.7	78.7	10
41	Car occupants in impacts with HGV – side to side	£32,629,733	12.0	65.7	1
42	Pedestrians in impacts with side of LCVs	£32,182,200	9.0	90.0	2
43	HGV occupants in impacts with HGVs	£31,891,933	11.0	70.7	-14
44	Pedestrians in impacts with OMVs – all sides	£25,963,933	7.7	69.0	10
45	Car occupants in impacts with HGV – front of car to side of HGV	£24,759,333	8.0	59.7	-6
46	Car occupants in impacts with Agricultural vehicles – all impact configurations	£22,930,400	8.0	50.0	2
47	Minibus occupants - all impact configurations	£22,274,667	6.0	64.3	-10
48	Riders of TWMV in impacts with HGVs – front of TWMV to side of HGV	£22,141,933	9.7	31.0	-1
49	Pedal cyclists in impacts with LCV – side to side	£21,952,733	9.7	30.0	21
50	Riders of TWMV in impacts with LCVs – front to front	£21,719,467	8.7	37.7	-7
51	Riders of TWMV in impacts with LPVs – all impact configurations	£21,095,133	8.3	37.3	4
52	Riders of TWMV in impacts with HGVs – front to front	£20,874,267	10.0	21.3	-3
53	Car occupants in impacts with OMVs – all impact configurations	£20,824,133	6.0	56.7	-7

Rank	1st impact of V1	Annual average KSI cost	Annual average fatalities	Annual average serious casualties	Ranking change
54	Riders of TWMV in impacts with Agricultural vehicles – all impact configurations	£19,896,867	8.3	31.0	15
55	OMV occupants in impacts with cars – all impact configurations	£19,752,000	6.0	51.0	12
56	Pedestrians in impacts with rear of LCVs	£18,490,667	6.0	44.3	0
57	LPV occupants in impacts with other vehicles – all impact configurations	£18,062,133	2.0	77.7	-6
58	Pedal cyclists in impacts with LPVs – all impact configurations	£17,815,933	5.0	49.7	5
59	Car occupants in impacts with LCVs – front of car to rear of LCV	£17,557,333	5.3	45.3	6
60	OMV occupants in single vehicle accidents	£16,983,400	5.7	39.3	6
61	Riders of TWMV in impacts with OMVs – all impact configurations	£16,478,867	5.7	36.7	16
62	Car occupants in impacts with minibuses - all impact configurations	£15,545,533	5.0	37.7	-9
63	OMV occupants - rollover	£15,274,267	6.0	27.3	16
64	Car occupants in impacts with LPVs - front of LPV to side of car	£15,204,867	6.3	24.0	-3
65	LCV occupants in impacts with object on the carriageway	£15,053,667	4.3	41.0	-8
66	HGV occupants in impacts with object on the carriageway	£14,719,333	5.3	30.3	-7
67	HGV occupants in impacts with cars – all impact configurations	£14,252,800	3.3	45.7	-9
68	Pedestrians in impacts with front of OMVs	£14,101,333	4.7	33.0	8
69	Car occupants in impacts with LCVs – front of car to side of LCV	£13,571,733	2.7	48.0	-5
70	Minibus occupants in impacts with other vehicles – all impact configurations	£13,111,267	3.7	36.7	-18
71	LPV occupants in impacts with objects off the carriageway	£13,023,133	1.7	54.0	16
72	OMV occupants in impacts with objects off the carriageway	£12,978,800	4.0	33.0	10
73	Riders of TWMV in impacts with HGVs – side to side	£12,884,067	5.7	17.7	8
74	Pedal cyclists in impacts with HGVs – front of pedal cycle to side of HGV	£12,877,733	6.0	14.7	24
75	Riders of TWMV in impacts with LCVs – front of TWMV to rear of LCV	£12,613,067	3.3	37.0	-7
76	Car occupants in impacts with LCVs – front of LCV to rear of car	£12,430,200	3.0	39.0	-14
77	Pedestrians in impacts with minibuses – all sides	£12,089,533	4.3	25.3	13
78	Pedestrians in impacts with the rear of HGVs	£11,641,733	4.7	20.0	8

Rank	1st impact of V1	Annual average KSI cost	Annual average fatalities	Annual average serious casualties	Ranking change
79	Riders of TWMV in impacts with LCVs – side to side	£11,623,000	2.3	40.7	1
80	Riders of TWMV in impacts with agricultural vehicles – front of TWMV to side of agricultural vehicle	£11,376,800	5.3	12.7	17
81	LCV occupants in impacts with HGVs - front of LCV to rear of HGV	£11,269,667	4.3	21.0	-6
82	Riders of TWMV in impacts with HGVs – front of TWMV to rear of HGV	£10,708,400	4.0	21.0	2
83	Car occupants in impacts with LCVs – side to side	£10,405,733	3.3	25.3	5
84	LCV occupants in impacts with HGVs – front to front	£10,260,600	4.3	15.7	-24
85	Car occupants in impacts with OMVs – front to front	£9,894,867	3.7	19.7	-7
86	Pedal cyclists in impacts with HGVs - front of HGV to side of pedal cycle	£9,245,200	4.7	7.3	14
87	Agricultural vehicle occupants – all impact configurations	£8,457,000	3.0	18.0	-15
88	Pedal cyclists in impacts with LCVs - front of pedal cycle to side of LCV	£8,249,067	0.7	37.7	3
89	Car occupants in impacts with minibuses – front to front	£7,832,667	2.7	17.7	0
90	Riders of TWMV in impacts with LPV - front of TWMV to side of LPV	£7,756,933	3.3	11.3	17
91	Pedal cyclists in impacts with HGVs - front of HGV to rear of pedal cycle	£7,744,267	4.0	5.3	-6
92	Pedal cyclists in impacts with LCVs - side to side	£7,725,533	1.7	26.0	13
93	Riders of TWMV in impacts with LCV - front of LCV to side of TWMV	£7,599,400	1.7	25.3	18
94	Pedestrians in impacts with front of minibuses	£7,511,000	3.0	13.0	n/a
95	Riders of TWMV in impacts with LPV - front to front	£7,441,600	3.3	9.7	4
96	Pedestrians in impacts with the side of OMVs	£7,151,600	2.0	20.0	19
97	HGV occupants in accidents where there was no external impact	£7,082,200	2.3	16.7	16
98	Minibus occupants in impacts with cars – all impact configurations	£6,975,067	1.3	25.0	-27
99	Car occupants in impacts with agricultural vehicles - front of car to side of agricultural vehicle	£6,949,733	2.7	13.0	2
100	LCV occupants in accidents where there was no external impact	£6,949,733	2.7	13.0	18

Appendix C Countermeasure definitions

The following Appendix contains descriptions of all the countermeasures that are mentioned in this report. Smith *et al* (2007) contains a full list of countermeasures.

1a. Front underrun protection (FUP) - *Front VOI to front of car*

Description	When the front of a car collides with the front of an HGV, the energy absorbing structures of the car need to interact with the structure of the HGV in order for the car to absorb the energy of the crash. The structure of an HGV is typically higher from the ground than a car which can result in the structure of the car passing under the front of the HGV. This is referred to as 'underrun' and in extreme cases the A-pillars of the car interact with the front structure of the HGV. Recent legislation requires new HGVs to be fitted with FUP which is intended to provide a structure against which the car can interact and absorb energy. Many vehicles on the road are not fitted with FUP and some new vehicles are exempt from the legislation. Although intended for head on collisions, there may be additional benefits in accidents of other impact configurations. For example, when an HGV collides with the rear of a car, the HGV can override the rear of the car, FUP may reduce the amount by which the car is overridden. Similarly, if an HGV collides with the side of a car, the HGV can override the chassis of the car causing massive intrusion of the passenger compartment. It is considered that this measure will mostly provide benefit to non-struck side occupants.
Vehicle type that could be fitted to (VOI)	HGV, LPV, OMV, Agricultural
Target casualty group	Car occupants
Likely year of introduction	pre 2012
Barrier to introduction	Market penetration
Cost per vehicle	£50 to £100 (http://www.monash.edu.au/muarc/reports/muarc205.html)

2a. Energy absorbing FUP - *Front VOI to front of car*

Description	The energy absorbing FUP will absorb more energy from the collision than a standard FUP. This will enable the car occupants to be protected at higher impact speeds. The FUP will be fitted in the same location as the current FUP and will absorb energy over a distance of 400mm. This also has potential to offer protection where the VOI is already fitted with FUP or where underrun did not occur
Vehicle type that could be fitted to (VOI)	HGV, LPV, OMV, Agricultural
Target casualty group	Car occupants

Likely year of introduction	Pre 2012
Barrier to introduction	Proof of effectiveness
Cost per vehicle	£70 to £140 (for 'advanced FUP' - Improvement of Vehicle Crash Compatibility through the Development of Crash Test procedures (VC-COMPAT))

3a. Extended energy absorbing FUP - *Front VOI to front of car*

Description	The extended energy absorbing FUP will absorb more energy from the collision than a standard energy absorbing FUP. This will enable the car occupants to be protected at higher impact speeds. This concept adds 800mm to the front of the vehicle in order to absorb more impact energy. When combined with the energy absorbing FUP this provides 1,000mm energy absorbing material. This also has potential to offer protection where the VOI is already fitted with FUP or where underrun did not occur
Vehicle type that could be fitted to (VOI)	HGV, LPV, OMV, Agricultural
Target casualty group	Car occupants
Likely year of introduction	pre 2012
Barrier to introduction	Proof of effectiveness Maximum weights & Dimensions Test procedures
Cost per Vehicle	Set at £90 to £160 because it is slightly more expensive than energy absorbing

4. Current rear underrun protection (RUP)

Description	When the front of a car collides with the front of an HGV, the energy absorbing structures of the car need to interact with the structure of the HGV in order for the car to absorb the energy of the crash. The structure of an HGV is typically higher from the ground than a car which can result in the structure of the car passing under the rear of the HGV. This is referred to as 'rear underrun' and in extreme cases the A-pillars of the car interact with the rear structure of the HGV. Some HGVs are exempt from the requirements to fit under run protection. RUP could also be fitted to other vehicle types where cars underrun the vehicle structure.
Vehicle type that could be fitted to (VOI)	HGV, LPV, OMV, Agricultural
Target casualty group	Car occupants

Likely year of introduction	pre 2012
Barrier to introduction	Exemptions
Cost per vehicle	£18-£9131 (€20-€100, VC-Compat newsletter, issue nr 2, June 2006)

5. Improved rigid RUP

Description	Current designs of RUP have been criticised for insufficient strength and also for having excessive ground clearances that mean the guard does not fully engage the energy absorbing frontal structure of a car. Improved RUP addresses these issues based on recommendations from research carried out as part of the EC VC-Compat project and subsequent research for the EC (Smith, 2008). Improved RUP has a lower ground clearance, increased height of the cross member and are subject to static loading of 300kN distributed along the cross member.
Vehicle type that could be fitted to (VOI)	HGV, LPV, OMV, Agricultural
Target casualty group	Car occupants
Likely year of introduction	pre 2012
Barrier to introduction	Currently under investigation Test procedures Concern over operational constraints and ground clearance
Cost per Vehicle	£90-£4,182[31] (€100 - €4,600 depending on complexity of design, although majority of vehicles would not require the most expensive RUP). Note that this range is reflecting that implementation is complex for some vehicles. It is not suggesting that the average cost across all vehicles could be as much as £4k. Given that most vehicles e.g. semi-trailers are simple then the average would be much closer to the bottom end of range. For example, assuming 20% of vehicles require a folding design and 5% a sliding design gives an average cost of €557 Therefore apply cost range £90- £500 in addition to current RUP.

6. Energy absorbing RUP

Description	It will be assumed that these rear guards will be strong enough not to break away from their mountings and low enough to prevent car underrun. In addition to this, these guards will have the capability to absorb a higher proportion of the crash energy than current or improved rear guards (based on energy absorbing capability of energy absorbing front underrun protection).

[31] Assume exchange rate £1 = 1.1€

Vehicle type that could be fitted to (VOI)	HGV, LPV, OMV, Agricultural
Target casualty group	Car occupants
Likely year of introduction	2013-2018
Barrier to introduction	Cost, Ground clearance Test procedures
Cost per Vehicle	£300 - £350 slightly more than non energy absorbing

13. Improve LCV/Minibus to car compatibility

Description	Improve the crashworthiness compatibility between cars and LCVs or minibuses in head on collisions to allow the crash structure of the car to be engaged during the impact.
Vehicle type that could be fitted to (VOI)	LCV, Minibus
Target casualty group	Car occupants
Likely year of introduction	2013-2018
Barrier to introduction	
Cost per Vehicle	£250

19. Improve side impact crashworthiness

Description	Improving side impact crashworthiness increases the energy dissipated by the side of the VOI reducing the severity to the occupant of the VOI.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	VOI occupants
Likely year of introduction	Pre 2012
Barrier to introduction	
Cost per Vehicle	£500

27. Seatbelt enforcement

Description	There are two main benefits to be derived from wearing a seatbelt: • Prevention of ejection during a rollover, and • Prevention of ejection or reduced peak deceleration and/or risk of contact with the steering wheel or other internal structures during a frontal collision

Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural Agricultural vehicles
Target casualty group	VOI occupants
Likely year of introduction	Pre 2012
Barrier to introduction	
Cost per Vehicle	The cost of employing an extra 1,000 traffic police officers at an average salary of £23k per year is £23 million. There are approximately 600,000 new registrations per year of HGVs, LPVs, OMVs, Minibuses, LCVs and agricultural vehicles. This gives the estimated cost per vehicle as ~£40.

29. Fit and use 3-point belt

Description	A 3-point seat belt will reduce the amount of upper body movement allowed during an impact or rollover. This is the main advantage over just a lap belt where the occupant's upper body remains unrestrained. A 3- point seat belt therefore reduces the risk of the occupant contacting with the intruding cabin during a collision.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	VOI occupants
Likely year of introduction	Pre 2012
Barrier to introduction	
Cost per Vehicle	£30 http://wescoperformance.stores.yahoo.net/resebe.html

32. Front airbag

Description	Airbags act as a supplementary restraint system in addition to seatbelts. Frontal airbags have the potential to reduce injury to occupants involved in frontal crashes.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	VOI occupants
Likely year of introduction	Pre 2012
Barrier to introduction	
Cost per vehicle	£100 (£250 ($500 http://en.wikipedia.org/wiki/Airbag#Costs))

38. Pedestrian directive to all vehicle types

Description	Clever design and use of particular materials on the front structure of cars can reduce the severity of the injuries sustained by pedestrians when involved in an impact with the front of a vehicle. In theory it should be possible to do the same for the VOI. In the scenario of the VOI, the kinematics of the pedestrian after impact is very different to a car. The pedestrian's whole body will absorb the energy from the initial impact, as opposed to the lower leg. As a result the pedestrian is more likely to be run over.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	Pedestrians
Likely year of introduction	2013-2018
Barrier to introduction	
Cost per Vehicle	£500

39. Energy absorbing front (for pedestrians)

Description	Fitting an energy absorbing front to the VOI will increase the distance over which the pedestrian can be decelerated allowing the pedestrians to be protected at higher impact speeds than specified in the pedestrian directive. This measure is only effective where the pedestrian was not run over.
Vehicle type that could be fitted to (VOI)	HGV, LPV, OMV, Agricultural
Target casualty group	Pedestrians
Likely year of introduction	2013-2018
Barrier to introduction	
Cost per Vehicle	£500

40. Prevent run over from front of vehicle – reduced ground clearance

Description	When a pedestrian is struck by a VOI, the flat front design of the vehicles front end means that the pedestrian is typically knocked over to the ground. There is, therefore, a risk that the pedestrian could subsequently be run over depending on the exact kinematics of the accident. By reducing the ground clearance at the front of the VOI the risk of being run over by the front axle should be reduced.
Vehicle type that could be fitted to (VOI)	HGV, LPV, OMV
Target casualty group	Pedestrians

Likely year of introduction	Pre 2012
Barrier to introduction	
Cost per Vehicle	£15-£70 (Cost Analysis: Current and Improved Truck and Trailer Underrun Protection VC-Compat Workshop Eindhoven, The Netherlands, Axel Malczyk, German Insurance Assoc., Accident Research October 18, 2006)

41. Prevent run over from front of vehicle – change kinematics (e.g. nosecone)

Description	When a pedestrian is struck by a VOI, the flat front design of the vehicles front end means that the pedestrian is typically knocked over to the ground. There is, therefore, a risk that the pedestrian could subsequently be run over depending on the exact kinematics of the accident. Adding a Pedestrian Front Over-run Protection System that changes the kinematics of the impact is intended to reduce the tendency for the pedestrian to be pushed down to the ground, increasing the likelihood that braking will commence before the pedestrian falls to the ground, reducing the chances of the pedestrian being run-over. It may also deflect the pedestrian away from the vehicle reducing the risk of the pedestrian being run over from other axles on the vehicle of interest, although it is possible that this action could displace the pedestrian into the path of other vehicles.
Vehicle type that could be fitted to (VOI)	HGV, LPV, OMV
Target casualty group	Pedestrians
Likely year of introduction	2013-2018
Barrier to introduction	
Cost per Vehicle	£50-100

48. Brake-assist (utilising maximum braking performance)

Description	Brake assist systems (BAS) are designed to improve the ability of a typical driver to exploit the maximum braking performance available to him in emergency situations. The system can detect when the driver intends emergency braking by measuring the speed with which the brake pedal is applied by the driver. The system then automatically increases the brake pressure to its maximum.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All
Likely year of introduction	Pre 2012 Pre 2010 (Cost-benefit assessment and prioritisation

	of vehicle safety technologies)
Barrier to introduction	
Cost per Vehicle	£500

55c. Extend scope of current driver hours to more vehicle types

Description	Current driver's hours regulations only apply to certain types of vehicle. This option considers extending the scope of the regulation to include all types of VOI.
Vehicle type that could be fitted to (VOI)	LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All
Likely year of introduction	Pre 2012
Barrier to introduction	
Cost per Vehicle	There are approximately 3 million LCVs (DfT vehicle licensing statistics). If it is assumed that the cost to the driver of each of these vehicles was £10 per day, the total cost to the LCV fleet would be approximately £7.8 billion. Dividing this by the number of new registrations gives the cost as ~£25,000 per new vehicle. OMV: £3,300 Agricultural: £64,000 For the other vehicle types a range of £3,300-£65,000 has been used.

56. Improved forward visibility

Description	One of the most common accident types involving pedestrians and HGVs is caused by the pedestrian crossing the road in front of an HGV as the driver starts to pull away, unaware that the pedestrian is there and running them over. An improvement in the driver ability to see directly ahead at close proximity to his vehicle would reduce the possibility of this type of accident occurring. Accidents also occur when cars or motorcycles are in a blind-spot to the front offside of left-hand drive vehicles where the vehicle is trying to change lane to right. Also relevant to domestic vehicles changing lane to left.
Vehicle type that could be fitted to (VOI)	HGV, OMV
Target casualty group	Pedestrians, Pedal cyclists, Motorcyclists, Car occupants
Likely year of introduction	Pre 2012
Barrier to introduction	
Cost per vehicle (exc VAT)	£70 - 140 (Cost benefit assessment and prioritisation of vehicle safety technologies)

57. Improved side visibility

Description	A common accident mechanism reported is the HGV driver failing to see a cyclist or pedestrian along their nearside as they turn left at a junction. Improved visibility to the side via larger windows or improved window design could give the driver an improved chance of avoiding a collision. Improving mirrors could also provide benefits. There is also a risk of accidents when the large vehicle changes lanes, when other vehicles may be in the blind-spots. Improved vehicle design and mirrors could reduce the risk of accidents.
Vehicle type that could be fitted to (VOI)	HGV, LPV, OMV, Agricultural
Target casualty group	Pedestrians, Pedal cyclists, Motorcyclists, Car occupants
Likely year of introduction	Pre 2012
Barrier to introduction	
Cost per vehicle (exc VAT)	£100 (Cost benefit assessment and prioritisation of vehicle safety technologies)

58. Improved rear visibility

Description	The view to the immediate rear of all large vehicles is obscured to their drivers. In the case of agricultural vehicles visibility will be affected by the size and shape of the cab and any equipment fitted to, or trailers towed at, the rear of the vehicle.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	Any
Likely year of introduction	Pre 2012
Barrier to introduction	
Cost per vehicle (exc. VAT)	£70 - 140 (Cost benefit assessment and prioritisation of vehicle safety technologies)

65. Mobile phone interlock

Description	It is well documented that driving whilst using a mobile phone affects the safety of the driver and everyone else on the roads. Parkes, *et al* state 'certain aspects of driving performance are impaired more by using a phone that having a blood alcohol level at the legal limit'. A system to ensure that drivers are barred from using their phone whilst the ignition is switched on would ensure that the driver is not distracted by a call whilst driving his vehicle.
Vehicle type that could	HGV, LCV, LPV, Minibus, OMV, Agricultural

be fitted to (VOI)	
Target casualty group	All
Likely year of introduction	Post 2019
Barrier to introduction	Technology
Cost per Vehicle	£1000

66. Lane departure warning (LDW)

Description	In some cases, accidents are caused by vehicles drifting across lanes into the path of other vehicles. If such a vehicle was fitted with a sensor to indicate when it is about to move out of its own lane, then the driver could be alerted to their inattention and could regain control of their vehicle before an accident occurred.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All
Likely year of introduction	Mandatory for M2/M3 N2/N3 from 2013 (although some exemptions likely)
Barrier to introduction	
Cost per vehicle	£200 (Cost benefit assessment and prioritisation of vehicle safety technologies)£270, reducing to £180 in 2020 €200-€448 (Visvikis et al, 2008) £180- £410

67. Lane following

Description	In some cases, accidents are caused by vehicles drifting across lanes into the path of other vehicles. If a system is fitted to such a vehicle to ensure that it follows the lane in which it is driving, the number of accidents could be reduced. The system should prevent all accidents except where if the vehicle remains in its lane it would have another type of accident.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All
Likely year of introduction	2013-2018
Barrier to introduction	
Cost per vehicle	£200

70. Segregate vehicle types by in cab information systems

Description	It may be that vehicles can be restricted to certain roads or travelling at certain times of day depending on their vehicle type. In-cab information systems could be used to plan routes to avoid certain roads at certain times of day
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All
Likely year of introduction	post 2019
Barrier to introduction	Technology
Cost per Vehicle	£200-1000

76. De-restrict speed of agricultural vehicles

Description	The slow moving nature of agricultural vehicles can contribute to the cause of some accidents where a vehicle behind fail to appreciate the speed differential or drivers become aggressive and carry out inappropriate overtaking manoeuvres.
Vehicle type that could be fitted to (VOI)	Agricultural vehicles
Target casualty group	Any
Likely year of introduction	Pre 2012
Barrier to introduction	
Cost per Vehicle	£1

78. Improved driver training

Description	In some cases, accidents may be caused by a lack of awareness of a driver concerning the specifications of his vehicles, other vehicles, traffic regulations, speed limits, etc. Improved driver training would enable such drivers to be more aware of legislation affecting both his driving and his vehicle enabling him to be more alert to potentially dangerous situations.
Vehicle type that could be fitted to	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All
Likely year of introduction	Pre 2012
Barrier to introduction	
Cost per Vehicle	The cost of a 1-day training course per year is estimated at £100 per person. Assuming that the number of drivers is the same as the number of vehicles, the cost per year per

	number of new registrations is estimated as: • Agricultural: £2,500 • HGV: £712 • LPV: £4,300 • LCV: £945 • OMV: £127 • Minibus: £127-£4,300

79. Driver alertness monitoring

79a. Warning

Description	In the event of a driver losing alertness whilst driving a system would warn the driver. The alerts can be audible or tactile and are intended to make the driver aware of their loss of alertness. This system will cut down the number of accidents due to inattention by alerting the driver and enabling them to regain control before an accident occurs.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All
Likely year of introduction	Pre 2012 DAS (Driver Alert Support) introduced by Volvo 2008
Barrier to introduction	
Cost per vehicle	£700-1000

79b. Intervention – mitigation

Description	In the event of a driver losing alertness during driving this system applies the brakes of the vehicle to gradually reduce the speed of the vehicle. This will either bring the vehicle to rest or reduce the impact speed if an impact occurs. The system could incorporate activation of the hazard warning lights to reduce risk of other vehicles colliding with the vehicle once the system has activated.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All
Likely year of introduction	2013-2018
Barrier to introduction	Liabilities and unintended consequences
Cost per Vehicle	£700-2000

79c. Intervention – avoidance

Description	In the event of a driver losing alertness during driving a system will gradually reduce the speed of the vehicle and safely bring the vehicle to a halt. This can include steering the vehicle to a safe location. This is considered to be an aspirational system.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All
Likely year of introduction	>2018
Barrier to introduction	Liability, unintended consequences, technology
Cost per Vehicle	£1000-3000

80. Vulnerable road user (VRU) sensors

80a. Warning

Description	Accidents have occurred when the driver has been unaware of the presence of a VRU and has collided with them. This system will compensate for the blind spots in the drivers field of view by alerting them to the presence of any users in this area to reduce the accidents where the driver runs over them through not knowing they are there.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	Pedestrians, Pedal cyclists, Motorcyclists
Likely year of introduction	Post 2019
Barrier to introduction	
Cost per Vehicle	£800-£2000 Lane change assistance systems cost €200-€576 would require sensors on all four sides of vehicle.

80b. Intervention – mitigation

Description	This system will automatically apply the brakes if an inevitable collision with a VRU is detected (in a similar way to a collision mitigation braking system). If the vehicle is stationary and a VRU is detected, the brakes will be applied and the vehicle will not be permitted to move.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	Pedestrians, Pedal cyclists, Motorcyclists
Likely year of introduction	Post 2019
Barrier to introduction	

Cost per Vehicle	£2500-3000

80c. Intervention – avoidance

Description	Accidents have occurred when the driver has been unaware of the presence of a VRU and has collided with them. This system will prevent such accidents occurring by detecting the VRU and stopping the vehicle from colliding with them possibly by applying the brakes and steering. This is an aspirational system
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	Pedestrians, Pedal cyclists, Motorcyclists
Likely year of introduction	Post 2019
Barrier to introduction	Liability, unintended consequences, technology
Cost per Vehicle	£3000-3500

85. Rear collision system

Description	Some collisions occur when drivers fail to notice/react to a vehicle ahead that has slowed down, braked sharply or is stationary in the road. This system will aim to reduce the severity and the number of accidents that occur due to this mechanism by alerting the driver to the change in relative speed between the VOI and the vehicle ahead. The system would not detect pedestrians, pedal cyclists or motorcycles
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	VOI occupants, Car occupants
Likely year of introduction	Pre-2012 for warning systems and mitigation systems, 2013-2018 for avoidance (Cost-benefit assessment and prioritisation of vehicle safety technologies 2004).
Barrier to introduction	
Cost per Vehicle	Warning - £500 Intervention – mitigation - £2500-3000 Intervention – avoidance - £3000-3500

87. Inter-vehicle communication system

Description	A system that allows the VOI to track its position relative to other vehicles on the road could alert the driver to potential impacts with other vehicles. The system relies on sensors attached to the other vehicles and therefore excludes pedestrians and pedal cyclists.

Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All except pedestrians or pedal cyclists
Likely year of introduction	
Barrier to introduction	
Likely year of introduction	Post 2018
Barrier to introduction	
Cost per Vehicle	Fatality reduced to non-injury £1500

88. Safer vehicle front

Description	This countermeasure and would involve extending the length of the front of the vehicle to provide a bonnet to protect the VOI occupants through greater ride-down distance and offering VRU and other vehicle occupants better protection. It is essentially a combination of: • Extended energy absorbing front underrun protection; • Improved pedestrian kinematics; • Energy absorbing front for pedestrians; • Improved forward field of view; and • Improved frontal impact performance for VOI occupants
Vehicle type that could be fitted to (VOI)	HGV, LPV
Target casualty group	Pedestrians, pedal cyclists, car occupants in collision with the front of the vehicle of interest. Occupants of the vehicle of interest.
Likely year of introduction	2013-2018
Barrier to introduction	Vehicle length legislation
Cost per Vehicle	£1000

89. Faster response braking system

Description	Brake assist systems are designed to improve the ability of a typical driver to exploit the maximum braking performance available to him in emergency situations. The systems can detect when the driver intends emergency braking by measuring the speed at which the brake pedal is applied by the driver. The system then automatically increases the brake pressure to its maximum. Combining a brake assist system with electronically controlled brakes will improve the time to reach maximum

	deceleration compared to a vehicle equipped with pneumatic brakes
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All
Likely year of introduction	Pre 2012
Barrier to introduction	
Cost per Vehicle	£500

90. Forward collision system for VRU

Description	It has been shown that reducing the overall reaction times before an impact can significantly reduce the risk of an accident (Povel and Von Glasner, 2000). A forward collision warning system for VRUs would detect the risk of an impact with a pedestrian or pedal cyclist in front of the vehicle. The consequence of detecting a potential impact would either be a warning to the driver, intervention by applying the brakes or avoidance of the impact by braking and steering the vehicle.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	Pedestrians, Pedal cyclists
Likely year of introduction	Pre-2012 for warning systems and mitigation systems, 2013-2018 for avoidance (Cost-benefit assessment and prioritisation of vehicle safety technologies 2004).
Barrier to introduction	
Cost per Vehicle	Warning - £1,000 Intervention – mitigation - £2,250-2,750 Intervention – avoidance - £3,000-3,500

100. Head up displays (HUDs)

Description	Head-up displays (HUDs) project visual information to a position within the user's field of view so that the display is visible to the driver while they are looking at the road ahead. The systems consist of a projector, a combiner, which reflects the images from a projector while allowing the road ahead to be seen, and an electronic circuit which controls the display information and brightness. HUDs allow the driver to access visually displayed information in closer proximity to forward scene events than a conventional head-down (HD) instrument panel display.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All

Likely year of introduction	Currently fitted to higher specification cars (in particular as part of night vision systems) and expected to very slowly filter down to more mainstream models when costs reduce.
Barrier to introduction	Costs, consumer acceptance and possible unintended consequences (e.g. continues to cause its own distraction or affects particular groups of population e.g. older people)
Cost per Vehicle	Relatively high – often in conjunction with a night vision system.

101. Lane Change Assistant (LCA)

Description	Lane change assistance (LCA) systems warn the driver when it is unsafe to change lanes. The system will not take any direct action to prevent a possible collision; hence the driver remains responsible for the safe operation of the vehicle. They function by monitoring the area around the vehicle during a lane change manoeuvre and issuing a warning if certain criteria are met. These criteria usually relate to the proximity of other vehicles in the driver's intended lane of travel. Highly capable systems will warn the driver when another vehicle is adjacent to theirs, or when another vehicle is approaching from the rear. However, less capable systems may provide only one of these functions.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All except pedestrians
Likely year of introduction	For passenger cars 5-20% by 2010, 50-80% by 2020 (eSafety Forum), 0.6% by 2010 and 7% by 2020 (Abele et al, 2005) Currently available on passenger cars
Barrier to introduction	Appropriate legislation, driver acceptance
Cost per Vehicle	€200-€576 (Visvikis *et al*, 2008) **£180-£525**

102. Overtake Assistant

Description	Overtaking assistance systems inform the driver when it is unsafe to overtake. They will not take any direct action to prevent a possible collision; hence the driver remains responsible for the safe operation of the vehicle. Highly capable systems function by monitoring the preceding vehicle and any oncoming traffic. A warning is issued if certain criteria are met. For example, the criteria might relate to the time available before the arrival of an oncoming vehicle. Less capable systems inform the driver about sections of the road that are unsafe for overtaking, based on the geometry of the road and other attributes. The speed and dynamics of the subject vehicle may be taken into account, but preceding and oncoming vehicles are not monitored.
Vehicle type that could	HGV, LCV, LPV, Minibus, OMV, Agricultural

be fitted to (VOI)	
Target casualty group	All except (pedal cycles or) pedestrians
Likely year of introduction	Market penetration is currently very low, post 2019
Barrier to introduction	Needs further studies
Cost per Vehicle	No indication of cost in literature

103. Tyre Pressure monitoring Systems (TPMS)

Description	Tyre pressure monitoring systems (TPMS) are designed to inform drivers when a tyre has deflated below a recommended pressure. There are two main designs: direct and indirect systems. Direct systems that monitor tyre pressures using a sensor mounted in each wheel. The sensor transmits the pressure reading via a radio signal to a display in the instrument cluster. Indirect monitoring uses the ABS wheel-speed sensor to compare the rotation speed. A tyre losing air pressure shrinks in diameter and rotates faster. When the system detects a difference in wheel speeds it triggers a warning on the vehicle's instrument cluster. Most new vehicles also already include wheel speed sensors as part of the braking system meaning that some of the sensing required for indirect systems is already fitted.
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All
Likely year of introduction	Already available although current fitment rates are low
Barrier to introduction	Needs further studies on effectiveness
Cost per Vehicle	£27 (€30) per wheel for new vehicles. Fitting to older cars would cost £42 ($70) for direct system, £12 ($20) for vehicles already fitted with ABS and £86 ($143) for vehicles not equipped with ABS for an indirect system. £100-£500

104. Advanced Front Lighting Systems (AFS)

Description	Advanced Front-lighting Systems (AFS) is a technology which varies the pattern of light produced by headlamps to maximise road clarity at night whilst minimising the glare posed to oncoming vehicles. AFSs are designed to provide drivers with a better field of view when driving at night; static, front-facing headlights offer the same performance in curves, on motorways and in urban environments, despite the different illumination pattern requirements for these environments. AFS offers optimal carriageway illumination patterns depending on a variety of driving parameters (steering angle, speed, activation of indicators, etc). From these inputs a series of algorithms predict the vehicle's road environment and adjust the performance of the headlamps

	accordingly. Future systems will incorporate GPS information to select illumination patterns based on a prediction of road conditions (the need for which has been demonstrated empirically; drivers prefer lighting angles to be changed in advance of a corner, rather than in response to steering inputs when in the corner).
Vehicle type that could be fitted to (VOI)	HGV, LCV, LPV, Minibus, OMV, Agricultural
Target casualty group	All
Likely year of introduction	Some functionality already available
Barrier to introduction	
Cost per Vehicle	£250-£850 retail price for optional extra (2008)

Appendix D Countermeasure ranking

Table 30. Ranking of countermeasures by KSI cost.[32]

Rank	Countermeasure	Vehicle type	Timeframe for introduction	KSI cost (£million)			Best estimate of casualties affected	
				Min	Best estimate	Max	Fatal	Serious
1	Driver alertness monitoring - intervention - avoidance	HGV	Long	43.35	184.68	231.61	54.4	491.9
2	Vulnerable road user sensors - intervention - avoidance	HGV	Long	175.29	175.29	175.29	51.6	466.9
3	Vulnerable Road User Sensors - intervention - mitigation	HGV	Medium	121.95	129.74	131.98	42.2	381.7
4	Safer vehicle front	HGV	Medium	59.07	107.27	368.24	34.9	315.6
5	Segregate vehicle types by in cab information systems	HGV	Long	79.42	79.42	79.42	23.4	211.5
6	Faster response braking system	HGV	Short	29.01	72.26	654.93	23.5	212.6
7	Vulnerable road user sensors - warning	HGV	Medium	71.67	71.67	71.67	23.3	210.9
8	Improved driver training	HGV	Short	29.92	57.53	235.07	16.9	153.3
9	Brake assist (utilising max braking)	HGV	Short	40.75	49.70	234.25	16.2	146.2
10	Vulnerable road user sensors - intervention - avoidance	LPV	Long	49.04	49.04	49.04	14.4	130.6
11	Safer vehicle front	LPV	Medium	30.43	45.69	85.04	14.9	134.4
12	Improved driver training	LCV	Short	23.68	45.55	186.09	13.4	121.3
13	Segregate vehicle types by in cab information systems	LCV	Long	44.10	44.10	44.10	13.0	117.5
14	Improved forward visibility	HGV	Short	43.80	43.80	43.80	12.9	116.7
15	Driver alertness monitoring - intervention - avoidance	LPV	Long	9.60	43.40	50.68	12.8	115.6
16	Driver alertness monitoring - warning	HGV	Short	23.36	39.04	123.24	11.5	104.0
17	Inter-vehicle communication system	HGV	Long	13.06	38.35	646.11	11.3	102.1
18	Vulnerable road user sensors - intervention - mitigation	LPV	Medium	34.12	36.29	36.92	11.8	106.8
19	Rear collision system - intervention - avoidance	HGV	Medium	12.22	35.65	652.32	10.5	95.0
20	Faster response braking system	LCV	Short	8.95	34.91	443.88	11.4	102.7
21	Seatbelt enforcement	LCV	Short	28.84	34.33	53.93	11.2	101.0

[32] A dash indicates a value could not be calculated because of insufficient or inappropriate data.

Rank	Countermeasure	Vehicle type	Timeframe for introduction	KSI cost (£million)			Best estimate of casualties affected	
				Min	Best estimate	Max	Fatal	Serious
22	Seatbelt enforcement	HGV	Short	9.20	32.57	91.54	10.6	95.8
23	Rear collision system - intervention - mitigation	HGV	Short	10.80	30.75	589.78	10.0	90.5
24	Faster response braking system	LPV	Short	5.99	29.85	243.81	9.7	87.8
25	Driver alertness monitoring - warning	LCV	Short	17.23	28.94	91.29	8.5	77.1
26	Driver alertness monitoring - intervention - mitigation	HGV	Medium	13.23	24.99	118.82	8.1	73.5
27	Fit and use 3-point belt	LCV	Short	24.63	24.97	26.76	8.1	73.5
28	Prevent run over from front of vehicle – reduced ground clearance	HGV	Short	22.63	24.97	51.55	8.1	73.5
29	Segregate vehicle types by in cab information systems	LPV	Long	24.45	24.45	24.45	7.2	65.1
30	Drivers hours: make current requirements more stringent	HGV	Short	12.02	24.04	36.06	7.1	64.0
31	Rear collision system - warning	HGV	Short	7.33	21.39	647.43	6.3	57.0
32	Vulnerable road user sensors - warning	LPV	Medium	20.05	20.05	20.05	6.5	59.0
33	Front airbag	HGV	Short	11.35	18.75	43.70	6.1	55.2
34	Prevent run over from front of vehicle – reduced ground clearance	LPV	Short	12.24	18.08	48.97	5.89	53.2
35	Front airbag	LCV	Short	10.34	17.70	49.31	5.8	52.1
36	Fit EBS	LPV	Short	17.33	17.33	17.33	4.8	43.4
37	Intelligent speed limiters (zoning)	HGV	Short	13.73	17.03	171.24	5.5	50.1
38	Prevent run over from front of vehicle – change kinematics (e.g. nosecone)	LPV	Medium	12.31	16.94	46.64	5.5	49.8
39	Vulnerable road user sensors - intervention - avoidance	Agricultural	Long	16.80	16.80	16.80	4.9	44.7
40	Fit EBS	HGV	Short	16.71	16.71	16.71	7.0	63.7
41	Eliminate load box projections	HGV	Medium	8.52	16.45	20.48	4.8	43.8
42	Improved rear visibility	LCV	Short	10.55	16.35	18.00	4.8	43.6
43	Laminated glazing/prevent loss of window	HGV	Medium	15.45	16.23	20.82	5.3	47.7
44	Drivers hours: extend scope of current driver hours to more vehicle types	LCV	Short	7.92	15.84	23.76	4.7	42.2
45	Seatbelt interlock	LCV	Medium	9.38	15.23	41.65	5.0	44.8
46	Fit ABS	HGV	Short	13.53	14.54	48.78	4.7	42.8

Rank	Countermeasure	Vehicle type	Timeframe for introduction	KSI cost (£million)			Best estimate of casualties affected	
				Min	Best estimate	Max	Fatal	Serious
47	De-restrict speed of agricultural vehicles	Agricultural	Short	12.94	14.48	15.03	4.3	38.6
48	Transfer LPV design features to HGVs (lower seating position)	HGV	Medium	13.65	14.36	16.42	4.2	38.2
49	Brake assist (utilising max braking)	LPV	Short	9.71	14.01	103.10	4.6	41.2
50	Brake assist (utilising max braking)	LCV	Short	9.61	13.74	231.70	4.5	40.4
51	Seatbelt enforcement	OMV	Short	5.93	13.25	37.07	4.3	39.0
52	Laminated glazing/prevent loss of window	LCV	Medium	12.96	13.20	15.09	4.3	38.8
53	Improved sideguards (including behind rear axles)	HGV	Medium	6.08	13.14	16.08	4.3	38.7
54	Improved driver training	LPV	Short	6.59	12.67	51.76	3.7	33.7
55	Prevent pre-impact rollover	HGV	Medium	12.20	12.52	31.16	3.7	33.3
56	Energy absorbing front (for pedestrians)	LPV	Medium	7.77	12.44	49.23	4.0	36.6
57	Vulnerable road user sensors - intervention - mitigation	Agricultural	Medium	11.69	12.43	12.65	4.0	36.6
58	Improve conspicuity of vehicle	HGV	Short	8.23	12.26	46.97	3.6	32.7
59	Mobile phone interlock	HGV	Long	12.22	12.22	12.22	3.6	32.6
60	Improve rollover crashworthiness	HGV	Medium	12.17	12.17	12.17	4.0	35.8
61	Pedestrian directive to all vehicle types	LPV	Medium	8.57	11.78	37.95	3.8	34.7
62	Separate driver from load	LCV	Medium	10.13	11.00	16.58	3.2	29.3
63	Improved driver training	OMV	Short	5.70	10.97	44.81	3.2	29.2
64	Eliminate vehicle defects	HGV	Medium	10.54	10.89	48.86	3.2	29.0
65	Alcohol interlock	LCV	Short	10.89	10.89	10.89	3.2	29.0
66	Direct load around driver “pod” (post impact)	LCV	Medium	10.13	10.45	16.58	3.1	27.8
67	Drug interlock	HGV	Long	10.18	10.18	10.18	3.0	27.1
68	Pedestrian directive to all vehicle types	HGV	Medium	8.80	10.18	31.43	3.3	30.0
69	Curtain airbags (prevent ejection)	LCV	Medium	9.24	9.98	17.75	3.2	29.4
70	Tyre pressure monitoring	LCV	Short	2.15	9.73	527.47	3.2	28.6
71	Fit and use 3-point belt	HGV	Short	7.86	9.23	20.74	3.0	27.2

Rank	Countermeasure	Vehicle type	Timeframe for introduction	KSI cost (£million)			Best estimate of casualties affected	
				Min	Best estimate	Max	Fatal	Serious
72	Fit ABS	LPV	Short	5.68	8.76	10.68	2.8	25.8
73	Energy absorbing front (for pedestrians)	HGV	Medium	6.36	8.43	48.07	2.7	24.8
74	Improve side impact crashworthiness	Minibus	Short	6.15	8.40	8.40	2.7	24.7
75	Driver alertness monitoring - warning	LPV	Short	5.02	8.31	25.89	2.4	22.1
76	Allow protective structure to transmit loads to chassis	HGV	Medium	5.37	7.93	34.34	2.6	23.3
77	Speed limiters	LCV	Short	4.19	7.69	160.14	2.5	22.6
78	Eliminate vehicle defects	LCV	Medium	7.38	7.65	28.09	2.3	20.4
79	Eliminate “hard” structures inside buses etc	LPV	Long	6.18	7.48	12.79	2.4	22.0
80	Intelligent speed limiters (zoning)	LCV	Short	5.24	7.39	149.90	2.4	21.7
81	Front airbag	OMV	Short	3.70	7.36	13.35	2.4	21.7
82	More friendly external projections	HGV	Medium	0.67	7.15	7.10	2.3	21.0
83	Seatbelt interlock	HGV	Medium	4.33	7.06	42.97	2.3	20.8
84	Vulnerable Road User Sensors - warning	Agricultural	Medium	6.87	6.87	6.87	2.2	20.2
85	Improve rollover crashworthiness	LCV	Medium	6.64	6.64	6.64	2.2	19.5
86	Segregate vehicle types by in cab information systems	OMV	Long	6.40	6.40	6.40	1.9	17.1
87	Separate driver from load	HGV	Medium	5.93	6.22	11.85	1.8	16.6
88	Direct load around driver “pod” (post impact)	HGV	Medium	5.93	6.22	11.85	1.8	16.6
89	Lane departure warning	HGV	Short	2.43	6.16	21.26	1.8	16.4
90	Drivers hours: extend scope of current driver hours to more vehicle types	OMV	Short	3.07	6.15	9.22	1.8	16.4
91	Energy absorbing rear underrun protection	HGV	Medium	5.45	5.80	9.41	1.9	17.1
92	Driver alertness monitoring - warning	OMV	Short	3.41	5.67	17.58	1.7	15.1
93	Improve LCV-car compatibility	Minibus	Medium	1.54	5.38	9.22	1.8	15.8
94	Driver alertness monitoring - intervention - avoidance	Minibus	Long	1.56	5.35	8.23	1.6	14.2
95	Seatbelt enforcement	Minibus	Short	2.25	5.18	12.09	1.7	15.2
96	Improved side visibility	HGV	Short	5.15	5.15	5.93	1.5	13.7

Rank	Countermeasure	Vehicle type	Timeframe for introduction	KSI cost (£million)			Best estimate of casualties affected	
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97	Fit and use 3-point belt	OMV	Short	5.06	5.06	5.06	1.6	14.9
98	Improve frontal crashworthiness	LCV	Medium	1.32	4.94	49.56	1.6	14.5
99	Forward collision system - intervention - mitigation	LPV	Short	0.77	4.86	359.47	1.6	14.3
100	Drivers hours: make current requirements more stringent	LPV	Short	2.38	4.75	7.13	1.4	12.7
101	Improved rigid rear underrun protection	HGV	Short	4.46	4.75	8.42	1.5	14.0
102	Segregate vehicle types by in cab information systems	Agricultural	Long	4.58	4.58	4.58	1.4	12.2
103	Brake assist (utilising max braking)	OMV	Short	3.90	4.48	25.79	1.5	13.2
104	Prevent pre impact load movement	HGV	Short	4.30	4.47	48.92	1.3	11.9
105	Fit ABS	OMV	Short	3.70	4.46	5.00	1.5	13.1
106	Laminated glazing/prevent loss of window	OMV	Medium	4.27	4.27	4.27	1.4	12.6
107	Drug interlock	LCV	Long	3.50	4.07	4.07	1.2	10.9
108	Seatbelt enforcement	LPV	Short	2.87	4.01	13.64	1.3	11.8
109	Seatbelt interlock	OMV	Medium	1.11	3.95	22.61	1.3	11.6
110	Eliminate vehicle defects	Agricultural	Medium	3.65	3.88	7.42	1.1	10.3
111	Drivers hours: enforce current drivers hours restrictions	HGV	Short	2.71	3.81	8.14	1.1	10.1
112	Curtain airbags (prevent ejection)	OMV	Medium	3.70	3.75	4.45	1.2	11.0
113	Fit and use 3-point belt	LPV	Short	3.74	3.74	3.74	1.2	11.0
114	Improved front vehicle lighting	HGV	Short	3.69	3.71	12.86	1.1	9.9
115	Improved rear visibility	OMV	Short	3.68	3.68	3.68	1.1	9.8
116	Improved driver training	Agricultural	Short	1.87	3.60	14.70	1.1	9.6
117	Flat panel sideguards (including behind rear axles)	HGV	Short	1.78	3.59	11.34	1.2	10.6
118	Forward collision system - warning	LPV	Short	0.57	3.58	396.76	1.1	9.5
119	Driver alertness monitoring - intervention - mitigation	LPV	Medium	2.22	3.56	20.21	1.2	10.5
120	Improved rear visibility	HGV	Short	4.23	3.54	4.23	1.0	9.4
121	Curtain airbags (prevent ejection)	HGV	Medium	3.22	3.52	12.88	1.2	10.4

Rank	Countermeasure	Vehicle type	Timeframe for introduction	KSI cost (£million)			Best estimate of casualties affected	
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122	Extended energy absorbing front underrun protection front of VOI to front of car	HGV	Short	2.48	3.50	49.53	1.1	10.3
123	Pedestrian directive to all vehicle types	Minibus	Medium	2.14	3.33	3.89	1.1	9.8
124	Tyre pressure monitoring	OMV	Short	0.15	3.23	107.63	1.0	9.5
125	Improve conspicuity of vehicle	LCV	Short	2.13	3.18	18.33	0.9	8.5
126	Sliding cabs – provide ride-down	HGV	Short	2.15	3.14	15.03	1.0	9.2
127	Bonneted cabs – provide ride-down	HGV	Short	2.15	3.14	15.03	1.0	9.2
128	Improve side impact crashworthiness	OMV	Short	0.75	3.08	17.05	1.0	9.1
129	Improved side vehicle lighting	HGV	Short	3.00	3.02	10.78	0.9	8.0
130	Segregate vehicle types by in cab information systems	Minibus	Long	3.00	3.00	3.00	0.9	8.0
131	Forward collision system – Intervention - mitigation	Minibus	Short	0.46	2.99	46.66	1.0	8.8
132	Improve LCV-car compatibility	LCV	Medium	1.62	2.83	44.52	0.9	8.3
133	Improved driver training	Minibus	Short	1.46	2.80	11.45	0.8	7.5
134	Brake assist (utilising max braking)	Minibus	Short	1.85	2.76	16.35	0.9	8.1
135	Improve maximum brake performance (max deceleration)	HGV	Short	2.14	2.70	204.22	0.9	7.9
136	Alcohol interlock	OMV	Short	2.65	2.65	2.65	0.8	7.1
137	Improve human machine interface	HGV	Medium	1.08	2.56	9.45	0.8	6.8
138	Improved side visibility	LPV	Short	2.40	2.40	2.40	0.7	6.4
139	Improved front vehicle lighting	LCV	Short	2.24	2.25	6.72	0.7	6.0
140	De-restrict speed of STGO or SO vehicles	HGV	Short	2.04	2.22	105.85	0.7	5.9
141	Forward collision system - warning	Minibus	Short	0.34	2.20	51.37	0.6	5.9
142	Energy absorbing FUP front of VOI to front of car	HGV	Short	1.49	2.10	48.54	0.7	6.2
143	Forward collision system – intervention - avoidance	LPV	Medium	0.66	2.08	394.00	0.6	5.5
144	Seatbelt interlock	Minibus	Medium	1.13	2.00	8.71	0.6	5.9
145	Rear collision system - intervention - avoidance	LPV	Medium	0.31	1.98	394.26	0.6	5.3
146	Extended energy absorbing front underrun protection front of VOI to side of car	HGV	Short	1.55	1.96	30.91	0.6	5.8

Rank	Countermeasure	Vehicle type	Timeframe for introduction	KSI cost (£million)			Best estimate of casualties affected	
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147	Eliminate vehicle defects	Minibus	Medium	1.94	1.94	1.94	0.6	5.2
148	Fit and use 3-point belt	Minibus	Short	1.92	1.92	1.92	0.6	5.7
149	Lane following	HGV	Medium	1.24	1.88	4.42	0.6	5.5
150	Front underrun protection (FUP) front VOI to front of car	Agricultural	Short	1.07	1.87	4.28	0.6	5.5
151	Energy absorbing FUP front of VOI to front of car	Agricultural	Short	1.07	1.87	4.28	0.6	5.5
152	Extended energy absorbing front underrun protection front of VOI to front of car	Agricultural	Short	1.07	1.87	4.28	0.6	5.5
153	Improve frontal crashworthiness	HGV	Medium	1.07	1.85	29.59	0.6	5.4
154	Rear collision system - intervention - mitigation	LPV	Short	0.28	1.79	356.96	0.6	5.3
155	Prevent post impact load movement	HGV	Medium	1.70	1.77	52.10	0.5	4.7
156	Improve conspicuity of vehicle	OMV	Short	1.06	1.77	22.48	0.5	4.7
157	Eliminate vehicle defects	OMV	Medium	1.65	1.72	5.87	0.5	4.6
158	Seatbelt interlock	LPV	Medium	1.08	1.71	8.25	0.6	5.0
159	Improved side vehicle lighting	LCV	Short	1.63	1.63	2.36	0.5	4.3
160	Move external projections	LCV	Medium	1.60	1.60	1.60	0.5	4.3
161	Move external projections	LPV	Medium	1.56	1.56	1.56	0.5	4.2
162	Driver alertness monitoring - warning	Agricultural	Short	1.00	1.54	5.17	0.5	4.1
163	Energy absorbing FUP front of VOI to rear of car	HGV	Short	1.49	1.49	2.26	0.5	4.4
164	Extended energy absorbing front underrun protection front of VOI to rear of car	HGV	Short	1.49	1.49	2.26	0.5	4.4
165	Side airbag	LCV	Short	0.66	1.46	31.44	0.5	4.3
166	Prevent pre-impact rollover	Minibus	Medium	1.31	1.45	3.80	0.4	3.9
167	Faster response braking system	Agricultural	Short	1.18	1.44	33.98	0.5	4.2
168	Curtain airbags (prevent ejection)	LPV	Medium	1.43	1.43	1.43	0.5	4.2
169	Front underrun protection (FUP) front VOI to front of car	HGV	Short	0.99	1.40	48.04	0.5	4.1
170	Curtain airbags (prevent ejection)	Agricultural	Medium	1.02	1.38	3.41	0.5	4.1
171	Laminated glazing/prevent loss of window	LPV	Medium	1.38	1.38	1.38	0.4	4.1

Rank	Countermeasure	Vehicle type	Timeframe for introduction	KSI cost (£million)			Best estimate of casualties affected	
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172	Driver alertness monitoring - warning	Minibus	Short	0.84	1.34	4.33	0.4	3.6
173	Tyre pressure monitoring	Minibus	Short	0.11	1.31	26.32	0.4	3.8
174	Pre-impact pre-tensioners	LPV	Short	0.51	1.30	23.86	0.4	3.8
175	Forward collision system – intervention - avoidance	Minibus	Medium	0.39	1.28	49.73	0.4	3.4
176	Drivers hours: extend scope of current driver hours to more vehicle types	Minibus	Short	0.62	1.24	1.87	0.4	3.3
177	Rear collision system - warning	LPV	Short	0.18	1.19	394.14	0.3	3.2
178	Improve human machine interface	LCV	Medium	0.71	1.18	6.18	0.3	3.1
179	Intelligent speed limiters (zoning)	LPV	Short	0.95	1.18	48.97	0.4	3.5
180	Improved forward visibility	OMV	Short	1.08	1.08	1.08	0.3	2.9
181	Driver alertness monitoring - intervention - mitigation	Minibus	Medium	0.55	1.02	4.47	0.3	3.0
182	Drug interlock	Minibus	Long	1.01	1.01	1.01	0.6	5.4
183	Laminated glazing/prevent loss of window	Agricultural	Medium	0.98	0.98	0.98	0.3	2.9
184	Brake assist (utilising max braking)	Agricultural	Short	0.91	0.98	2.80	0.3	2.9
185	Knee airbags	LCV	Medium	0.66	0.94	21.49	0.3	2.8
186	Prevent run over from front of vehicle – change kinematics (e.g. nosecone)	HGV	Medium	0.71	0.90	41.71	0.3	2.7
187	Energy absorbing FUP front of VOI to side of car	HGV	Short	0.77	0.87	17.00	0.3	2.6
188	Improve rear cab strength (HGVs)	HGV	Medium	0.80	0.84	5.10	0.3	2.5
189	Extended energy absorbing front underrun protection front of VOI to front of car	LPV	Short	0.60	0.83	10.74	0.3	2.4
190	Adaptive cruise control	HGV	Short	0.81	0.81	0.81	0.3	2.4
191	Eliminate vehicle defects	LPV	Medium	0.76	0.79	6.40	0.2	2.1
192	Improve maximum brake performance (max deceleration)	LPV	Short	0.51	0.76	95.94	0.2	2.2
193	Front underrun protection (FUP) front VOI to rear of car	HGV	Short	0.76	0.76	1.53	0.2	2.2
194	Improved rear visibility	LPV	Short	0.76	0.76	0.76	0.2	2.0
195	Improve maximum brake performance (max deceleration)	LCV	Short	0.51	0.75	224.62	0.2	2.2
196	Lane departure warning	Minibus	Short	0.24	0.68	1.45	0.2	1.8

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197	Overtake assist	LPV	Long	1.73	0.67	38.38	0.2	1.8
198	Improve manoeuvrability	HGV	Medium	0.61	0.64	13.37	0.2	1.7
199	Overtake assist	Minibus	Long	0.76	0.63	12.35	0.2	1.7
200	Improve conspicuity of vehicle	LPV	Short	0.38	0.60	12.67	0.2	1.6
201	Alcohol interlock	HGV	Short	0.57	0.57	0.57	0.2	1.5
202	Prevent run over from front of vehicle – reduced ground clearance	OMV	Short	0.52	0.52	0.52	0.2	1.5
203	Move external projections	Agricultural	Medium	0.52	0.52	0.52	0.2	1.4
204	Improved front vehicle lighting	Minibus	Short	0.48	0.48	0.48	0.1	1.3
205	Improved front vehicle lighting	OMV	Short	0.45	0.47	6.95	0.1	1.2
206	Lane departure warning	LPV	Short	0.25	0.40	0.83	0.1	1.1
207	Eliminate load box projections	LCV	Medium	0.37	0.40	12.93	0.1	1.1
208	Improved side vehicle lighting	LPV	Short	0.36	0.39	6.32	0.1	1.0
209	Improved front vehicle lighting	LPV	Short	0.31	0.32	6.27	0.1	0.8
210	Improved side vehicle lighting	Minibus	Short	0.31	0.31	0.31	0.1	0.8
211	Improve rear impact crashworthiness	LPV	Short	0.29	0.29	0.29	0.1	0.9
212	Move external projections	OMV	Medium	0.29	0.29	0.29	0.1	0.8
213	Speed limiters	HGV	Short	0.22	0.26	81.74	0.1	0.8
214	Improved rigid rear underrun protection	OMV	Short	0.25	0.25	0.25	0.1	0.7
215	Improve maximum brake performance (max deceleration)	OMV	Short	0.21	0.24	22.91	0.1	0.7
216	Improve manoeuvrability	LPV	Medium	0.21	0.22	4.77	0.1	0.6
217	Lane following	Minibus	Medium	0.21	0.21	0.21	0.1	0.6
218	Improve human machine interface	LPV	Medium	0.13	0.20	1.12	0.1	0.5
219	Improve human machine interface	Minibus	Medium	0.11	0.20	0.92	0.1	0.5
220	Intelligent speed limiters (zoning)	OMV	Short	0.19	0.19	0.56	0.1	0.6
221	More friendly external projections	Agricultural	Medium	0.11	0.18	2.44	0.1	0.5

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222	Improved side vehicle lighting	OMV	Short	0.15	0.16	6.65	0.0	0.4
223	Improve maximum brake performance (max deceleration)	Minibus	Short	0.10	0.15	14.98	0.0	0.4
224	Improved front vehicle lighting	Agricultural	Short	0.11	0.12	2.20	0.0	0.3
225	Energy absorbing FUP front of VOI to rear of car	LPV	Short	0.06	0.06	1.18	0.0	0.2
226	Inter-vehicle communication system	LPV	Long	0.04	0.06	389.72	0.0	0.1
227	Improve maximum brake performance (max deceleration)	Agricultural	Short	0.05	0.05	2.13	0.0	0.2
228	Front underrun protection (FUP) front VOI to rear of car	LPV	Short	0.03	0.03	1.15	0.0	0.1
229	Improve side impact crashworthiness	HGV	Short	1.92	-	40.45	0	0
230	Energy absorbing front (for pedestrians)	Minibus	Medium	1.24	-	4.08	0	0
231	Side airbag	OMV	Short	0.52	-	10.60	0	0
232	Lane change assist - manoeuvring	LPV	Long	0.34	-	8.95	0	0
233	Drug interlock	OMV	Long	0.34	-	0.34	0	0
234	Mobile phone interlock	LPV	Long	0.23	-	0.23	0	0
235	Drug interlock	LPV	Long	0.11	-	0.11	0	0
236	Mobile phone interlock	Minibus	Long	0.11	-	0.11	0	0
237	Improve human machine interface	Agricultural	Medium	0.02	-	0.13	0	0
238	Improve human machine interface	OMV	Medium	0.01	-	0.01	0	0
239	Improved rear visibility	Minibus	Short	0.00	-	0.00	0	0
240	Faster response braking system	OMV	Short	-	-	95.23	0	0
241	Improve position of seatbelt	HGV	Short	-	-	58.73	0	0
242	Pedestrian directive to all vehicle types	LCV	Medium	-	-	27.17	0	0
243	Pre-impact occupant positioning	LPV	Medium	-	-	26.58	0	0
244	Side airbag	HGV	Short	-	-	23.61	0	0
245	Knee airbags	HGV	Medium	-	-	18.25	0	0
246	Improve frontal crashworthiness	OMV	Medium	-	-	17.05	0	0

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247	Front underrun protection (FUP) Front VOI to side of car	HGV	Short	-	-	16.23	0	0
248	Energy absorbing side underrun protection (including behind rear axles) car occ	HGV	Medium	-	-	15.09	0	0
249	Improve position of seatbelt	LCV	Short	-	-	11.66	0	0
250	Energy absorbing FUP front of VOI to front of car	LPV	Short	-	-	10.15	0	0
251	Improve side impact crashworthiness	LPV	Short	-	-	10.04	0	0
252	Front underrun protection (FUP) front VOI to front of car	LPV	Short	-	-	9.55	0	0
253	Speed limiters	Minibus	Short	-	-	8.61	0	0
254	Intelligent speed limiters (zoning)	Minibus	Short	-	-	8.61	0	0
255	Current sideguards	Agricultural	Short	-	-	6.98	0	0
256	Improve rear impact crashworthiness	LCV	Short	-	-	6.38	0	0
257	Improve position of seatbelt	LPV	Short	-	-	6.18	0	0
258	Current rear underrun protection	HGV	Short	-	-	5.45	0	0
259	Current sideguards	HGV	Short	-	-	5.33	0	0
260	Energy absorbing side underrun protection (including behind rear axles) car occ	Agricultural	Medium	-	-	3.78	0	0
261	Side airbag	Agricultural	Short	-	-	3.41	0	0
262	Improve rear impact crashworthiness	HGV	Short	-	-	3.22	0	0
263	Side airbag	Minibus	Short	-	-	3.07	0	0
264	Improve frontal crashworthiness	LPV	Medium	-	-	3.01	0	0
265	Fit current sideguards behind rear axles	Agricultural	Short	-	-	2.33	0	0
266	Improve frontal crashworthiness	Minibus	Medium	-	-	2.25	0	0
267	Front airbag	Minibus	Short	-	-	2.25	0	0
268	Extended energy absorbing front underrun protection front of VOI to side of car	LPV	Short	-	-	2.23	0	0
269	Improved side vehicle lighting	Agricultural	Short	-	-	2.09	0	0
270	Front underrun protection (FUP) front VOI to front of car	OMV	Short	-	-	1.99	0	0
271	Energy absorbing FUP front of VOI to front of car	OMV	Short	-	-	1.99	0	0

Rank	Countermeasure	Vehicle type	Timeframe for introduction	KSI cost (£million)			Best estimate of casualties affected	
				Min	Best estimate	Max	Fatal	Serious
272	Front underrun protection (FUP) front VOI to side of car	Agricultural	Short	-	-	1.89	0	0
273	Energy absorbing FUP front of VOI to side of car	Agricultural	Short	-	-	1.89	0	0
274	Extended energy absorbing front underrun protection front of VOI to side of car	Agricultural	Short	-	-	1.89	0	0
275	Front airbag	LPV	Short	-	-	1.73	0	0
276	Knee airbags	LPV	Medium	-	-	1.73	0	0
277	Front underrun protection (FUP) Front VOI to side of car	LPV	Short	-	-	1.11	0	0
278	Energy absorbing FUP front of VOI to side of car	LPV	Short	-	-	1.11	0	0
279	Current rear underrun protection	Agricultural	Short	-	-	1.07	0	0
280	Improved rigid rear underrun protection	Agricultural	Short	-	-	1.07	0	0
281	Current rear underrun protection	LPV	Short	-	-	0.60	0	0

Appendix E Investigating the real-world effectiveness of the introduction of mandatory fitment of front underrun protection to HGVs

E.1 Introduction

EC Directive 2000/40/EC, effective since August 2003, requires all heavy goods vehicles (HGVs) registered after this date to be fitted with rigid front underrun protection (FUP)[33]. This requirement was expected to reduce the number of fatal and serious casualties resulting from car to HGV head-on collisions, but previous analysis (Smith *et al*, 2007) has failed to verify this effect – it was considered that the low numbers of vehicles fitted with FUP involved in accidents occurring between 2003 and 2005 had prevented any effects from being visible in large scale accident data. The first part of this analysis aimed to update the analysis previously undertaken to include data from accidents occurring between 2003 and 2008 inclusive.

Passenger car occupants that are involved in a head-on collision with an HGV remain the largest casualty group for accidents involving HGVs and research into the mitigation of injury to this group is still, therefore, a priority. It has been six years since the Directive came into effect and it is known that some manufacturers were voluntarily fitting FUP from 1997, so the proportion of the HGV fleet fitted with FUP should now be significant. However, a number of factors that could influence the effectiveness of FUP have changed since the research preceding the introduction of FUP was carried out. These factors include advances in passenger car design; increasing traffic volumes; and changes in the way that HGVs are used. It is therefore important to monitor the effectiveness of measures after they are implemented, especially where the measure adds mass to the vehicle, which in turn, can reduce productivity and increase carbon emissions.

The second part of this analysis undertook in-depth investigation of factors that can influence the effect that FUP is having on the road casualty population.

E.2 Casualty rates

There is no specific way to identify vehicles fitted with FUP in the National accident data (Stats19). Therefore, the year of registration of the vehicle has been used as an approximation, but this would include some vehicles that are not fitted (those claiming exemptions) and exclude some vehicles that are fitted (where voluntarily fitted prior to 2003). Vehicles registered prior to 2003 are assumed not to be fitted with FUP, and those registered in 2004 or later are assumed to be fitted with FUP. Vehicles registered in 2003 were excluded on the basis that fitment would be particularly uncertain for that year of registration.

If FUP is effective, it would be expected that the proportion of accidents resulting in fatal or serious injury and involving an impact to the front of an HGV would be lower for HGVs fitted with FUP than for those not fitted with FUP. Therefore, the severity of casualties involved in HGVs with FUP was compared with those without FUP. Stats19 data for the period 2003 to 2005 inclusive was used for the initial analysis (Smith *et al*, 2007), with car occupant casualty numbers split by severity and also by registration year of their HGV collision partner. Table 31 shows the distribution of these casualties by impact location on the HGV.

[33] Goods vehicles of category N2 with a maximum mass not exceeding 7,500kg need only comply with the requirements for ground clearance not structural strength. Off-road vehicles and vehicles where fitment would be incompatible with their use are exempt from all requirements.

Table 31. Original Stats19 analysis using accident data for 2003 to 2005.

HGV impact location	HGV year of registration					
	Fatal casualties		Serious casualties		Slight casualties	
	1990-2002	2004-05	1990-2002	2004-05	1990-2002	2004-05
Front	72%	75%	54%	58%	54%	51%
Back	16%	15%	22%	17%	15%	15%
Side	12%	10%	24%	25%	31%	34%
N=100%	351	52	1289	133	10079	1161

The limited dataset above produced the reverse of the expected effect for fatal and serious casualties. That is, a higher proportion of casualties resulting from frontal collisions with HGVs that were registered after the fitment of FUP became mandatory. The increase seen in fatal casualties is not statistically significant, but the differences for serious and slight are. From this result it was apparent that other factors may be masking any potential effect of FUP, and from the low numbers of vehicles that may be equipped, that limited fleet penetration may be a key issue. There are a number of possible explanations for this result:

- FUP has not been effective;
- The fleet penetration of FUP equipped vehicles remained sufficiently low such that the number of equipped vehicles in the analysis was low, limiting the statistical power of the analysis and the ability to detect the FUP effectiveness;
- The effect of FUP has been masked by inaccuracies in the method of classifying FUP fitment (based only on year of registration), in particular the influence of exemptions and early optional fitment;
- Changes affecting the severity of collisions to the rear or side of HGVs theoretically could mask the effect of FUP. However, there have been no significant changes to the design of the side and rear of HGVs within the time periods considered; or
- The effect of FUP has been masked by other differences between pre and post 2003 registered vehicles, for example differences in their usage (e.g. new vehicles typically used by large distribution companies, older vehicles typically used by owner drivers).

Table 32 and Table 33 are updated versions of Table 31 incorporating more recent Stats19 accident data.

Table 32. Updated figures, accident data for 2003 to 2007 inclusive.

HGV impact location	HGV year of registration					
	Fatal casualties		Serious casualties		Slight casualties	
	1990-2002	2004-07	1990-2002	2004-07	1990-2002	2004-2007
Front	68%	71%	55%	56%	53%	50%
Back	19%	17%	22%	18%	15%	14%
Side	13%	12%	24%	26%	33%	36%
N=100%	376	130	1338	360	10112	3200

The relationship between the pre-2003 and post-2003 registered vehicles observed in the updated analysis in Table 32 is similar to that seen in the original analysis, with a higher proportion of fatal and serious casualties in collision with the front of the HGVs more likely to be equipped with FUP (e.g. 71% of fatalities involving post 2003 vehicles compared to 68% for pre-2003 vehicles). However the proportion of casualties of all severities involved in frontal collisions has reduced since the original analysis (e.g. in fatal accidents involving pre-2003 vehicles it was 72% for accidents occurring between 2003 and 2005, reducing to 68% for accidents occurring 2003 to 2007). The increase in the proportion of fatal and serious casualties is not statistically significant, whereas the decrease seen in slight casualties is. FUP was designed to be effective in more serious collisions making this another counter-intuitive finding not easily explained at this time.

Table 33. Updated figures, accident data for 2003 to 2008 data inclusive.

HGV impact location	HGV year of registration					
	Fatal casualties		Serious casualties		Slight casualties	
	1990-2002	2004-07	1990-2002	2004-07	1990-2002	2004-2007
Front	69%	69%	55%	54%	53%	50%
Back	19%	16%	21%	20%	14%	14%
Side	13%	15%	24%	26%	32%	35%
N=100%	409	185	1428	531	10839	4674

Comparing each of the above tables (Table 31, Table 32 and Table 33) shows that for both fatal and serious collisions, the percentage of casualties occurring in frontal impacts with HGVs registered after 2003 has been reducing (e.g. from 75% to 69% of fatalities for post 2003 vehicles) as the dataset has been updated to include accidents that occurred up to the end of 2008. When considering the difference between the pre and post 2003 registered vehicles, the trend is similar, with a difference of +3% for fatalities in the original analysis and 0% for the sample containing accidents from 2003 to 2008.

An alternative approach to investigating FUP effectiveness is to consider the change in distribution of passenger car casualty severity over the period of its introduction. Table 34 shows the severity of those car occupants that have collided with the front of an HGV, split by year of HGV registration.

Table 34. Severity distribution for car occupant casualties in collisions with HGVs, relative to likely FUP fitment (accidents 2003-2008).

Casualty severity	HGV year of registration	
	1990-2002	2004-08
Fatal	4.2%	4.4%
Serious	11.6%	15.0%
KSI	16.8%	19.4%
Slight	84.2%	80.6%
	100.0%	100.0%

A counter-intuitive result is shown, with a shift from slight casualties to more serious and fatal casualties for vehicles likely to be equipped with FUP. The change in serious and slight casualties is statistically significant but the increase in fatal casualties is not.

Analysis of the killed and seriously injured casualties together shows a statistically significant higher proportion of casualties that are KSI when in collision with HGVs that are more likely to be fitted with FUP. In order to attempt to explain this shift in casualty severity, an investigation of the characteristics of collisions between cars and the front of HGVs was required.

E.3 Investigation of accidents relevant to FUP

The following investigation aims to provide an insight into the characteristics of collisions between cars and the front of HGVs which result in car occupant casualties. The analysis reported so far has only considered casualties that are in collision with the front of the HGV, regardless of the impact location on the car. Given that FUP design is such that it is most effective in head-on collisions, the impact locations on both collision partners should be assessed. A more detailed examination of impact configuration, vehicle overlap and closing speed has been carried out using the Heavy Vehicle Crash Injury Study (HVCIS) fatal accident database; with the intention of providing useful information about the nature of these types of collision. The HVCIS phase II database contains accidents between 1997 and 2008, although because of low numbers of cases for 2007 and 2008, this analysis has been restricted to accidents occurring up to the end of 2006.

E.3.1 Representativeness of HVCIS sample

Front underrun protection is primarily designed to be effective in front to front (head-on) car to HGV collisions. For this reason collisions with this configuration are of most interest here and need to be identified. The HVCIS fatal accident database contains 896 car occupant fatalities where the first impact to their vehicle was with an HGV (between 1997 and 2006). The distribution of impact location on each vehicle is shown in Table 35, allowing a comparison with the Stats19 data for 2006 to 2008 (

Table 36).

Table 35. Collision configuration for first point of impact between car and HGV, resulting in a car occupant fatality (HVCIS 1997-2006, N=896).

1st impact	HGV impact side				
Car impact side	Back	*Front*	Nearside	Offside	Grand total
Back	0.0%	9.5%	0.1%	0.0%	9.6%
Front	11.7%	**34.8%**	1.2%	5.1%	52.9%
Nearside	0.0%	14.5%	0.1%	0.9%	15.5%
Offside	1.5%	16.1%	1.6%	2.5%	21.5%
Top	0.0%	0.1%	0.3%	0.0%	0.4%
Grand Total	13.2%	75.0%	3.3%	8.5%	100.0%

Table 36. Collision configuration for first point of impact between car and HGV, resulting in a car occupant fatality (STATS19 2006-2008, N=394).

1st impact	HGV impact side				
Car impact side	**Back**	***Front***	**Nearside**	**Offside**	**Grand total**
Back	0.8%	13.7%	0.0%	0.8%	15.2%
Front	17.3%	**35.3%**	1.5%	5.1%	59.1%
Nearside	0.3%	6.6%	0.8%	1.0%	8.6%
Offside	0.3%	10.9%	2.8%	3.0%	17.0%
Grand Total	18.5%	66.5%	5.1%	9.9%	100.0%

The proportion of casualties from head-on collisions in the HVCIS sample is comparable to that seen in the Stats19 data, however the overall proportion of casualties that are in collision with the front of the HGV is slightly lower in HVCIS compared with Stats19. However, the HVCIS sample mostly consists of accidents that occurred prior to 2008. Smith *et al* (2007) showed that for accidents occurring between 2003 and 2005 inclusive, 39.5% of fatally injured car occupants were in head-on collisions with HGVs with a total of 71.5% in collision with the front of the HGVs. Again, this shows that the distribution of the HVCIS sample is comparable to Stats19, but that the collisions with the front of the HGVs are slightly under-represented. It is also clear in both datasets that head-on (front to front) collisions remain the largest casualty group.

The first impact between vehicles is not necessarily the one most likely to have caused serious injury, for example, if a car side swipes an oncoming HGV and then collides with a tree it may be that the first collision has not caused the injuries. The HVCIS fatal database allows analyses to be based on the collision judged by the coder to be the most severe, as shown in Table 37. In this case, a head-on collision was the most severe impact event for 329 of 919 passenger car fatalities. It should be noted that analysis by the most severe impact can identify a larger number of relevant fatalities than analysis by first impact. This is because, for example, a car could have a side-swipe impact with another vehicle and then subsequently a head-on collision with an HGV. If the number of this type of accident, not identified in an analysis of first point of impact, is greater than the number of accidents such as the tree example above that would not appear in an analysis by most severe impact, then the total number identified will be greater.

Table 37. Collision configurations for most severe impact between car and HGV, resulting in a car occupant fatality (HVCIS 1997-2006, N=919).

Most severe impact	HGV impact side					
Car impact side	**Rear**	***Front***	**Nearside**	**Offside**	**Top**	**Grand total**
Rear	0.1%	7.9%	0.1%	0.0%	0.0%	8.2%

Front	11.3%	**35.7%**	1.5%	4.6%	0.0%	53.1%
Nearside	0.4%	14.1%	0.0%	0.3%	0.0%	14.9%
Offside	2.0%	16.6%	0.9%	2.0%	0.1%	21.5%
Top	0.0%	0.2%	1.4%	0.5%	0.0%	2.3%
Grand total	**13.8%**	**74.6%**	**3.9%**	**7.4%**	**0.1%**	**100.0%**

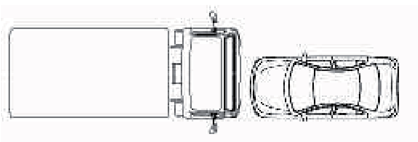
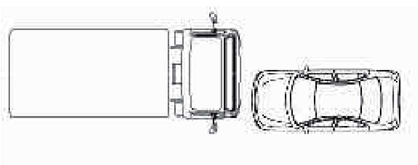
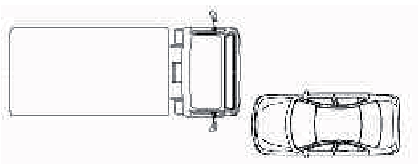
Comparison of

Table 36 and Table 37 indicates excellent correlation between distributions of impact configuration that lead to fatalities. Therefore, the results of the analysis of this impact configuration based on the HVCIS fatal accident sample can be considered representative of head-on collisions in Stats19.

E.3.2 Vehicular overlap and FUP

The vehicle and occupant dynamics in a car to HGV head-on impact are greatly affected by the level of vehicle to vehicle overlap. Within the HVCIS database there are 323 fatality cases where a head-on collision has occurred and the car-HGV overlap is known. The distribution of these car occupant fatalities is shown in Table 38; the most severe impact for both vehicles was used.

Table 38. Distribution of overlap configurations for HGV vs. car frontal impacts (HVCIS 1997-2006, N=323).

Ref No.	Overlap configuration		Percentage of fatalities
1	**Full car overlap only.** Impact distributed across the full width of the car but between only 1/3 or 2/3 of the front of the HGV.		29.1% of fatalities
2	**Large car overlap.** Impact distributed over 2/3 of the width of the car, and only 2/3 or less of the width of the HGV.		27.6% of fatalities
3	**Minimal overlap for both vehicles.** Impact distributed across only 1/3 of the front of both the HGV and car.		22.6% of fatalities

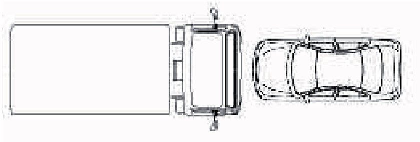
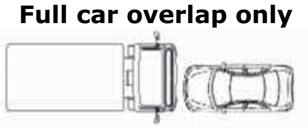
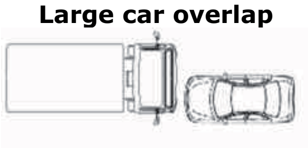
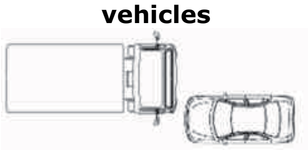
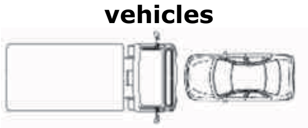
4	**Full overlap for both vehicles.** Impact is distributed across the full width of both the HGV and the car.		17.7% of fatalities
5	**Other configurations**		3.0% of fatalities

Table 38 shows that the majority of head-on collisions between HGVs and cars involve an overlap across a larger proportion of the width of the front of the car. Three-quarters of car occupant fatalities occurring in head-on collisions with HGVs have the most severe impact distributed across at least two-thirds of the width of their car (groups 1, 2 and 4 above). It is also worth noting that the primary and secondary damage to a smaller vehicle will be extensive due to the mass difference between collision partners and therefore may give the appearance of a larger overlap than actually occurred. It can also be difficult to distinguish between the two types of damage from photographs, which is one of the main sources of information for the HVCIS fatal accident database.

Also of interest is whether underrun has occurred for each impact configuration, and generally how prevalent underrun is within fatal car to HGV collisions. For the collisions shown above with known overlap information, 287 of these also had details of whether underrun occurred. Table 39 shows the number of fatalities in each collision configuration group and the percentage of those fatalities that were in cars that under-ran the front of an HGV.

Table 39. Distribution of overlap configurations and prevalence of under-run for HGV vs. car frontal impacts (HVCIS 1997-2006, N=287).

Ref No.	Overlap configuration	Number of fatalities	Percentage involving under-run
1	**Full car overlap only** 	67	**72.2%** (57 under-ran, 22 did not)
2	**Large car overlap** 	71	**69.5%** (57 under-ran, 25 did not)
3	**Minimal overlap for both vehicles** 	51	**61.9%** (39 under-ran, 24 did not)
4	**Full overlap for both vehicles** 	42	**69.8%** (37 under-ran, 16 did not)

5	**Other configurations**	9	**33.3%** (3 under-ran, 6 did not)

For all impact configurations that have resulted in a fatality, collisions that involve underrun account for the majority, indicating that underrun is likely to still be a key factor in fatal injury causation. To fully determine if this is the case, a detailed study of a sample of individual accidents looking at the injury mechanisms would be required, which is beyond the scope of this investigation.

E.3.3 Impact speed and FUP

Where available from police fatal file information, the HVCIS Fatal Accident database contains records of travel speeds and impact speeds for vehicles involved in collisions. For cars this predominantly comes from Police calculations using physical evidence at the scene and witness evidence from Police statements. For HGVs this information often comes from tachograph analysis and so is generally more frequently available and subject to fewer assumptions. For the 329 fatalities involved in head-on collisions between cars and HGVs, 118 have known closing speeds[34] associated with them, which are shown in the cumulative percentage plot below (Figure 21).

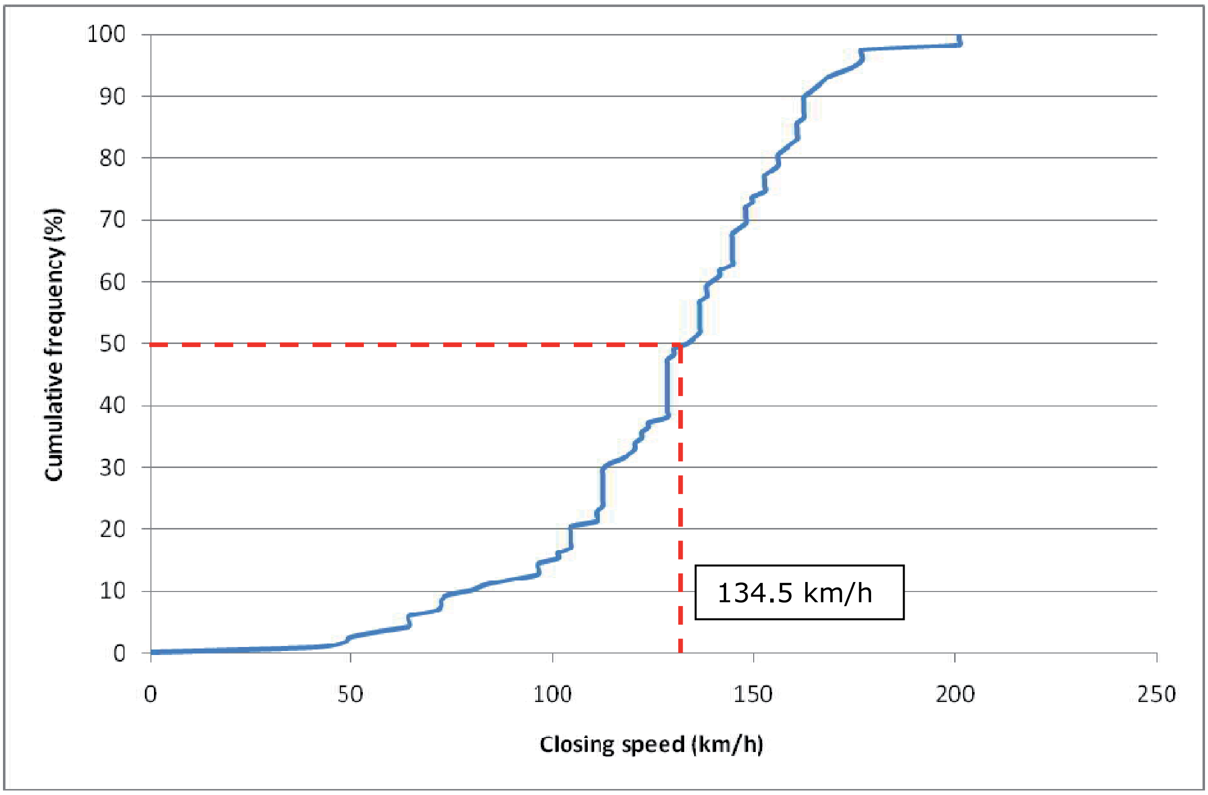


Figure 21. Cumulative percentage plot for car occupant fatalities involved in head-on HGV collisions (HVCIS 1997-2006, N=118).

The above sample of fatalities indicates that to make significant savings in fatality numbers, HGV FUP and passenger car occupant protection would need to tolerate much higher closing speeds than they are currently expected to, with a median closing speed for this sample of accidents of approximately 135 km/h. It is well established that the severity of injury in crashes is generally linked to the change in velocity. In Europe,

[34] Closing speed is the relative speed between the two vehicles. For head-on collisions, the closing speed is the sum of the speeds of the two vehicles.

frontal impact regulations involve an impact between a test vehicle and a deformable barrier at 56 km/h. Euro NCAP undertake similar tests at the slightly higher speed of 64 km/h. For each test regime, the barrier used absorbs around 40 kJ of energy, which means that the test will represent a head-on collision between two identical cars each travelling at a little less than the test speed in opposite directions. How much less the speed is depends on the mass of the vehicle, but for a typical car, a test speed of 64 km/h would approximate a head-on collision with a closing speed of 112 km/h (56 km/h for each car in opposite directions). In such a collision cars that do well in the tests would be expected to prevent life threatening injuries to healthy adult occupants.

When considering collisions between a car and a truck the change in velocity (delta V) experience by the car is greater because the truck is typically heavier than the car. **Figure 22** shows the delta V experienced by a car as a proportion of the closing speed for different mass ratios.

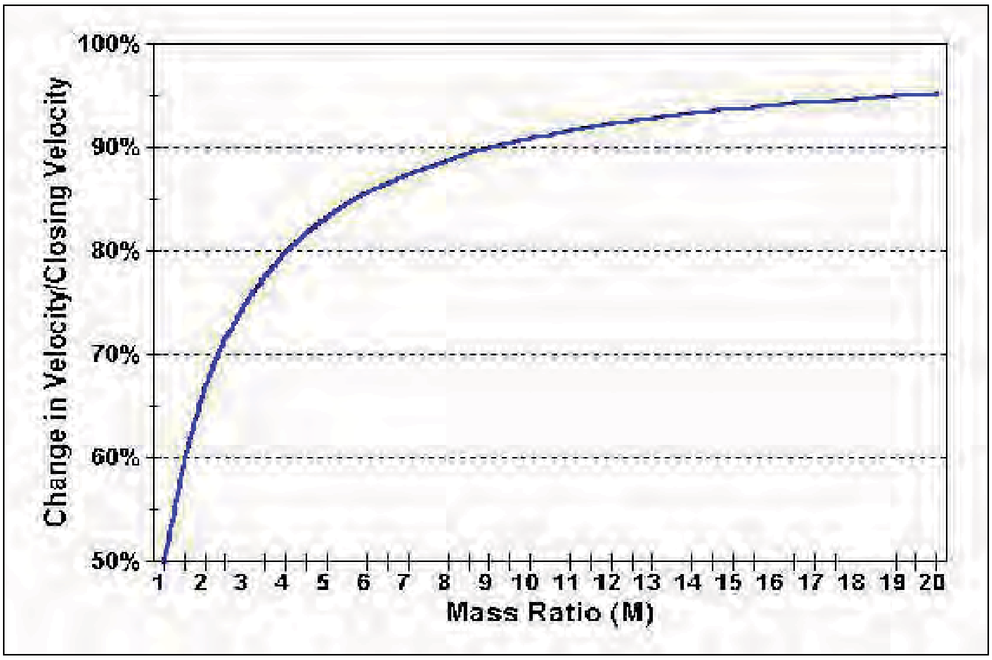


Figure 22: Relationship between the difference in weight of two vehicles involved in collision (mass ratio) and the relative change in velocity sustained by the smaller vehicle (FHWA, 2000).

This sample includes all types of car and truck and so can include collisions where a 2.5 tonne passenger car collides with an unladen 7.5 tonne truck (approximately 3.5 tonnes in weight) where the mass ratio would be in the region of 1:1.4. In this case a collision at the median closing speed of 135 km/h would result in a change in velocity of approximately 75 km/h, only slightly higher than test speeds for passenger cars. However, if a 1 tonne car collides with a fully laden 44 tonne truck then the mass ratio is 1:44, which is off the scale of the chart (**Figure 22**) and will result in the car change in velocity being almost 100% of the closing speed. In this case a collision at the median closing speed of 135 km/h would be very far in excess of the current test speeds meaning that even perfect structural interaction between the vehicles is unlikely to prevent life threatening injuries. Thus only a relatively small proportion, considerably less than 50% of the cases in HVCIS are likely to be affected by the fitment of FUP.

Previous analyses have also considered the closing speed on impact as a factor that will influence the effectiveness of FUP. Figure 23 compares the latest data with that from earlier studies (Knight and Whitehead, 1999) in order to give an idea of how closing speeds have changed over time. The HVCIS phase II data has been divided into two groups, to be more consistent with the time periods covered in previous analyses, although to maintain a decent sample size the most recent data covers a six year period rather than three years.

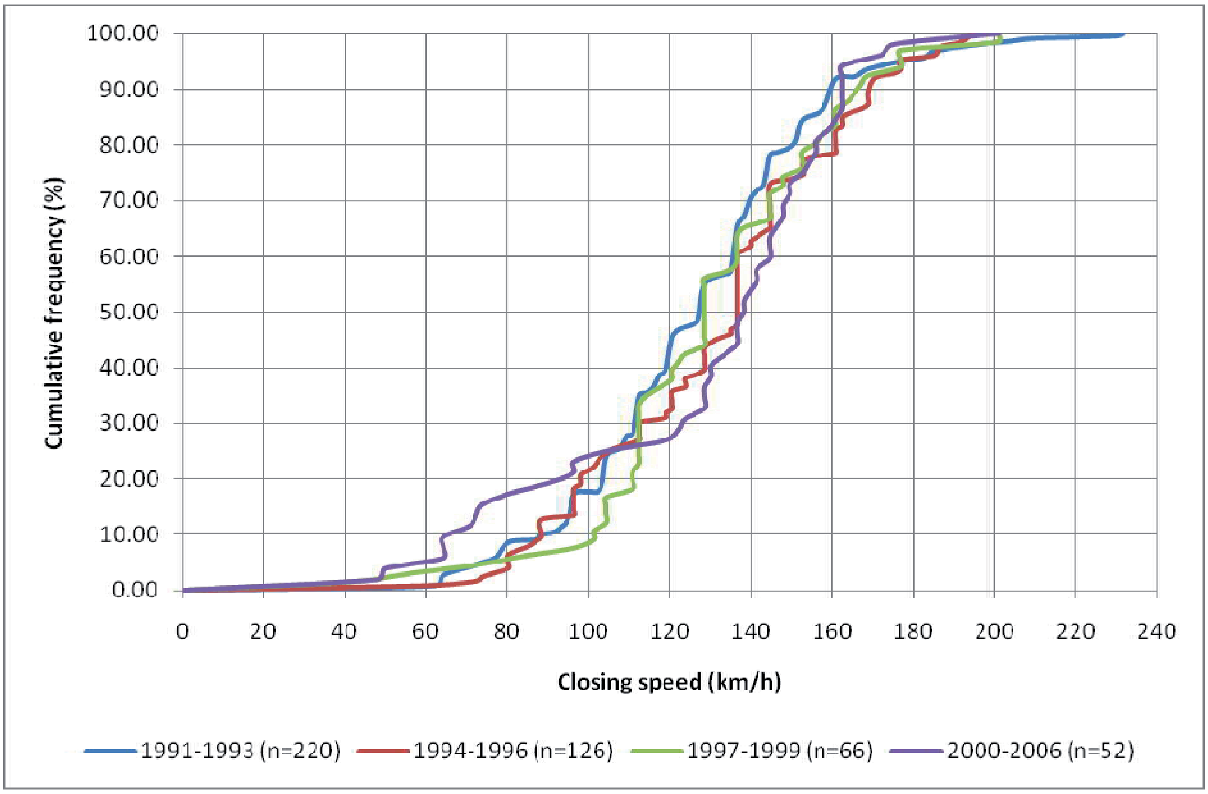


Figure 23. Car occupant fatalities involved in head-on HGV collisions cumulative percentage plot (1991 – 2006) data.

It can be seen that although there is variation in the speed distributions for different time periods there is no clear trend and it is likely that this variation is random. Thus, changes in the speed at which collisions are occurring cannot be considered a factor likely to mask the influence of FUP.

E.3.4 Seatbelt use

The rate of seatbelt use will affect the fatality numbers in any given group and so for frontal collisions between cars and HGVs it is important to check that this rate is consistent with other collision groups. 919 fatalities were previously shown where the most severe impact to their car was known; 707 had information about their seatbelt use available, of which 578 (81.8%) of these were belted and 129 (18.2%) were unbelted. Figure 24 shows the percentage of car occupants that were belted for each of the five most common collision configuration groups.

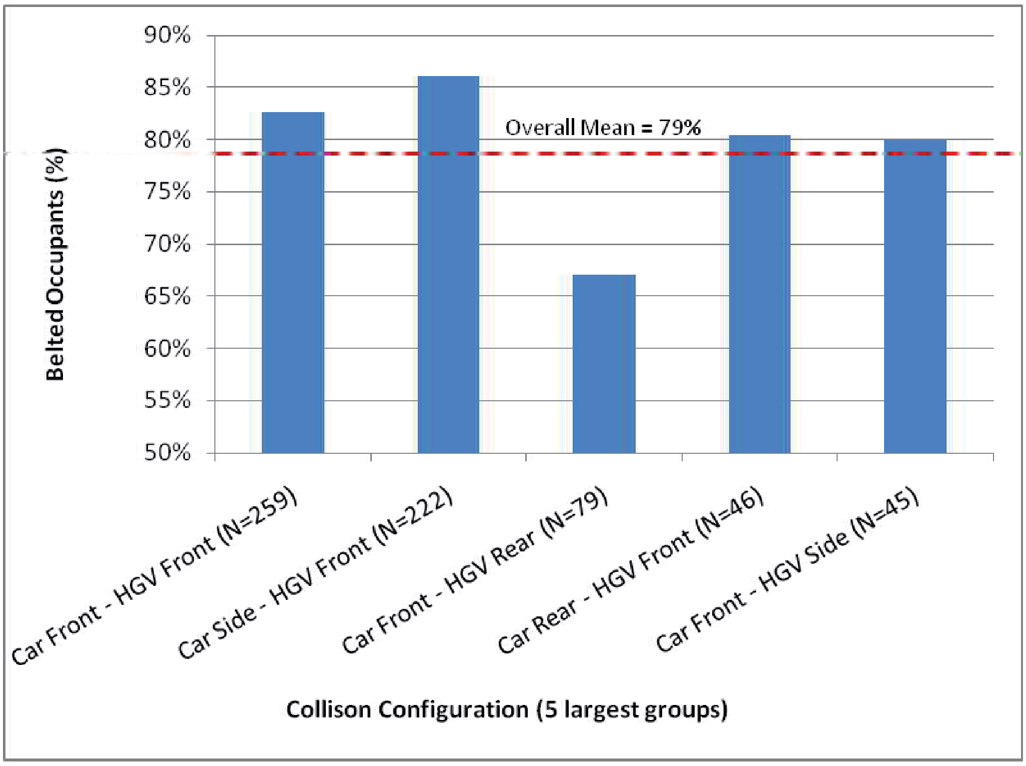


Figure 24. Percentage of belted fatalities in each collision configuration (HVCIS 1997-2006, N=707).

All but one of the collision configurations shows similar belt wearing rates of around 80% to overall sample. This is consistent with previous research for seatbelt wearing rates for the front seat occupants of passenger cars which dominate this casualty group. Passenger cars colliding into the rear of HGVs are the only group of collisions with a significantly lower rate of 64%, although an interesting and concerning find, it is not relevant to the effectiveness of front underrun protection and should be investigated elsewhere in future research.

Most importantly, Figure 24 indicates that the large fatality numbers seen in head-on collisions are not as a result of abnormal belt use rates, and that they do not appear to be of concern in relation to FUP.

E.3.5 Occupant age

The average age of a group of casualties is often a good indicator of the type of road user that they are and can help illustrate trends within accident. For the HVCIS dataset, 896 of the 919 car occupant fatalities that had their most severe collision with an HGV had known ages. The average age of fatalities in the five most common collision configurations is shown below in Figure 25.

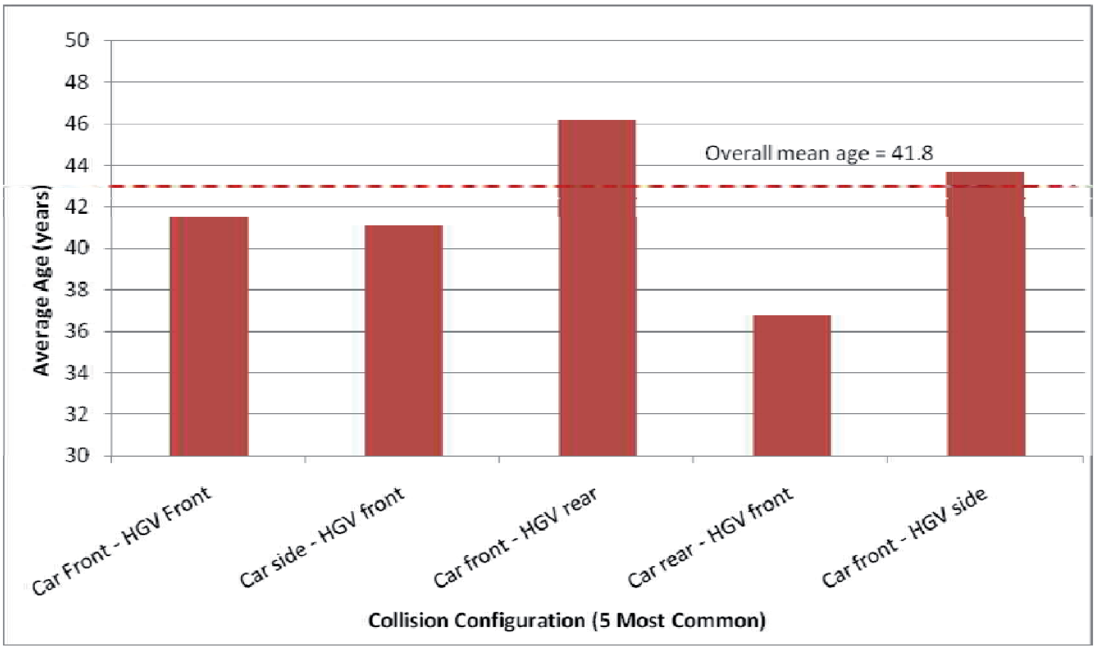


Figure 25. Average age of car fatalities by collision configuration (HVCIS 1997-2006, N=896).

The most striking feature is the low average age of car occupant casualties involved in rear end collisions with the front of heavy vehicles. This is likely to be due to a combination of rear impacts to cars from HGVs causing serious injury to rear seat passengers and the usual demographic of rear seat passengers being younger occupants with lower belt wearing rates.

Of the 121 fatalities involved in collisions with known closing speed at impact, 99 also have information about belt use at the time of the collision available. This has been combined with age information for each of the casualties and is shown in Figure 26 below.

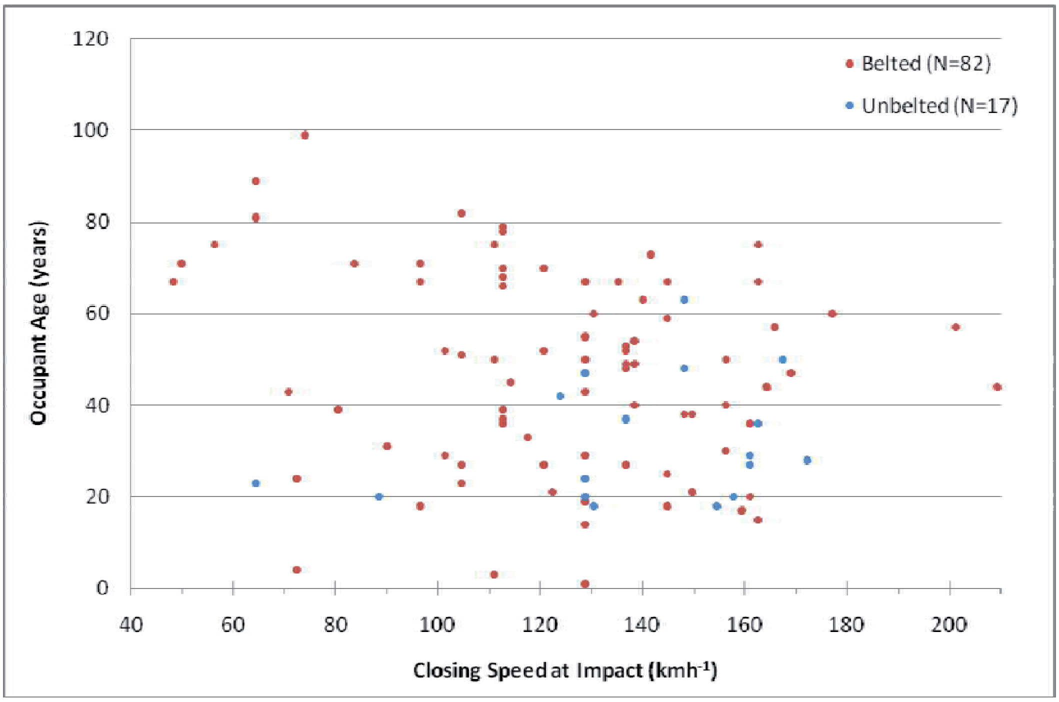


Figure 26. Fatal car occupant age against impact closing speed and belt use (HVCIS 1997-2006, N=99).

Unbelted fatalities tend to populate the higher end of the closing speed (at impact) range and the lower end of the age range, both of which may be an indication of the lower injury tolerances generally seen in older occupants. This is a judgement based on inspection of Figure 26 rather than a significant statistical relationship; because of the limited number cases where belt use and impact speed are both available.

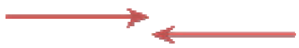
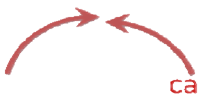
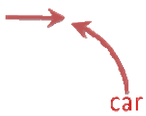
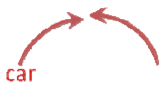
E.4 Alternative approaches

With an apparent increase in closing speeds and recent increases in vehicle masses, the amount of energy that FUP are required to manage is substantially higher than during the development of FUP in the 1980s. With an increase in environmental awareness and difficult trading conditions for hauliers, minimising the mass of FUP while still providing the required protection remains a substantial challenge. The lack of evidence to show the effectiveness of FUP combined with an increase in the implementation of active safety systems such as lane departure warning and advanced emergency braking systems, suggests it may be appropriate to consider alternative approaches to reducing the number of car occupant casualties in head-on collisions with HGV. This section of the analysis considers the causes of head-on collisions and potential for avoiding accidents rather than mitigating the consequences. The HVCIS Fatal Accident database holds details of pre-impact movement and driver behaviour factors, allowing trends in accident type and causation to be identified.

E.4.1 Pre-impact manoeuvre

Of the 919 fatalities originally identified as being involved in an impact with an HGV, 329 were involved in a front to front (head-on) impact. The most frequent combinations of pre-impact manoeuvre for the vehicles involved in these head-on collisions are shown in Table 40.

Table 40. Intended manoeuvre before impact (HVCIS 1997-2006, N=329).

Pre-impact manoeuvre		%
Car Straight Ahead – HGV Straight Ahead		42.9%
Car LH Bend - HGV RH Bend		21.6%
Car overtaking - HGV Straight Ahead		8.2%
Car LH Bend - HGV Straight Ahead		7.3%
Car RH Bend - HGV LH Bend		7.0%
Other		13.1%

The largest group of fatalities are in the 'straight ahead-straight ahead' category, a group which needs further explanation as to why a collision occurred when naturally the two vehicles would pass each other without event. The second and third largest groups are those for which it could be hypothesised that the blame is attributed to the car driver, given that left hand bend collisions often involve loss of control and running-wide on the part of the vehicle travelling in this direction, and that the overtaking vehicle in a head-on collision is generally assigned blame. Further investigation into the driver behaviour is needed to confirm this hypothesis. Section E.5 below considers the driver behavioural factors that have been recorded as causative or influential in each fatal collision.

E.5 Driver behaviour

Behavioural factors that relate to the driver of all vehicles involved in the collision are recorded for every accident in the HVCIS database. Each factor is selected based on information extracted from police fatal files. For frontal collisions between HGVs and passenger cars (329 fatalities), the percentage of car occupant fatalities that have each factor associated with the driver of the vehicles involved are shown in Table 25. Note that each driver can be assigned more than one behaviour factor and so the total may add up to more than 100%.

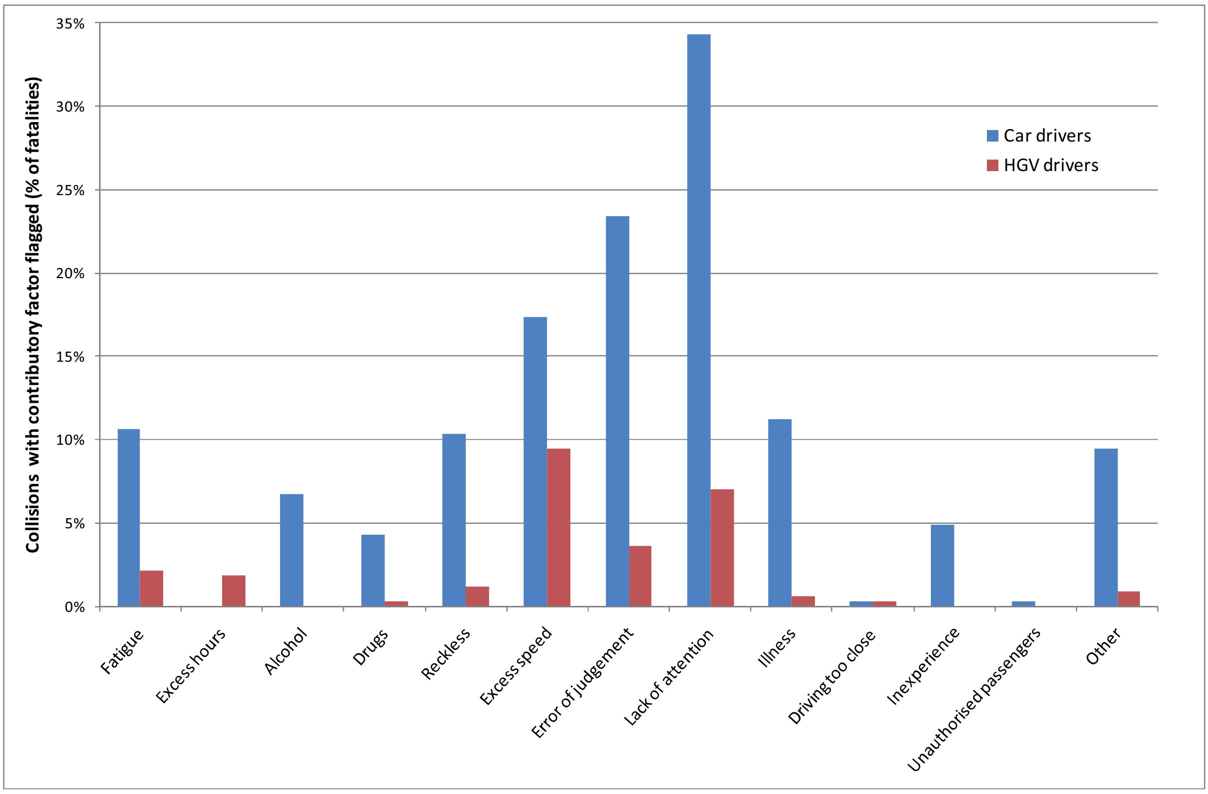


Figure 27. Contributory factors assigned in front–front, car vs. HGV collisions (HVCIS 1997-2006, N=329).

The percentage of fatalities for which no driver behaviour factor has been attributed is 16% for car drivers and 79% for HGV drivers, thereby confirming the hypothesis that blame is likely to be attributed to the car driver. Excess speed is the most common causation factor assigned to HGV drivers in head-on collisions and is generally one that is reliably coded from Police calculations and tachograph analysis.

Car drivers are most commonly linked to factors associated with poor behaviour such as 'lack of attention' and 'error of judgement'. More than a third of all car occupant fatalities in head-on collisions were drivers with the 'lack of attention' causation factor. The same applies for 'excess speed' and 'fatigue', both of which are common in collisions where vehicles cross into the path of oncoming traffic. Figure 28 expands on this, showing that 'fatigue' is more often considered contributory in head-on collisions where both vehicles were being driven straight ahead; and 'excess speed' is more often linked to collisions occurring on bends. Both statements appear obvious but do serve to confirm that drivers continue to make the same errors leading to fatal head-on collisions between cars and HGVs.

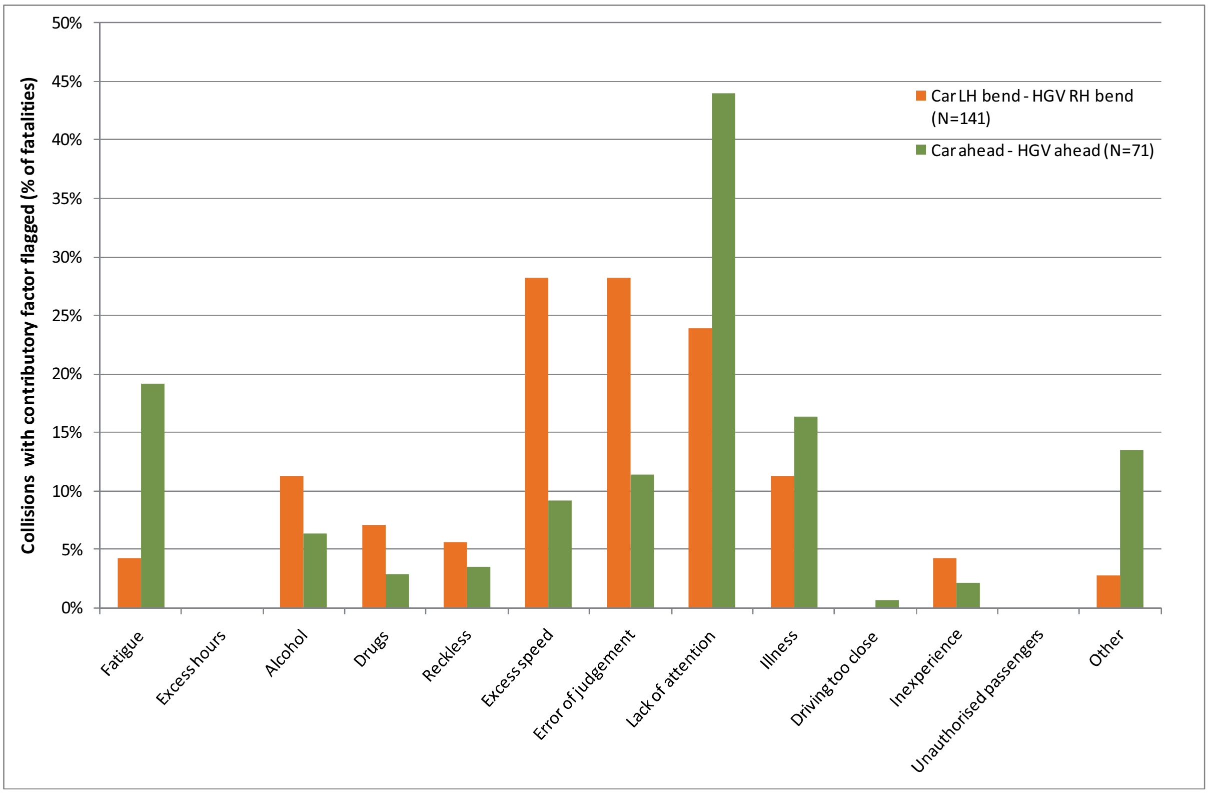


Figure 28. Contributory factors assigned to car drivers for the two largest pre-impact manoeuvre groups (HVCIS 1997-2006, N=232 together).

'Lack of attention' forms a large percentage of all coded behaviour factors for head-on collisions, particularly for those where both vehicles had been travelling straight ahead prior to the collision. It could be inferred from this that a large proportion of these collisions involve car drivers becoming distracted, causing them to enter the path of an oncoming HGV. To confirm this, the accident scenarios would need to be inspected on an individual level.

Car occupant fatalities from head-on car to HGV collisions don't seem to have any unusual traits in terms of average age or use of seatbelts. Given these two findings, it could be inferred that head-on collisions can be defined better by consideration of driver behaviour rather than by stereotyping occupant age or seatbelt use. In order to gain a greater understanding of how age and driver behaviour relate to each other. Figure 29 shows the average age for the five largest intended pre-impact manoeuvre groups (of the 329 fatalities used in the pre-impact manoeuvre plots, 321 had occupant age available).

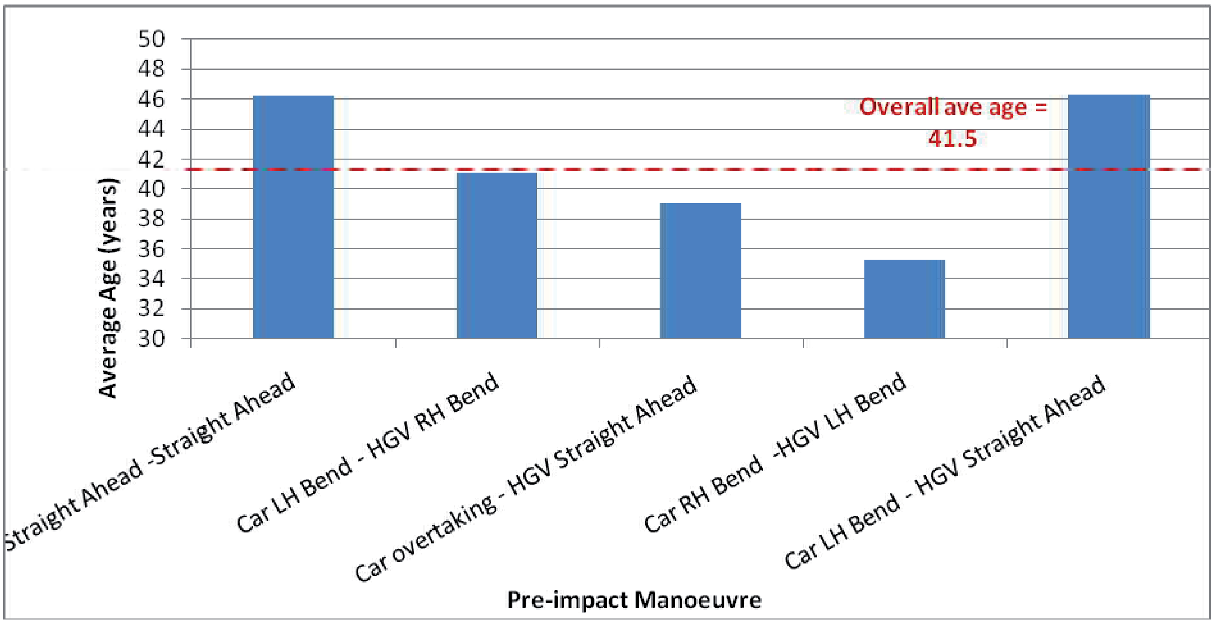


Figure 29. Average fatality age by intended pre-impact manoeuvre (HVCIS 1997-2006, N=321).

The overall variation in average occupant age is fairly high at just over ten years. Occupants of vehicles that were intending to continue straight ahead are the oldest, possibly correlating with this group's second and third most common causation factors of 'fatigue' and 'illness'. The lower ages seen in cars travelling around bends and cars overtaking before impact could also be pulled down by the younger, more reckless occupants that are often seen in these types of collision. Figure 28 has already illustrated how factors such as 'excess speed' and 'error of judgement' are regularly coded for those collisions occurring on bends.

E.6 Discussion

The analysis described above has shown a counter-intuitive result in relation to the effectiveness of FUP. The evidence available suggested that the mandatory fitment of FUP has not resulted in a reduction in the severity of car occupant casualties in collision with the front of HGVs. Although the analysis indicates that FUP has not been effective based on the data analysed, there are a number of other possible explanations for the result:

- The statistical power of the analysis is low because of the number of vehicles equipped with FUP is low;
- The effect of FUP has been masked by the difficulty in identifying FUP equipped vehicles in the accident data; or
- The effect of FUP has been masked by other differences between equipped and non-equipped vehicles, for example vehicle usage.

Thus, at this time it is not possible to confidently identify whether FUP has genuinely not been effective or whether the absence of evidence is a feature of limited data or confounding factors.

The analysis of in-depth accident data found no changes over time to the speed (delta V) at which fatal collisions occurred and concluded that this was unlikely to be a factor that could potentially act to mask the effect of FUP. It may be that a much more comprehensive and wide ranging analysis, based on data from multiple EU countries would help to identify the effect, if any, of FUP and to isolate it more rigorously from other confounding factors

.

Some other potentially confounding factors, such as the use of seatbelts and the age of the fatalities, were ruled out because they did not differ substantially from the overall levels for all fatalities in car to HGV impacts.

Car drivers are more frequently assigned contributory behaviour factors when compared with the HGV drivers involved. This suggests that the potential benefits of fitting alternative technology such as lane departure warning or driver alertness monitoring to prevent head-on collisions between cars and HGVs could be greater if fitted to the car rather than the HGV, although the costs and benefits of doing so have not been quantified in this study.

E.7 Conclusions

The evidence available suggests that the mandatory fitment of FUP has not resulted in a reduction in the severity of car occupant casualties in collision with the front of HGVs, though it is not known whether this is because of inadequate data or a genuine lack of effect.

If rigid front underrun protection has not been as effective as it had been predicted to be, then the most important commercial vehicle casualty group will not reduce in size as quickly as previously expected. This could also affect the relative priorities of future countermeasures.

If it is considered appropriate to better understand the reasons why FUP does not appear to be as effective as had been expected the following steps could be taken:

- Establish alternative means of identifying the vehicles fitted with FUP in the analysis.
- Repeat the retrospective analysis as FUP continues to penetrate the vehicle fleet.
- Undertake a detailed analysis of head-on collisions between cars and HGVs to better identify the characteristics of such accidents.
- Refer the current analysis to an appropriate European scientific committee (e.g. EEVC Working Group 14) for consideration.
- Promote ideas for collaborative research within the European research arena.

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Smith T, Richards D, Cookson R, Broughton J, Couper G, Dodd M, Lawton B, Massie P, Minton R and Hill J (2007). *Large passenger, goods and agricultural vehicle safety – effectiveness of existing measure and ranking of future priorities in the UK.* TRL published project report PPR307, Crowthorne, UK, December 2007.

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Goods vehicles, large passenger vehicles and other large vehicles such as agricultural vehicles and mobile machinery make up a relatively small proportion of the vehicles on the roads in Great Britain (GB). However, the frequency and/or severity of their involvement in accidents can be disproportionate to the distances they travel. In 2008 they were involved in accidents that resulted in approximately 29% of all GB road fatalities and so these vehicles can have a significant influence on road safety performance in the UK.

This study has defined, quantified and prioritised a list of casualty groups that can be used to inform the relative priorities for future developments in vehicle safety. An assessment of potential safety measures has been undertaken and five measures that could be implemented through vehicle design and construction standards were selected for more detailed cost-benefit analysis. This is the second review of this kind, the first having taken place in 2006.

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