

An evaluation of options for road safety beyond 2010

B Sexton and B Johnson





PUBLISHED PROJECT REPORT PPR397

An evaluation of options for road safety beyond 2010

by **B Sexton and B Johnson (TRL)**

Prepared for: Project Record: PPRO 4/001/049

Post 2010 Analysis and Forecasting

**Client: Department for Transport, Road User Safety
Division**

(Chris Watts, Sofia Marçal Whittles)

Copyright Transport Research Laboratory April 2009

This Report has been prepared for Department for Transport.

The views expressed are those of the author(s) and not necessarily those of Department for Transport.

	Name	Date Approved
Project Manager	Ben Johnson	15/04/2009
Technical Referee	Chris Baughan	15/04/2009

When purchased in hard copy, this publication is printed on paper that is FSC (Forestry Stewardship Council) and TCF (Totally Chlorine Free) registered.

Contents

Executive summary	iii
1 Introduction	1
2 Method: approach, assumptions, data and evidence	4
2.1 Introduction	4
2.2 Net present value	4
2.3 Implementation and maintenance	5
2.4 Exchequer impact	5
2.5 Casualties	6
2.6 Emissions and fuel	9
2.7 Speeds	13
2.8 Other data, evidence and inputs	16
3 Options taken to full cost benefit analysis	18
3.1 Reduce the national speed limit on single carriageway roads without median barriers to 50mph	19
3.2 Maintain the national motorway speed limit at 70mph and improve compliance using average speed cameras	22
3.3 Use 20 mph zones in metropolitan residential areas more widely	24
3.4 Increase investment in road safety engineering	28
4 Options taken to partial cost benefit analysis	31
4.1 Increase the motorway speed limit to 80mph and improve compliance using average speed cameras	32
4.2 Reduce the motorway speed limit to 60mph and improve compliance using average speed cameras	34
4.3 Undertake mass action programmes: IHIE guidelines for motorcycles	35
4.4 Undertake mass action programmes: barriers	38
4.5 Get younger drivers into newer cars so that they benefit from improved safety features	40
4.6 Introduce single double summer time (SDST)	41
5 Options with quantitative casualty benefit estimates	43
5.1 Reduce the drink drive limit to 50mg or 20 mg	44
5.2 Introduce programmes to fit alcolocks	48
6 Options with qualitative casualty benefit estimates	56
6.1 Apply Manual for Streets design standards on all new residential roads	57
6.2 Undertake an intensified and extended road safety education programme	59
6.3 Introduce fiscal incentives for improving driving	61

6.4	Increase enforcement for speeding, seat belt and drink / drug drive offences and consider random versus intelligence led enforcement	66
6.5	Focus enforcement on gross speeding	68
6.6	Reduce pedestrian drunkenness and increase driver awareness	70
6.7	Provide more pedestrian crossings	73
7	Summary	75
	Acknowledgements	78
	References	79
Appendix A	Initial list of options	85
Appendix B	Review of approach in estimating casualty changes	86
Appendix C	Estimated effects of assumed alterations in drivers' BACs upon casualty numbers	89

Executive summary

Great Britain's extant road safety strategy, *Tomorrow's Roads – Safer for Everyone* (Department for Transport, 2000) sets out targets for reduction in the number of casualties in the target year of 2010. As 2010 approaches, consideration has been given to what can be achieved in road safety in Great Britain post 2010. This report forms part of the evidence base for the Department for Transport's (DfT) consultation on Great Britain's Road Safety Strategy post 2010.

The DfT established a Steering Group of cross-government stakeholders tasked with preparing the DfT Road Safety Strategy beyond 2010. The Group met to consider, inform and direct activities in the development of the strategy. This report presents some of the work that TRL has carried out under the direction and guidance of the Steering Group. The work has two main aims:

- To support casualty-forecasting and target-setting over the period of the new road safety strategy in the period beyond 2010
- To provide part of the evidence base to support selection and prioritisation of activity areas for potential road safety gains post 2010

Supporting casualty forecasting and target setting

The 2010 casualty reduction targets were informed by a range of casualty forecasts developed around 10 years ago, and described in Broughton *et al* (2000). The casualty forecasts have proven broadly reliable over the period of the current road safety strategy. The approach in Broughton *et al* (2000) incorporated the effects of road safety measures *where they could be estimated reliably*. This was found to be true of only three types of measure: Drink drive, Engineering and Secondary Safety measures ('DESS' measures).

The remainder of the then current road safety effort and activity was grouped together as the 'core' measures. Core measures are those that already exist and should already be contributing to casualty trends. Forecasting estimates of casualty changes post 2010 for DESS and core measures only is presented as part of the DfT consultation on a road safety strategy post 2010 (Broughton, 2009).

A further category of measures was also considered in Broughton *et al* (2000): 'new' measures. New measures are those that either do not exist currently or, where they do already exist, have had no appreciable effect on casualty trends to date. This report presents some of the options for consideration as new measures in the period post 2010. It develops approaches for estimating the casualty benefits of some of the options considered tenable by the Steering Group.

It is anticipated that some of the measures included in this report may be taken forward and included future work as new measures, mirroring Broughton *et al* (2000). In service of this, the casualty benefits of the options presented in this report can be refined and incorporated into future casualty forecasting and target setting.

Selection and prioritisation of activity areas

In order to better understand the relative effectiveness of different potential new road safety interventions, TRL has examined the benefits in terms of casualty savings of the proposed measures.

Estimates of the likely impacts of implementing the options beyond casualty reduction are also put forward. The analysis has been carried out to increasing levels of detail under the direction and guidance of the Steering Group with net present values (NPV) estimated over 10 and 20 year timeframes for options of particular interest to the Steering Group. These are:

- Reduce the national speed limit on single carriageway roads without median barriers to 50mph

- Maintain the national motorway speed limit at 70mph and improve compliance using average speed cameras
- Use 20 mph zones in metropolitan residential areas more widely
- Increase investment in road safety engineering
- Increase the motorway speed limit to 80mph and improve compliance using average speed cameras
- Reduce the motorway speed limit to 60mph and improve compliance using average speed cameras
- Undertake mass action programmes: IHIE guidelines for motorcycles
- Undertake mass action programmes: barriers
- Get younger drivers into newer cars so that they benefit from improved safety features
- Introduce single double summer time (SDST)

These estimates include the consideration of implementation, casualty changes, journey times, fuel use and emissions. This is intended to help understand the potential for prioritising these options and inform considerations about routes and agencies best placed to take different options forward.

For other options, estimation of the casualty benefits was undertaken, but no estimation of the costs. This was done quantitatively or qualitatively, depending on the available research in the area. The options for which this was done were:

- Reduce the drink drive limit to 50mg or 20 mg
- Introduce programmes to fit alcolocks
- Apply Manual for Streets design standards on all new residential roads
- Undertake an intensified and extended road safety education programme
- Introduce fiscal incentives for improving driving
- Increase enforcement for speeding, seat belt and drink / drug drive offences and consider random versus intelligence led enforcement
- Focus enforcement on gross speeding
- Reduce pedestrian drunkenness and increase driver awareness
- Provide more pedestrian crossings

References

Broughton J, Allsop R E, Lynam D A and McMahon C M (2000). *The numerical context for setting national casualty reduction targets.* TRL Report TRL382. Crowthorne: Transport Research Laboratory.

Broughton J (2009). Post-2010 Casualty Forecasting. Road Safety Web Publication No.8. London: Department for Transport.

Department for Transport (2000). Tomorrow's Roads: Safer for Everyone. The Government's Road Safety Strategy and Casualty Reduction Targets for 2010. London: Department for Transport.

1 Introduction

In service of developing a Road Safety Strategy for the period beyond 2010, the Department for Transport established a Steering Group of cross-government stakeholders. The Group met to consider, inform and direct activities in the development of the strategy. TRL was commissioned to undertake analytical tasks under the direction of the Group.

This report presents the work TRL has undertaken under the direction and guidance of the Department for Transport (DfT) Steering Group tasked with preparing the DfT Road Safety Strategy beyond 2010.

Chapter 2 explains the underlying tools of the analysis in terms of methods, models, assumptions, evidence and data. Chapters 3 to 6 present the estimates of expected impacts including casualty reductions for each measure. The measures are grouped into categories according to the level of detail used for the analysis. Chapter 7 summarises the work. Much of this work has drawn heavily on a wide group of experts within TRL. Some of the work has also drawn heavily on inputs from experts outside TRL, particularly Chapter 5 for which TRL is grateful for the unpublished inputs from Richard Allsop of University College London and Ruth Welsh and colleagues at Loughborough University VSRC. Richard Allsop also provided an external peer review of the approach for estimating casualty changes linked to speed, Appendix B.

The extant road safety strategy, *Tomorrow's Roads - Safer for Everyone* (Department for Transport, 2000) sets out the targets for reduction in the number of casualties in the target year of 2010. The 2010 casualty reduction targets were informed by a range of casualty forecasts that were developed around 10 years ago. These are described in Broughton *et al* (2000) and were based on:

- analyses of disaggregate casualty trends from 1983-98 which took account as far as possible of the known effects of road safety measures
- extrapolation of these trends to 2010
- 'transport scenarios' that represented alternative views of the volume of road transport in 2010, in particular traffic growth
- the likely effects of new road safety measures that might be introduced by 2010.

Those forecasts considered the casualty savings expected to arise through various road safety activities. They included consideration of **D**rink drive, **E**ngineering and **S**econdary **S**afety (**DESS** measures), 'core' measures and 'new' measures. Broughton (2009) follows a similar approach to consider a target for road safety casualty reduction beyond 2010 but differs from Broughton *et al* (2000) in that 'new' measures are not included in the casualty forecasts. Instead, the forecasts in Broughton (2009) are intended to be used as a starting point, with the effects of potential new safety measures on the forecast figures being considered at a later date. The present report aims to understand the impact of a number of measures as considered by the Steering Group and it is anticipated that the some of the measures included in this report may be taken forward and included in a future publication mirroring Broughton *et al* (2000) and including 'new' measures.

After the casualty reduction target for 2010 was announced by the Government in March 2000, TRL was commissioned to monitor progress towards the target. Subsequently, the forecasts in Broughton *et al* (2000) have been re-examined annually, using the most recent casualty and exposure data. Broughton and Knowles (2009) presents the results with data to 2007. Through this process, the reliability of the Broughton *et al* (2000) forecasts has been checked annually against the actual data.

TRL has also supported DfT in developing casualty forecasts based on scenarios described in work by the cross-governmental Foresight project on Intelligent Infrastructure Futures (Curry *et al*, 2006). This has included translating visions of the

future from that work into casualty implications for each scenario. This work is explained in Lawton *et al* (in press).

One of the aims of early meetings of the Steering Group was, through discussion, to identify measures which could be of interest for inclusion in a new Road Safety Strategy. This included a brainstorming exercise to create a list of options to be considered. In this report the terms 'option' and 'measure' are used interchangeably to describe the policy, intervention or approach under consideration. The Group then refined these options and defined specific pieces of analysis which TRL then undertook to estimate the impact of the options. Options were considered in four themes:

- Safer, better performing roads
- Safer, greener vehicles
- Responsible road user behaviour
- Irresponsible road user behaviour

The initial set of measures is shown in Appendix A. As a first step, casualty savings estimates were presented to the Steering Group for all of these measures.

The estimates for casualty savings as well as other costs and benefits associated with each of the measures drew on a wide range of sources of guidance, published research and unpublished research. Underlying the analysis, a number of assumptions needed to be made and data and evidence was also drawn from the wide variety of sources and individuals.

The analytical process was necessarily highly collaborative involving, as it did, such a wide variety of experts, references and data. The inputs and views of economists, policy specialists, scientists and other stakeholders mainly from the Department for Transport were sought in service of reaching a consensus on the approaches and assumptions underlying the estimates in this report. The assumptions underlying the general approach are described in Chapter 2. Where assumptions were required specific to a particular measure, these are described in the section relating to that measure. The authors have tried to be as explicit as possible in presenting the assumptions, data and evidence used in the estimates of the impacts of the measures. Inevitably some assumptions will be implicit, in part because the references drawn on include their own assumptions.

The Steering Group decisions determined which measures were taken forward for more detailed analysis and estimation of casualty impact. As estimates of the benefits of the measures taken forward developed, the costs of these measures were also evaluated. This process of increasingly detailed evaluation of the measures taken forward is reflected in this report. The measures are presented respectively in four groups:

- Options taken to full cost benefit analysis
- Options taken to partial cost benefit analysis
- Options with quantitative casualty benefit estimates
- Options with qualitative casualty benefit estimates

These groups are presented in chapters 3 to 6 of this report. The titles used to describe these measures are used for brevity. Descriptions of each of the measures are given in more detail, but in reality complete definitions of the options comprise the combined effect of all of the analytical assumptions and approaches used. The measures which the Steering Group considered to merit a fuller evaluation in cost benefit terms (described in Chapters 3 and 4) are listed below.

- Reduce the national speed limit on single carriageway roads without median barriers to 50mph
- Maintain the national motorway speed limit at 70mph and improve compliance using average speed cameras
- Use 20 mph zones in metropolitan residential areas more widely

- Increase investment in road safety engineering
- Increase the motorway speed limit to 80mph and improve compliance using average speed cameras
- Reduce the motorway speed limit to 60mph and improve compliance using average speed cameras
- Undertake mass action programmes: IHIE guidelines for motorcycles
- Undertake mass action programmes: barriers
- Get younger drivers into newer cars so that they benefit from improved safety features
- Introduce single double summer time (SDST)

Only some of these proposals had a detailed calculation because it became clear (in the Steering Group) that some proposals were not considered tenable for other reasons. Under the direction of the Steering Group, options described in chapters 5 and 6 were not taken forward to the level of detail where the costs of implementation were considered by TRL. For these options, less detailed evaluation of the potential benefits was performed and is included in this report for completeness. In some cases these options were not considered further because the estimated casualty savings were relatively small or because the mechanism for achieving them was unclear.

The following section describes the approaches, assumptions, data and evidence used to estimate the casualty savings and other costs and benefits associated with each option.

2 Method: approach, assumptions, data and evidence

2.1 Introduction

The fundamental approach was to consider the associated costs and benefits accruing from the introduction of each option in or after 2010. Where directed to do so by the Steering Group, this has been developed into estimating the monetised impacts of each option under the following categories:

- Implementation and maintenance
- Exchequer impacts
- Changes in numbers of casualties
- Changes in emissions and fuel
- Changes in journey times

The structure of this section broadly reflects the categories of impact listed above. The parties affected by these in monetary terms may be government, business, private road users and wider society.

Many of the costs and benefits are strongly influenced by changes in vehicle speeds that might be expected to arise through introducing the measure. In general terms, reducing vehicle speeds is expected to reduce casualties, increase journey times and reduce fuel use and emissions. The picture is more complex than this in reality. For example, some reductions in speeds might lead to slight increases in fuel and emissions depending on the performance of the vehicles. Because of the importance of vehicle speeds in influencing some of the anticipated impacts, section 2.7 is included to specifically discuss the issue.

2.2 Net present value

The net present value of any proposed option is the difference between its costs and benefits discounted to a base year by applying a standard discount rate. In calculating the NPV a number of factors need to be taken into account:

- The real value of a given benefit or disbenefit will tend to change over the years as society becomes richer. For example, the real value assigned to saving a fatality will tend to increase over the years. The calculations take these changes into account. The real value of a casualty saving (available for 2007) was adjusted for future years using the guidance in COBA (DfT **CO**st **B**enefit **A**nalysis programme, Department for Transport, 2009a), and the real value of travel time (available for 2002) was adjusted for future years according to WebTAG 3.5.6 guidance¹.
- The value of a benefit (or cost) occurring in a given year can be expressed either in the prices of the year in question or, by adjusting for inflation, can be expressed in the prices of any other chosen year. WebTAG suggests 2002 as the base year for prices, and DfT asked TRL to comply with this guidance. This was done by applying a deflator based on GDP changes unless an alternative was suggested within the source document for a particular type of benefit.
- Society tends to prefer a benefit received now to the same benefit received in the future. In cost benefit analysis, this is taken account of by applying a standard discount rate to the stream of future costs and benefits to reduce that stream to its "present value". A discount rate of 3.5% was used here, reflecting current Treasury guidance (HM Treasury, 2003).
- For policies that have effects far into the future a decision needs to be made as to the time period over which discounted costs and benefits are summed. In this report, net

¹ WebTAG is the Transport Analysis Guidance Website, provided by the Department for Transport (2009) to provide detailed guidance on the appraisal of transport projects and wider advice on scoping and carrying out transport studies.

present values have been calculated over 10 and 20 year timeframes rather than the 60 years suggested by WebTAG. This is because the implementation period of the strategy is considered over the 10 and 20 year timeframe.

- Some benefits may be obtained illegally, and a decision has to be made as to whether to include them in the analysis. Specifically, people who reduce their journey time by exceeding the speed limit are receiving an illegal benefit. DfT considers that loss of this benefit (e.g. as a result of improved enforcement of speed limits) should not appear as a cost in the cost benefit analysis. This issue is discussed in more detail in Section 2.7.2.

In summary, the net present values presented in this report are discounted to the year 2010 using a discount rate of 3.5%, and expressed in 2002 prices.

2.3 Implementation and maintenance

The implementation costs include procurement costs, information campaigns and maintenance where relevant. The installation period may be tapered over a period of time, e.g. three years if the roll out of an option is expected to take three years. The impacts also may include revenue impacts to the Exchequer; these may be positive or negative and may be larger than the installation/maintenance costs for the proposed scheme.

Implementation impacts for emissions may be positive or negative depending on whether emissions and fuel use increase or decrease. Journey times tend to increase (where proposals reduce average speed) and so journey time impacts tend to be negative. Casualties are generally reduced and hence there is a positive casualty saving.

Impacts on the road user will accrue during the installation period, i.e. if it takes three years to install a scheme fully then the full impact will not be seen for three years. It is assumed that associated benefits (and costs) will also change in-line with the installation and be sustained, subject to maintenance, thereafter.

Costs, such as possible fuel increase, increase in emissions or increased journey times, have been presented with an appropriate sign. They are based on 2010 figures (at 2002 prices), and future traffic increases are factored in using DfT overall traffic projections. Department for Transport (2007e) projected traffic increases, relative to 2003, are shown in Table 2-3. Intermediate year increases are obtained by interpolation for this analysis.

2.4 Exchequer impact

The changes in fuel duty and VAT on fuel were calculated from the expected change in use of fuels (diesel and petrol). The net changes in fuel use are the result of a number of factors and can be complex. For example, petrol use may increase whereas diesel may decrease. The estimated fuel use will tend to increase due to traffic volume increases but decrease due to the introduction of more efficient vehicles. The saving or cost to the driver will also depend on whether more or less fuel is used in the 'after' scenario. The duty and VAT element will be a gain or loss to the Exchequer and hence potentially could appear as a cost or a benefit.

Duty changes on fuel apply to all travel use (work and non-work); however, tax (VAT) only applies to non-work fuel.

Changes in duty and tax will cancel out in the calculation of net present value since an increase in tax (say) will appear as both a cost to the driver and a benefit to the exchequer. However, the changes in duty are shown separately in the analyses as they are clearly of great interest to both drivers and the government.

2.5 Casualties

Road Casualties Great Britain (RCGB) (e.g. Department for Transport, 2008a), formerly Road Accidents Great Britain (RAGB) is the official statistical publication of the Department for Transport on traffic casualties, fatalities and related road safety data. It uses data from the Stats19 database. It is a primary source for data on road casualties in Great Britain and the edition published in 2008, which reports on 2007 data, has the average values of the benefits of prevention per casualty and per accident.

2.5.1 Stats19

The Department for Transport compiles data on personal injury road accidents, resulting casualties, and the vehicles involved. Accidents are those which occur on the public highway and which become known to the police within 30 days. Data are available for three main areas:

- Accidents - including the severity of the accident, the number of vehicles and casualties involved, time and location, road class and number, speed limit, weather and road conditions, and carriageway hazards;
- Vehicles - including type, location and manoeuvre at time of accident, and details of the driver (age, sex and breath test results);
- Casualties – age, sex, injury severity and whether a driver, passenger or pedestrian

Stats 19 data has been used for this analysis. Specific analyses have been drawn from TRL's Stats 19 database to support the approaches used in each option under consideration. This has been necessary where RCGB does not provide the required casualty data, network or population of interest.

2.5.2 Models: the effect of speed on accidents and casualties

Once the distribution of speeds under a specific proposal has been estimated and the mean speed calculated, it is possible to estimate what the effect on accidents or casualties might be. Such relationships already exist from a number of sources. The majority of these relate the number of injury accidents to the mean speed. Separate relationships exist according to accident severity. A useful review of the relationships between speed and the risk of road crashes has recently been published (Aarts and van Schagen, 2006).

The options for which estimated changes in mean speed are estimated and used to predict the costs and benefits of an option include:

- Reduce the national speed limit on single carriageway roads without median barriers to 50mph
- Maintain the national motorway speed limit at 70mph and improve compliance using average speed cameras
- Reduce the motorway speed limit to 60mph and improve compliance using average speed cameras
- Increase the motorway speed limit to 80mph and improve compliance using average speed cameras

Taylor *et al* (2000) reported a study of accident-speed relationships on rural single carriageway roads in the Netherlands, Sweden and England. The relationship, known as the EURO model, is:

$$A = k V^{1.536}$$

Where, A is the accident frequency, k is a constant, V is the mean traffic speed in mph. The range of mean speeds was from 33 to 54 mph. Taylor *et al* (2002) also carried out an extensive investigation of the relationship between speed and accidents on rural

single carriageways in England. Separate relationships for different types of accident were developed: fatal and serious; slight; all; link/junction; single vehicle/multiple vehicle. The relationships used were also of the form:

$$A = k V^a$$

Where, A is the accident frequency, k is a constant, V is the mean traffic speed in mph and a is a constant which has the value 2.792 for fatal and serious injury accidents (combined), 2.316 for slight injury accidents and 2.431 for all injury accidents combined. The range of mean speeds was from 26 to 58 mph.

The Taylor models are considered to be superior to and supersede the EURO relationships principally because the EURO equations do not disaggregate accident reductions by severity. Taylor *et al* (2000) suggest that the overall percentage reduction in accident frequency per one mph reduction in average speed is about 3%, (applying to all accident severities on higher speed urban roads and rural main roads and based on the EURO model), and this is the figure quoted by the Department for Transport (2005) (page 8).

Nilsson (2004) developed a relationship between speed, accidents and casualties. It has been reviewed, modified and evaluated by Elvik *et al* (2004). The latter includes a meta-analysis of 98 previous studies over the period from 1966 to 2004 which provided a total of 460 estimates of the relationship between speed and safety.

The relationship models suggested by Nilsson, can be derived from the Taylor model, and are as follows:

$$\text{Accidents after} = \text{Accidents before} * (\text{Mean speed after}/\text{Mean speed before})^a$$

$$\text{Casualties after} = \text{Casualties before} * (\text{Mean speed after}/\text{Mean speed before})^a$$

'Before' and 'after' refer to accident/casualty numbers and speeds 'before' and 'after' a change in average speed. The values of 'a' (exponent for the ratio of average speeds) as reported in Elvik *et al* (2004) for different severities of casualty are given in Table 2-1.

Table 2-1: The effect on casualties of average speed

Type of accident or casualty	Value of 'a'
Fatal casualty	4.5
Seriously injured casualty	3.0
Slightly injured casualty	1.5
<i>All casualties</i>	2.7

Source: Elvik *et al* (2004), Table 21, page 70

Table 2-1 indicates that the values of the exponent depend strongly on severity.

Elvik *et al* (2004) conclude that the relationship between changes in speed and changes in casualties holds for all speeds in the range from 25 kph to 120 kph and that the Nilsson type model with its logical simplicity and generality makes it superior to other models.

For the purposes of the evaluation being considered, where different proposals will have an impact on average vehicle speeds, TRL has adopted the Elvik version of Nilsson's model for estimating casualty reductions.

The estimation of changes in the numbers and severity of casualties uses the average traffic speed 'before' and 'after' the introduction of the proposal. This uses the ratio of 'after' to 'before' average speeds, where speed of traffic is changed by the proposal and calculated for 'real world' average speed estimates.

The 'real world' speed estimate was taken as being the value closest to reality - see Section 2.7.2. The impact of a speed limit change is taken as 2.4mph per 10mph change in the posted limit (Finch *et al*, 1994). This means that where methods to improve compliance are not assumed, a 10mph speed limit change is expected to result in a 2.4mph 'real world' mean speed change.

There are a number of alternative approaches which could be used to estimate casualty changes in relation to changes in speeds, some of which were discussed above. In order to provide a second unbiased opinion as to the most robust approach currently available, a review was conducted by Richard Allsop of the Centre for Transport Studies, UCL. He concurred with the approach adopted. His full review is available as Appendix B.

2.5.3 Evidence not from models

There are some cases where evidence not from models provides a better source of understanding the impact of an option. For example, where research has been carried out evaluating a particular intervention. One such case is for 20 mph zones. Webster and Layfield (2003) reported on the impact of installing self enforcing 20mph zones in London, and a similar study (Webster and Mackie, 1996) was undertaken nationally. Such research showed that 20mph zones in residential areas saw average speed reductions of around 9mph. There was an associated reduction in killed and seriously injured casualties of around 60%.

If an option makes a change to the driving environment, for example in introducing high grip surfaces on major junctions, there should be an associated reduction in collisions and hence casualties. This can be estimated by considering the proportion of existing collisions which were as a result of skidding or not stopping in time and if many of these would be eliminated due to junction treatment then an estimate of casualty saving can be obtained.² Sections 3.3, 4.3 and 4.4 describe the methods used to estimate casualty savings for options which do not rely on speed-accident models.

2.5.4 Casualty savings

The benefits in casualty reduction have been calculated for fatal, serious and slight injuries. It is recognised that the policy options assessed in this report may also affect the total cost of vehicle damage, but such costs have not been included in the analyses reported here. In part this is because it would be very difficult to reliably estimate the impact of the damage only element³. Generally speaking, damage only accidents are rarely included in cost benefit analysis of road safety schemes at a local level.

The value of benefit of prevention of a casualty (by severity) is given in the 2007 figures (Department for Transport, 2008a). The value of the benefit of prevention of a casualty is given at 2007 prices and values, and includes a willingness to pay element; an explanation of the figures is given in Department for Transport (2007a). COBA rates of growth in the real value of casualties and accidents are used to increase the real value of the benefit of prevention over time from the 2007 figures, shown in Table 2-2.

² Evidence from On The Spot data has been used in this case.

³ RCGB has values for damage only accidents, but does not report damage only and so a ratio of damage only to injury accident would need to be assumed. Further, the reduction of damage only accidents would have an impact on garage repair, car hire and other associated services; and this would be difficult to determine reliably (i.e. the societal cost savings would not necessarily all be positive) and is outside the scope of this work. It is also not usual DfT practice to include damage only collisions in this type of calculation.

Table 2-2: The values of the benefits of prevention of accidents and casualties by severity

Severity	Casualty	Accident
Fatal	£1,648,390	£1,876,830
Serious	£185,220	£215,170
Slight	£14,280	£22,230
Average	£52,850	£75,610
Damage only		£1,970

Source: Department for Transport (2008a)

The value of the benefit of prevention of a casualty for any one year is calculated by the sum of the value of the benefit of prevention of the fatal, serious and slight casualties multiplied by their respective values, where the casualty figures have been adjusted to take into account the projected decreases with time and the values have been increased by the COBA rates, but at 2002 prices.

2.5.5 Casualty trend projection

Forecasting shows that the general trend for casualties is downwards in future years. Estimates of the numbers by casualty type (car occupant, motorcyclist, cyclists, pedestrians and others) and by severity (killed, serious or slight injury), are available until 2040. These have been generated by Broughton (2009) and include considerations of traffic growth and safety benefits of newer cars. They have been used to prorate the estimated casualty saving associated with proposed post-2010 road safety initiatives.

For this work, casualty savings were estimated for 2006, (using an average of 2005, 2006 and 2007 to obtain a more stable estimate for 2006) but are adjusted according to future projections, i.e. if it is projected that in 10 years there will be 10% fewer fatal casualties then the 2006 figure would be reduced by 10% in 2016. The future projections take into account traffic growth.

2.6 Emissions and fuel

As with the estimates of the casualty impacts of the different options, the emissions and fuel use impacts can be estimated using a number of different approaches. Two of the important steps in the estimation are to understand the emissions and fuel changes associated with an option and then to monetise these for use in the net present value calculation.

CO₂, NO_x and PM (carbon dioxide, nitrous oxides and particulate matter) and fuel use are included in the analysis. Cost data for emissions use Defra shadow carbon, NO_x and PM costs (the published 2008 prices being converted to 2002 prices for the purpose of the analysis). Fuel costs use WebTAG values and it is assumed all business fuel use is diesel and all private fuel use is petrol. This is an approximation, but it is felt to be adequate for purpose.

Emissions will change over time as technology improves and the fleet changes. Rates derived from fuel changes in the SpeedTool model (see section 2.6.1) have been calculated and applied to reflect increases in efficiency. The rate of reduction in emissions and fuel due to changes in fleet composition and vehicle increases in efficiency are calculated for the 30 year time period from 2010. The rates are adjusted for

projected increases in traffic. These adjusted rates are applied to 2010 estimates in order to allow for both the increase in efficiency of vehicle engines together with the estimated growth in traffic.

The density of petrol is taken as 0.7347 tonnes per cubic metre and of diesel of 0.8446 tonnes per cubic metre. These are used to convert the estimated fuel changes in metric tonnes to litres when calculating resource, duty and tax cost figures.

2.6.1 SpeedTool

TRL developed a tool in conjunction with HA to assess emissions for a given speed profile and mix of vehicles; this is as discussed and applied in the ITS World Congress paper by Bell *et al* (2006). This tool (SpeedTool) uses the polynomial equations for estimating emissions as developed at TRL. They take into account changes in the emissions characteristics of newer vehicles and changes in the vehicle fleet (up to 2025).

SpeedTool derives emission factors from different sources:

- Cars have estimates from MODEM modelled data (Journard *et al*, 1995)
- HGVs have estimates from PHEM (Passenger cars and Heavy duty vehicle Emission Model) data
- LGVs (vans) have estimates from the NAEI's (National Atmospheric Emissions Inventory) emission function spreadsheet and from the Design Manual for Roads and Bridges (Highways Agency) screening assessment spreadsheet.

SpeedTool uses flows of different types of vehicles travelling at different speeds. It calculates the total emissions in metric tonnes (annual or daily) per kilometre for the vehicle fleet specified (i.e. number of vehicles of each type). An M25 traffic profile, and mix of vehicle types, and was used with the same average speed for whole day. The annual estimate per vehicle-km was computed by dividing emission/fuel change by the number of vehicles. The total emission effect was calculated from flow profiles (by vehicle type) for the type of road of interest and the emission rate per vehicle-km.

The SpeedTool was used to obtain estimates of annual emissions for before and after scenarios using average 'real world' congested speeds (see section 2.7.2).

Estimates of fuel use were also derived using SpeedTool. WebTAG gives the proportion of work/commuting/private time which were applied to each vehicle type. The calculation assumes that all work fuel use is diesel and all non-work is petrol. The estimates are adjusted, year by year, according to the expected traffic growth which is off-set by an increase in vehicle efficiency. The value of resource and duty costs for diesel and petrol are given by WebTAG (Table 11, WebTAG 3.5.6). Value Added Tax (at 17.5%) was only applied to private fuel use, i.e. petrol as defined for this calculation.

A standard relationship was used to estimate CO₂ from fuel. This was 3,114 gms of CO₂ from a metric tonne of diesel and 3,151 gms of CO₂ from a tonne of petrol.

2.6.1.1 Estimating the changes in emissions and fuel

In this analysis the metric tonnes of different emissions and of fuel are calculated using the HA/TRL SpeedTool. These estimates do not take into account growth or changes in the traffic volume projections; however these are incorporated into the calculations at a later stage. The initial (2010) estimates are adjusted, year by year, according to the expected traffic growth which is off-set by a predicted increase in vehicle efficiency.

Any change in emission levels (for a specific year) due to different speed scenarios can be computed per vehicle km (since the numbers of vehicles are known). The tonnes of emissions and fuel attributable to the proposed scenario being evaluated can then be calculated using vehicle flow, i.e.

$$\text{emissions} = \sum_{i=1}^m [\text{vehicle flow}]_i \frac{[(\text{emissions after per km})_i - (\text{emissions before per km})_i]}{[\text{number of vehicles}]_i}$$

The total emission figures for each year of interest can be calculated and are adjusted to take into account changes in the fleet and improved engine efficiency. The change in traffic growth is also taken into account in the calculation. This uses DfT figures interpolated as required. The Department for Transport (2007e) figures give the projected traffic growth increases shown in Table 2-3:

Table 2-3: Traffic changes from 2003

Traffic change from 2003	
year	% increase
0	0
7	11%
12	21%
22	31%

Source: Department for Transport (2007e)

2.6.1.2 The cost of emissions and fuel use changes

WebTAG guidance on the cost of carbon was considered. The WebTAG guidance includes proposed carbon values for the cost of emissions (for example, WebTAG proposes that one unit of NO_x is equivalent to 310 units of CO₂). Instead of using WebTAG guidance, however, advice from DfT Environmental Economists was to use Department for Environment, Food and Rural Affairs (Defra) shadow carbon values. Defra (2007) gives a figure of £25.50 per tonne for the shadow value of CO₂ (Annex 2, page 21). Defra figures for NO_x and PM were used in the final calculation. The Defra document also advises increasing 2008 values by 2% per annum to allow for the rising value of carbon emissions. This was incorporated into the final calculation.

Defra (2008b) also provides figures for NO_x and PM, see Table 2-4 and Section 2.8.3.

Table 2-4: Shadow values of NO_x and PM

Values in £ per tonne (2008 prices)	Annual pulse damage costs		
	Low	High	Central
PM (Transport)	34,753	50,439	44,430
NO _x	681	993	875

Source: Defra (2008b), Table 2, Page 5

These values have been used in the calculations appropriately inflated by growth factors to represent the increase in real value over time (2% as indicated by Defra). They have then been put into 2002 prices using the 2.5% inflation factor suggested by Defra. Finally, they were discounted back to 2010 using the 3.5% recommended Treasury discount rate.

2.6.1.3 Emissions and vehicle speed

The emission calculations are based on using mean speeds (by vehicle type). However, a more accurate estimate of the change in emission levels might be obtained by considering the distribution of vehicle speeds and obtaining a weighted average. To compare the different estimates provided by these two approaches, they were both used for petrol cars (Euro VI - 1.4 to 2 litre). The emission for each 5mph speed 'bin' was calculated and a weighted average obtained (using motorway current speeds). This was compared with the emissions obtained from just considering mean speeds. It was found that the two approaches agreed rather closely – the mean speed approach underestimated CO₂ emissions by about 1.5%. This good agreement results from the relatively 'flat' relationship between speed and emissions for CO₂, see Figure 2-1.

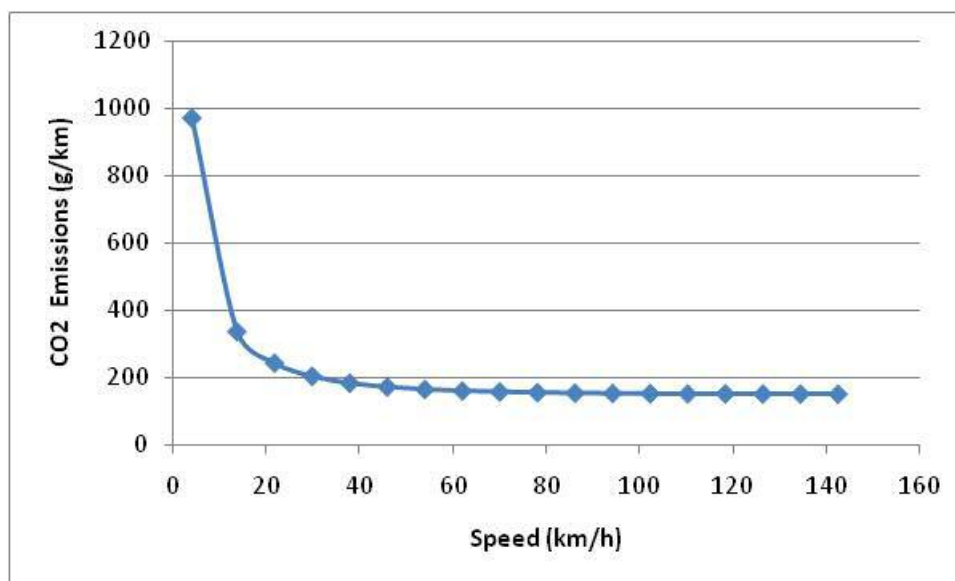


Figure 2-1 Relationship between speed and CO₂ emission for Euro IV petrol car

The relationship between NO_x and speed shows an increase in emission for speeds greater than 50kph, see Figure 2-2. The mean speed approach underestimated NO_x emissions by about 2.4% when compared to the approach using speed distributions and weighted averages (for motorway current speeds).

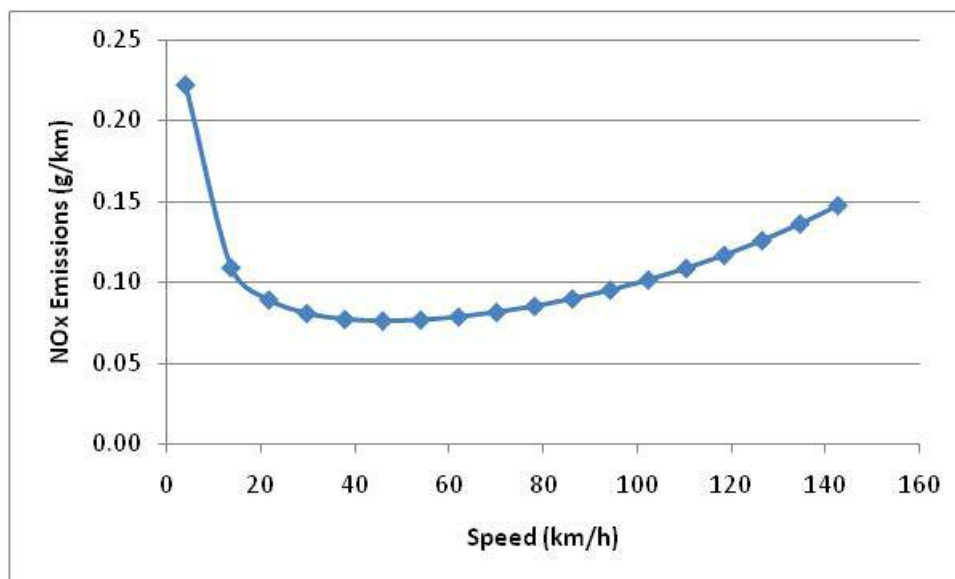


Figure 2-2 Relationship between speed and NO_x emission for Euro IV petrol car

The relationship between speed and particulates (PM) shows a steeper increase in emissions with higher speeds than that for NO_x, (resulting in an underestimate, if using a mean speed, of about 11%). However, PM levels are low, so the effect of the average speed approximation is considered to be minor.

The estimated emission values using mean speeds are close enough to the estimates using weighted averages to have only a minor effect on the overall results. Given this, it was concluded that the extra effect in applying a 'before' and 'after' speed distribution (even if they were available) to estimate the impact of an option would not significantly improve the precision of the change in emissions.

2.6.1.4 A note on emissions estimates

WebTAG has been used as baseline guidance for many of the estimates of impacts. In some cases it was felt that other approaches to estimating impacts were superior. This was the case for emissions where SpeedTool has been used to understand the impact of speed changes on CO₂, NO_x, PM and fuel use. SpeedTool integrates theoretical models with real world data. A new set of emission factors are in development and it is expected that these will be published in the near future. The CO₂, NO_x, PM and fuel use estimates from these new emissions factors are likely to be different from the current SpeedTool estimates. Going forward these are likely to be preferred for future analysis of the costs and benefits of the options described in this report.

2.7 Speeds

2.7.1 Vehicle speed and census point data

There are approximately 180 speed census data points (Department for Transport, 2007d) which have a frequency count of numbers of vehicles (by vehicle type) observed in 5mph bins. These data have been used when considering motorway speeds, however they are not sufficiently detailed to be used for National single carriageway 60mph roads and so the data from Department for Transport (2007f, Table 7.10) were used. This contains the distribution of vehicle speeds disaggregated by vehicle type.

The distribution of speeds is used, where necessary, to determine the average speeds and changes to average speeds that would result from the introduction of relevant options.

2.7.2 Changing speed limits

The effect of changing speed limits is estimated from speed distribution data by vehicle type and road type or from the census point data (Department for Transport, 2008d) where tenable. Following advice from DfT, a two-fold approach has been used when estimating the effect of changes in average speeds in order to allow for the problem of illegal journey time benefit, i.e. loss of illegal journey time benefit should not generally be included in the calculations. In order to address this issue two types of average speed are defined, 'compliant' and 'real world'.

- 'Compliant before speed': It is assumed that vehicle speeds are fully compliant with the speed limit before any change. This approach is used to ensure that the impact on journey time will not include any existing illegal benefit from speeding. Where the impact of an *increase* in speed limit is being considered, DfT suggested that the 'actual' average speed before the change (not assuming compliance) is used when calculating the effect on journey time. This is because using a 'compliant' speed in this case would give an overestimate of the journey time benefit, as it would include current illegal time benefit which would have become legal, as well as genuine time benefits.
- 'Real-world after speed': In calculating the new average speed after any change, it will generally be assumed that a 10mph change in the speed limit will result in a 2.4mph shift in the speed distribution (Finch *et al*, 1994). To determine the average speed after any change, the 2.4mph shift has been applied to the 'actual' speed before any change (i.e. not assuming compliance), in order to reflect the speeds that would be expected in the real world. In proposals where speeds are to be made compliant (use of cameras, calming etc.), then any drivers exceeding the new limit will be a distributional 'spike' at the new limit.

The benefit calculation will therefore be based on the difference between the modelled 'compliant before' average speed and 'real-world after' average speed. The average speed calculation is sensitive to the assumptions adopted and can have a significant impact on the estimated numbers of casualties, the emissions and especially the change in journey times. Speed calculations have been calculated using 'free flow' speeds. In practice the speed distributions included some congestion and hence the potential complication of explicitly accounting for congestion has effectively been addressed.

2.7.2.1 WebTAG – journey time values

Transport Analysis Guidance Website – WebTAG provides detailed guidance on the appraisal of transport projects and wider advice on scoping and carrying out transport studies. It includes, in section 3.5.6, values of journey times together with estimates of the proportion of journey time for work, commuting and other journeys. The values used within the required calculations refer to vehicle journey times as opposed to occupant journey time and values.

Table 7 of WebTAG Unit 3.5.6 has the proportions of travel in work and non-work time, and Table 9 the market price of values of time per vehicle in 2002 based on distance travelled (£ per hour, 2002 prices and values). For example, Table 7 states that cars spend 13.1% on a weekly average in work time at a cost, Table 9, of £30.18 per average all-week hour.

The real values of work and non-work time are expected to grow by the increases as given in WebTAG 3.5.6, Table 3.

2.7.2.2 Use in journey time calculations

'Compliant' journey times are calculated from average speeds computed as if drivers are fully compliant. The difference in the number of hours required to drive the annual

vehicle-km by vehicles between 'before' and 'after' scenarios is calculated and provides an estimate of the change in the number of hours driving required. WebTAG (Table 9, WebTAG 3.5.6) gives market cost for vehicle journey time for work and non-work time. The proportions of time vehicles are used in work and non-work time are given by Table 7 (WebTAG 3.5.6).

Initially a combination of WebTAG 3.5.6 tables was used to calculate occupant journey time costs. Table 1 for vehicle driver/rider working time market price, Table 2 for commuting and other non-working prices, Tables 4 and 5 to determine the vehicle occupancy rates and Table 8 for the proportion of occupant trips made in working time. On the advice of DfT economists, this use of several tables was replaced by using Table 9 which focuses on vehicle journey time delay costs (as opposed to occupant journey time costs) together with Table 7 for the proportion of vehicle use in work or non-work time. The real values of journey time increase for work and non-work time are adjusted according to a WebTAG inflator (Table 3, WebTAG 3.5.6).

A 2.5mph reduction in average speed across the network of motorway (about 100 billion vehicle-kilometres), results in an increase of 45 million hours per year. With an average cost per hour of about £10, this results in a journey time impact of £450m per year, attributable to an increase of just of a few minutes per hour of journey time.

The journey time calculation depends on the change in average compliant speeds by type of vehicle and the traffic flow per year. The average compliant journey times are computed as described above and the change in the number of hours travelling is computed by:

$$\text{change in hours} = \sum_{i=1}^m \left[\frac{(\text{vehicle flow})_i}{(\text{speed after in kph})_i} + \frac{(\text{vehicle flow})_i}{(\text{speed before in kph})_i} \right]$$

Where there are m types of vehicle (i=1 to m), and vehicle speeds have been converted to kph, since the vehicle traffic per year are in billion vehicle-kilometres.

The effect of traffic growth is not included in journey time cost estimates, this is because the interaction between traffic density and average speed is complex and it was not considered tenable to simply prorate journey times by the increase in traffic.

2.7.2.3 Use in emission and fuel calculations

The 'real world' average speeds are used in the casualty and the emission / fuel calculations. Where evidence of speed change is available for a specific proposal, it will be used as appropriate, e.g. when considering the wider use of 20mph zones.

If there is no proposed speed change but the current limits are being enforced, then the impact on average speed will be determined by comparing known average speeds with an estimated 100% compliant average. As discussed earlier in sections 2.7.2 and 2.2, DfT considers that any journey time costs resulting from the cessation of illegal speeds are not included within the analysis.

For the purposes of this analysis it is assumed that there are no behavioural changes in drivers other than the speed they may drive, and that they accept the revised traffic rules and 'go with the flow', e.g. if the road speed is lowered then it is assumed this will not cause more aggressive overtaking leading to an increase in accidents.

2.7.2.4 Sensitivity

In a proposed road safety scheme where average traffic speed is being influenced there are generally two dominant components. These are the journey time cost and the change in numbers of casualties. The difference between these two costs largely

determines whether the net present value is positive or negative. These costs, in turn, depend on the estimated change in average speeds. As has been discussed above, a 'compliant' current average speed is used when calculating journey time effects, and a 'real-world' average speed when estimating casualty savings.

A sensitivity analysis of the proposal to reduce National single carriageway speed limits from 60mph to 50mph has been conducted. The sensitivity analysis considered a range of average speed reductions (before to after) from zero to 6mph, and calculated the 10 year casualty saving and journey time costs at each speed point. Figure 2-3 shows how the estimated 10 years journey time costs vary by average speed difference (before to after). It shows a 'cross-over' point around the 2.5mph mean speed reduction, i.e. provided that the mean speed does not reduce by more than 2.5mph, then there will probably be a positive net benefit in adopting this proposal (i.e. casualty benefits will broadly be greater than journey time costs).

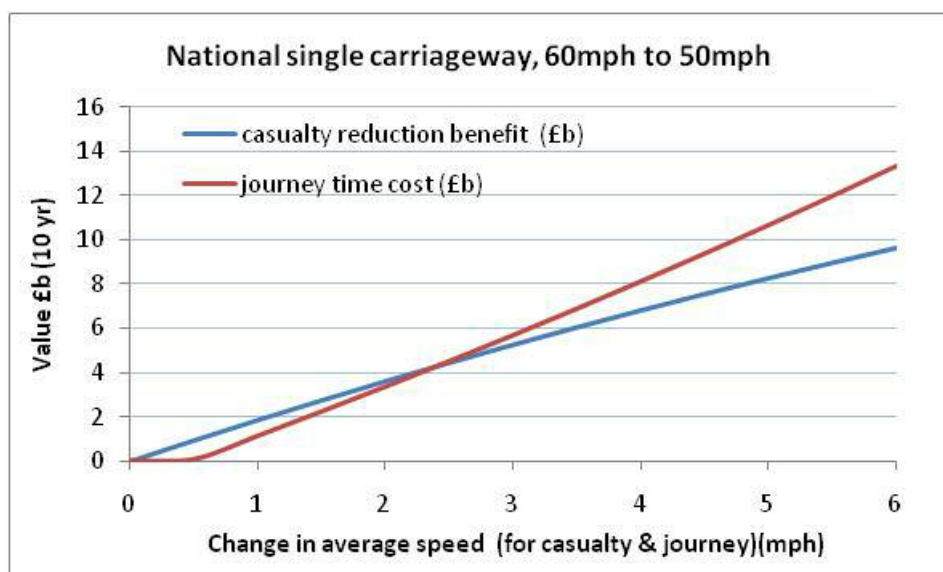


Figure 2-3 Sensitivity of casualty reduction benefit and journey time cost

Figure 2-3 indicates that the difference between the casualty benefits and journey time costs do not vary by much unless the average speed difference (between before and after) is outside of the range of 2-3mph.

2.8 Other data, evidence and inputs

2.8.1 Traffic growth

Future traffic increases are factored in using DfT overall traffic projections shown in Table 2-3. The traffic growth will affect emission and fuel use and potentially could affect journey times, although the interaction between traffic volume and average speed is not easy to incorporate.

2.8.2 HA data

TRL holds data relating to the HA network which has been used to obtain finer levels of detail on collisions, network traffic or network lengths than are available from published sources. These, necessarily, would only apply to the HA network but can be used to provide a better basis for estimating on specific road types. For example, the lengths of

CEN standard barrier⁴ for motorways and dual carriageway roads is not readily available from published sources, but a good estimate can be determined using HA survey data.

2.8.3 Environmental Analysis and Economics (EAE)

DfT environmental economists supplied information on the cost values associated with emissions, they also indicated that impacts on the Exchequer should be identified and, in effect, may become netted-off in the calculation, i.e. they may appear as a cost to the drivers and a benefit to the Exchequer (or vice versa). The cost values to use with emissions were advised to be those from Defra (2008a and 2008b).

The advice on the cost of fuel (resource, duty and tax) was to use data from WebTAG 3.5.6 Table 11.

2.8.4 Freight & Logistics Modelling (ITEA)

The DfT Freight & Logistics Modelling (ITEA) team have examined closely the methodology used in these calculations. They agreed that the basic approach was sound and provided advice on journey time calculation as well as checking the basic spreadsheet calculations. They concurred that the approach taken here to casualty saving estimates was the most defensible, as was also confirmed in the independent review by UCL (see Appendix B and Section 2.5.3). ITEA also endorsed the idea of using compliant 'before' average speeds and 'real-world' 'after' average speeds within the journey time calculation. This is the approach adopted for the figures presented.

The following sections describe the different options and present the net present value calculations for options considered in detail.

⁴ A European Committee for Standardization (Comité Européen de Normalisation – CEN) standard barrier means that the barrier has been tested to, and met the requirements of, the performance based European Norm (Standard) 1317. As the standard is performance based, the barrier can be manufactured from any material, and be of any design, so long as it meets the requirements of the associated full scale testing. Within the testing, the barrier is assessed for its ability to contain and redirect a test vehicle, deflection characteristics, and impact severity

3 Options taken to full cost benefit analysis

This section includes those proposals that the Steering Group considered should be take forward to full cost benefit evaluation. They are:

- Reduce the national speed limit on single carriageway roads without median barriers to 50mph
- Maintain the national motorway speed limit at 70mph and improve compliance using average speed cameras
- Use 20 mph zones in metropolitan residential areas more widely
- Increase investment in road safety engineering

3.1 Reduce the national speed limit on single carriageway roads without median barriers to 50mph

The Steering Group asked TRL to estimate the impact of reducing the National speed limit on single carriageway roads without median barriers to 50mph, (currently 60mph).

3.1.1 Implementation requirements and assumptions

Existing delimit signs would be interpreted as meaning 50mph instead of the current 60mph. It was assumed that media campaigns would be required to inform drivers, prior to introduction, at introduction and a reminder after 3-months – but still regarded as a first year cost. The new limits could be introduced 'over-night'. (Currently about 40% of cars travel on these roads above 50mph).

3.1.2 Costs

The following costs are considered:

- Media campaigns at £5m estimated total cost⁵ – split over two campaigns in first year.
- Cost of installing and maintaining 50mph signs – which will only be necessary where a 60mph sign is currently in use, (a nominal cost of £50 per sign has been assumed in order to replace 1000 signs in the first year and 100 per year thereafter). Most signs will be a delimit roundel and so will not need to be changed, i.e. if not a delimit sign then replace the 60mph sign with a 50mph or delimit. It is thought that there will be ongoing maintenance which may be necessary to clarify the new limit to drivers. It is assumed that a nominal sum will cover these costs, (£50k in the first year and £5k thereafter).

3.1.3 Calculations

The calculations were made using the assumptions as given above. However a number of other assumptions were also made.

- The number of 60mph roundels is not known and it has been assumed that there are 1000 to be changed to either 50mph or to the standard delimit sign. It has also been assumed that a small number of 50mph signs will always need replacing or maintaining every year, but that this will be a nominal cost which will not impact significantly on the overall costs and benefit figures.
- The SpeedTool model (HA/TRL) has been used to obtain an approximate idea of the change in emissions and fuel use. This tool can model speed distributions of vehicles and assess the differences in emissions and fuel use if the speed distribution is changed. The changes in emissions are small and suggest a small benefit as vehicle speeds reduce.
- Data have been obtained for National traffic flow for single carriageway roads from TRL held data (there are no appropriate published figures). The emission and fuel effects were estimated using the flow data and an associate cost per mile computed. The fuel (market price) cost was taken from WebTAG 3.5.6 table 11.
- The average speed on these roads will be lower if the speed limit is reduced to 50mph, and this means that there will be an increase in journey time. Estimates of the average speed reduction have been made using National Core Census (DfT) data. A value of 2.4mph has been employed (where necessary) in the 'real-world' approach used for emissions and casualty estimates. WebTAG 3.5.6 has estimates of value of travel time (Table 9) which have been used to calculate the (negative) disbenefit to drivers and passengers because their journey times increased under the proposal. The figures take into account the increase in real value of travel time over the years values of time (Table 3) and the proportion of vehicle trips in each travel type (Table

⁵ A figure of £2.5 per campaign was proposed by DfT

7) to identify business and non-business journey times. The number of hours delay was calculated using the TRL estimate of traffic flow per year of vehicle-Km on single carriageway roads together with the change in average vehicle speed.

3.1.4 Impact on road users

- 260 lives saved per year plus a reduction in other casualty severities (1045 serious and 3011 slight); these figures take into account projected traffic growth and anticipated casualty reductions due to improvements in secondary safety features and apply to 2006.
- Emission changes (overall CO₂ decrease of 0.01%, NO_x decrease of 0.7%)
- Overall fuel consumption decrease (0.1%)
- Increase in journey times of about 4%, (value of time).
- Note: Increased journey times, changes in emissions and fuel use estimates all depend upon an estimate of the vehicle-Km covered on derestricted single lane carriageways (by type of vehicle) as well as the average speeds and estimated compliant average speed as used within the journey time calculation.

3.1.5 Present values in 2010 (at 2002 prices) (2002 prices discounted to 2010)

Table 3-1: Present values in 2010 at 2002 prices

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Emissions and fuel (net of duty and tax) (£m)	Journey time (£m)	Duty and tax (not included in NPV) (£m)
	benefit-cost	cost	benefit	benefit	benefit	n/a
10 year	-149.2	5.1	4,458	37	-4,639	8.0
20 year	-1128.4	5.1	7,298	69	-8,490	14.3

Table 3-2: Fatal casualties and emission/fuel quantities

Sum over:	Fatal casualty reductions	NO _x (1000 Tonnes)	CO ₂ (1000 Tonnes)	PM (1000 Tonnes)	Petrol (1000 Tonnes)	Diesel (1000 Tonnes)
10 year	2,010	1.90	116.5	0.44	-43,960	81,894
20 year	3,550	4.21	258.1	0.98	-97,395	181,439
	decrease	decrease	decrease	decrease	increase	decrease

Note: Increases in emissions or fuel are shown as negative because they are negative benefits and then have the same 'sign' as the associated values

3.1.6 Observations

There is a negative net present value of the reduction in speed limit. This is in mainly due to a large negative benefit due to the cost of increased travel time (which equates to just over an extra 2.6 minutes per hour of the journey), off-set by the benefits due to reduced casualties. It is worth noting that relatively small changes in the average speed assumptions result in the NPV values changing from positive to negative, i.e. this proposal is close to having a zero NPV, i.e. costs and benefits balancing each other out.

For the purposes of the analysis it is assumed that previous levels of enforcement would continue and, as such, no additional costs for enforcement have been included.

3.2 Maintain the national motorway speed limit at 70mph and improve compliance using average speed cameras

The Steering Group asked TRL to estimate the impact of maintaining the National motorway speed limit to 70mph but making drivers as fully compliant as possible by using average speed cameras.

3.2.1 Implementation requirements and assumptions

A media campaign would be required. It would require installation of average speed camera systems (or equivalent) would need to be installed throughout the motorway network together with necessary infrastructure to process offence data. It was assumed that there would be an average speed camera system on every 'link', i.e. one system between every pair of motorway junctions and that implementation will take three years on a tapered basis, with 50% in the first year and a further 31% in the second year and 19% in the third year.

It was assumed that there will be that there are no changes to the legal speed limits for vehicles; i.e. those vehicles currently limited to 70 mph and those vehicles restricted to speeds below 70mph (HGVs, PSVs, trailers etc.) are assumed to remain restricted to their current speed limits.

3.2.2 Costs

The following costs are considered

- Media campaign – say £5m spread over first year of introduction.
- Installation cost which would be spread over period of three years (it is assumed that an average speed camera system would cost about £140k per system (DfT figure) and require about 800 systems).
- Maintenance of system (£12k pa per system – DfT figure)
- Infrastructure costs for issuing penalties etc. (estimated at an initial cost of £200k spread over three years)
- Potentially one could also consider that there is a cost to the Exchequer (loss) due to reduced fuel use

3.2.3 Calculations

- A critical calculation is on the number of average speed camera systems that would be required. It is estimated that (from 2007 HA motorway data) that the average link length is 4.4km. This suggests, that to cover the whole motorway system, that 800 average speed camera systems are required.
- It is assumed that the implementation would take three years, with a higher number being installed during the first year.
- It is also assumed that there would be an ongoing maintenance cost (£12k pa).
- There would also need to be an infrastructure cost to process the prosecution data. Assumed to be £200k capital cost spread over three years. No costs have been included for running or maintaining the 'back office'.
- The impact on average traffic speed is calculated such that drivers are fully compliant under the current motorway speed, i.e. do not exceed 70mph. This means that all drivers who currently exceed the speed limit are assumed to travel 70mph, and that the speeds of other drivers are assumed to be unchanged.
- As has been stated previously, any current illegal benefit gained due to exceeding the speed limit is not included in the calculation, i.e. there is no disbenefit due to reduced journey time for non-complaint drivers included in the calculation.
- There is a benefit due to lower CO₂ & NO_x emissions and fuel use.

3.2.4 Impact on road users

- 37 fewer lives lost per year plus decreases in other casualties (a decrease of 138 serious and 817 slight).
- Emission reduction (2.9% CO₂ and 4.0% NO_x)
- Fuel consumption reduction (2.9%)
- Journey times (an average increase of three minutes per hour of journey, but this effect is **not** included in the calculation as it is the loss of an illegally obtained benefit)

Table 3-3: Present values (2002 prices discounted to 2010 and 800 camera systems)

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Emissions and fuel (net of duty and tax) (£m)	Journey time (£m)	Duty and tax (not included in NPV) (£m)
	benefit-cost	cost	benefit	benefit	n/a	n/a
10 year	1251.1	167.1	620	798	0	748.7
20 year	2359.5	218.5	1,061	1,517	0	1,374.9

Table 3-4: Fatal casualties and emission/fuel quantities

Sum over:	Fatal casualty reductions	NO _x (1000 Tonnes)	CO ₂ (1000 Tonnes)	PM (1000 Tonnes)	Petrol (1000 Tonnes)	Diesel (1000 Tonnes)
10 year	289	20.0	5,236	3.7	380,425	1,296,607
20 year	510	43.4	11,364	8.0	825,615	2,813,954
	decrease	decrease	decrease	decrease	decrease	decrease

Note: Increases in emissions or fuel are shown as negative because they are negative benefits and then have the same 'sign' as the associated values

3.2.5 Observations

The net present value is positive. This is due to the benefits resulting from the decrease in emissions and fuel costs with no off-set for the decrease in illegal travel time, plus the benefit due to decreased casualties. The costs are high due to the estimated requirement for 800 average speed camera systems at a cost of £140k each (i.e. £112m), plus the associated maintenance and infrastructure costs.

3.3 Use 20 mph zones in metropolitan residential areas more widely

The Steering Group asked TRL to estimate the impact of the wider use of self enforced 20 mph zones. Specifically TRL was asked to analyse the wider use of these zones on residential roads in Greater London, Greater Manchester, Merseyside, South Yorkshire, Tyne and Wear, West Midlands, West Yorkshire, Strathclyde and Edinburgh.

There have been a number of studies assessing the casualty reduction impact of self enforcing 20 mph zones as well as evidence from local authorities which suggest different levels of casualty reduction. For example, results from analysis of casualty numbers from over 70 schemes in London showed killed and seriously injured casualties (combined) reductions of 57% (Webster and Layfield, 2003) and an earlier national study shows reductions of 60% (Webster and Mackie, 1996). More recent results show reductions of 33.5% for all accidents (personal communication, Metropolitan Authority). Results such as these can be applied to accident and casualty numbers on 'residential streets' to get an estimate of the achievable savings from rolling out engineered 20mph zones.

3.3.1 Implementation requirements and assumptions

The key assumptions are that:

- There is no distributed effect outside the zones – i.e. that drivers continue to drive at their current speeds where 20mph speed limits are not created.
- Suitable network lengths for 20mph zones, (as a proxy for 'residential roads'), are defined as Metropolitan minor urban roads which consist of about 39,523km (Department for Transport, 2008b).
- Scheme effectiveness with respect to fatal casualties is similar to that for killed, seriously or slightly injured.
- Effectiveness of self enforcing zones will be between 30% and 50% fatality reduction. This may seem an underestimate, but as zones are rolled out more widely they will be applied to areas with less potential for accident and casualty reduction. Wider use of zones will necessarily make them less targeted at areas where an accident problem has been specifically identified.
- Proportion of roads to which zones could be applied is 50%-70% of total road length (personal communication, metropolitan authority).
- Impact with respect to reductions in accident and casualty numbers is transferable. I.e. at a broad level a given percentage reduction in casualties can be taken to suggest a similar reduction in accidents.
- It is assumed that 12% of suitable roads already have 20mph zones (personal communication, metropolitan authority).
- Implementation (hence the engineering costs and subsequent benefits) would be scheduled over a three year period.
- It is not known what percentage of journey time would be in a 20mph zone, so for the purposes of calculating fuel and emission effects a 5% figure has been assumed.
- A 5% figure was also assumed for the purpose of calculating the impact on journey time, but the calculated journey time cost has not been included within the NPV. This is because many drivers who currently drive from or through residential areas will probably only experience a small increase in their actual journey time and so there is considerable uncertainty associated with this figure.

3.3.2 Costs

Costs are assumed to include:

- Cost of signs, marking roads and engineering (personal communication with Local Authorities suggests a cost of £59.3k per km). Maintenance cost should be minimal

over the time period and no associated costs have been included, albeit this is not strictly correct.

- Media campaign specific to zoned areas, leaflet drop assumed as £5m spread over introduction period.

3.3.3 Impacts on road users

- 38-84 lives saved per year (from a total of 240 in 2006) plus a reduction in other casualties (reduction of between 593 and 1384 serious casualties (from 3,954 in 2006) and between 5,191 and 12,112 (from 34,607 in 2006). The minimum casualty savings occur when 50% of suitable sites are converted to 20mph zones with an associated 30% saving in casualties at each site. The maximum casualty savings occur when 70% of suitable sites are converted to 20mph zones with an associated 50% saving at each site.
- Emission changes (increase within 20mph zones)
- Journey times (increase in journey time within 20mph zones, which is not included within the NPV for the reasons outlined above), these will be off-set by a small amount due to an increase in cycling.
- Fuel consumption (increase within 20mph zones)

3.3.4 Assumptions and associated calculations

There are a number of critical calculations required.

- The estimates are based on the assumption that between 50% and 70% of suitable residential roads will be converted to 20mph zones.
- The casualty savings will be between 30% and 50% at each site.
- About 12% of suitable roads already have 20mph zones.
- Only the speed of vehicles within the zone will be affected, journey time costs and emissions are calculated on this basis. The average speed, in a study of London 20mph zones (Webster and Layfield, 2003) dropped from an average of 25.8mph to 16.6mph after implementation.
- These average speeds have been used to calculate journey time change and emission/fuel effects and apply to all vehicles. The emission and fuel changes have been calculated using the SpeedTool developed by HA/TRL assuming the same average speeds for all vehicle types. (It is appreciated that if speed distributions for metropolitan 30mph roads were available then more precise estimates could be obtained).
- The estimated network length suitable for 20mph zones is 39,523km from Metropolitan urban unclassified roads (Department for Transport, 2008b). If 50% is converted the zones will apply to 18,773km and if 70% is converted this will be 26,285km.
- An estimate of vehicle-Km was used to pro-rate the values in Table 1a (c) of Road Casualties GB (2007) by those in Table 1a (d) in order to estimate figures for urban minor roads. This figure was derived from vehicle type flow data available from single carriageway roads used in section 3.1. (Only motorcycles, cars and van data have been used).
- It has been assumed that only 5% of journeys in residential roads would be affected, i.e. existing residential roads suitable for changing from 30mph to 20mph zones are only involved in 5% of journeys on urban unclassified roads. This is based on what seems reasonable and affects the fuel, emission and journey time estimates. However, as explained earlier, the journey time values are not included in the NPV.
- The average cost per km of implementing a 20mph zone is based on a figure of £59,334. It is assumed that, once a zone is established, that maintenance is minimal and no associated costs have been included. Maintenance programmes might routinely be expected to cover these costs.
- No costs for road safety officers have been included.

- In Ealing a study of 20mph zones showed that between 22% and 42% feel safer walking now that the zone has been implemented and between 5% (Hanger Hill) and 20% (Brent Road) had increased their walking or cycling since the zone's introduction (Ealing Local Implementation Plan, 2007).
- A conservative figure of 10% has been used to estimate an increase use of cycling for travelling with associated benefits within the 20mph zones. This is because 20mph zones tend to encourage more cycling (Ealing Local Implementation Plan, 2007). No other benefits from walking or health improvements have been included within the current calculations.

3.3.5 Present values: 30% casualty reduction (2002 prices discounted to 2010)

The calculations under the assumptions stated produced the following present values. It assumes the minimum benefit in casualty savings and (i.e. a 30% reduction in casualties when a site is converted to a 20mph zone) and that 50% of suitable residential roads are converted to 20mph zones.

Table 3-5: Present values: 30% casualty reduction (50% of suitable residential roads converted to 20mph zones)

Sum over:	Net present value (excluding journey time)(£m)	Implement ⁿ cost (£m)	Casualty (£m)	Emissions and fuel (net of duty and tax) (£m)	Journey time (5%) (including a cycling benefit) (£m)	Duty and tax (not included in NPV) (£m)
	benefit-cost	cost	benefit	benefit	n/a	n/a
10 year	578.1	867.0	1,538	-93	-2,346	-101.6
20 year	1669.8	867.0	2,727	-190	-4,525	-190.1

Table 3-6: Fatal casualties and emission/fuel quantities (50% of residential roads converted to 20mph zones)

Sum over:	Fatal casualty reductions	NO _x (1000 Tonnes)	CO ₂ (1000 Tonnes)	PM (1000 Tonnes)	Petrol (1000 Tonnes)	Diesel (1000 Tonnes)
10 year	294	-0.6	-654	0.0	-155,212	-52,985
20 year	518	-1.2	-1,326	-0.1	-325,316	-111,054
	decrease	increase	increase	increase	increase	increase

Note: Increases in emissions or fuel are shown as negative because they are negative benefits and then have the same 'sign' as the associated values

3.3.6 Present values: 50% casualty reduction (2002 prices discounted to 2010)

The calculations under the assumptions stated produced the following benefit cost ratios. It assumes the maximum benefit in casualty savings and 70% implementation of 20mph zones.

Table 3-7: Present values: 50% casualty reduction (70% of suitable residential roads converted to 20mph zones)

Sum over:	Net present value (excluding journey time)(£m)	Implement ⁿ cost (£m)	Casualty (£m)	Emissions and fuel (net of duty and tax) (£m)	Journey time (5%) (including a cycling benefit) (£m)	Duty and tax (not included in NPV) (£m)
	benefit-cost	cost	benefit	benefit	n/a	n/a
10 year	2202.2	1,212.0	3,545	-130	-3,284	-142.3
20 year	4807.2	1,212.0	6,286	-266	-6,336	-266.2

Table 3-8: Fatal casualties and emission/fuel quantities (70% of residential roads converted to 20mph zones)

Sum over:	Fatal casualty reductions	NO _x (1000 Tonnes)	CO ₂ (1000 Tonnes)	PM (1000 Tonnes)	Petrol (1000 Tonnes)	Diesel (1000 Tonnes)
10 year	649	-0.8	-916	-0.1	-217,296	-74,179
20 year	1,146	-1.7	-1,919	-0.1	-455,443	-155,476
	decrease	increase	increase	increase	increase	increase

Note: Increases in emissions or fuel are shown as negative because they are negative benefits and then have the same 'sign' as the associated values

3.3.7 Observations

The net present values are positive but have been calculated without journey times. Estimates of the present value of journey time impacts are provided for information and it has been assumed that 5% of a journey on these metropolitan roads may be in a 20mph zone. The present values of the emissions figures are included in the net present value calculation.

Even though the extra journey time is likely to be small (and a small proportion of the overall journey), the calculation suggests that (even at 5% of the journey) there would be a significant cost. This cost is larger than the benefit gained from fewer casualties and would make the net present benefit negative. The travel cost includes an allowance for an increase in cycling which would be expected to arise if there were more 20mph zones. The estimated cycling benefit after 10yrs for the 50% 20mph zone case is about £36m.

3.4 Increase investment in road safety engineering

The Steering Group asked TRL to estimate the impact of an annual average 25%, 50% or 100% increase in investment in road safety engineering schemes from 2010 to 2020. Department for Transport (2009b) presents findings of a study into the contribution of local safety schemes to casualty reduction which sits alongside this evaluation.

3.4.1 Implementation requirements and assumptions

Atkins (2008) produced an unpublished comprehensive note on the effects of increasing investment in road safety schemes. This supplied figures on current funding for road safety engineering schemes in 2005/2007 on Local Government and Highways Agency roads. The figures supplied in Atkins (2008), together with the casualty savings have been used in the benefit cost calculations. The mix of road safety engineering projects will vary and may include some maintenance, they may also overlap with other proposals and so there is a potential to double-count.

3.4.2 Costs

An increase of 25%, 50% or 100% on money for road safety engineering schemes from 2010 to 2020. This consists of 25%, 50% or 100% of current spending, the following spends have been assumed (2005 prices):

- Local Government
 - Safety schemes £524.4m
 - Road Crossing schemes £97.7m
 - Local Road Improvement schemes £297.1m
- Highways Agency - £110m Specific Road Safety Grant

3.4.3 Impacts on road users

Reduction of casualties per year are estimated and given in the Atkins report. The report finds that for a 25% increase in funding the estimated casualty saving varies between 0.61% and 2.45%, i.e. between 1583 and 6331 (at 2006 levels in the first year and equating to between 19 and 77 fewer fatal casualties). The 50% and 100% increases give a range of casualty savings from 1.23% - 4.90% and 2.45% - 9.80% respectively. It is assumed this benefit applies in the first year of the extra investment (2010) and continues thereafter for the next nine years with the expected number of casualty savings increased accordingly. Because the extra funding allows for engineering projects, (i.e. they are permanent benefits), it is assumed that the level of casualty saving is maintained after the increase in funding reverts in 2020.

3.4.4 Calculations

- The costs are assumed to be 25%, 50% or 100% of the total budgets listed above (25% is estimated at £249m pa in 2010 at 2002 values).
- The road safety engineering schemes are assumed to be permanent improvements to road safety and as such remain effective after completion, hence they are assumed to continue to result in reduced casualty numbers after 2020.
- The benefits are the number of casualties saved pro-rated to take into account the decreasing trend in numbers of casualties. The casualty saving is a weighted average of the HEN costs for fatal, serious and slight casualties (£52,850 per casualty at 2007 values and prices).

3.4.5 Present values – 25% increase in budget (2002 prices discounted to 2010)

The calculations, under the assumption of a 25% increase in road safety budgets and either minimum (0.61%) or maximum (2.45%) casualty reductions, generated the following net present values after 10 or 20 years.

Table 3-9: Present values - 25% increase in budget and minimum number of casualty reductions (n= 1,583 in 2006)

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Casualty reductions
10 year	1,774	2,000	3,774	14,878
20 year	7,499	2,000	9,499	14,486

Table 3-10: Present values - 25% increase in budget and maximum number of casualty reductions (n= 6,331 in 2006)

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Casualty reduction
10 year	12,312	2,000	14,312	54,842
20 year	33,414	2,000	35,414	53,396

3.4.6 Present values – 50% increase in budget (2002 prices, discounted to 2010)

The calculations, under the assumption of a 50% increase in road safety budgets and either minimum (1.23%) or maximum (4.90%) casualty reductions, generated the following net present values after 10 or 20 years.

Table 3-11: Present values - 50% increase in budget and minimum number of casualty reductions (n=3,166 in 2006)

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Casualty reductions
10 year	3,415	4,000	7,415	28,954
20 year	14,556	4,000	18,556	28,191

Table 3-12: Present values - 50% increase in budget and maximum number of casualty reductions (n=12,663 in 2006)

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Casualty reduction
10 year	22,708	4,000	26,707	98,599
20 year	60,647	4,000	64,647	95,999

3.4.7 Present values – 100% increase in budget (2002 prices discounted to 2010)

The calculations, under the assumption of a 100% increase in road safety budgets and either minimum (2.45%) or maximum (9.80%) casualty reductions, generated the following net present values after 10 or 20 years.

Table 3-13: Present values - 100% increase in budget and minimum numbers of casualty reductions (n=6,331 in 2006)

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Casualty reductions
10 year	6,313	7,999	14,312	54,842
20 year	27,415	7,999	35,414	53,396

Table 3-14: Present values - 100% increase in budget and maximum numbers of casualty reductions (n=25,326 in 2006)

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Casualty reduction
10 year	38,758	7,999	46,757	160,653
20 year	100,574	7,999	108,574	156,418

3.4.8 Observations

The net present values are all positive and depend on the estimated number of casualties. As noted above, the investment in road safety engineering is assumed to have a cumulative effect in the first 10 years and with the benefit continuing thereafter the benefit continues. However, since the number of casualties is reducing the actual number saved is smaller after 20 years as compared to the 10 year figure – but the proportion of projected numbers of casualties are higher.

4 Options taken to partial cost benefit analysis

The Steering Group considered that some measures were not suitable to be taken forward to full cost benefit analysis. For these measures, however, some level of cost benefit analysis has been undertaken. These measures were:

- Increase the motorway speed limit to 80mph and improve compliance using average speed cameras
- Reduce the motorway speed limit to 60mph and improve compliance using average speed cameras
- Undertake mass action programmes: IHIE guidelines for motorcycles
- Undertake mass action programmes: barriers
- Get younger drivers into newer cars so that they benefit from improved safety features
- Introduce single double summer time (SDST)

4.1 Increase the motorway speed limit to 80mph and improve compliance using average speed cameras

The Steering Group asked TRL to estimate the impact of increasing the National motorway speed limit to 80mph with compliance improved through the use of average speed cameras.

4.1.1 Implementation requirements and assumptions

Similar implementation considerations apply as for the proposal discussed in section 3.2. It would also require changes to the legal speed limit for vehicles to 80mph for just those vehicles currently limited to 70 mph, other vehicles restricted to speeds below 70mph (HGVs, PSVs, trailers etc.) are assumed to remain restricted to their current speed limits. Some current illegal journey time benefit becomes legal due to the speed limit increase; this element is not taken as being part of a benefit in journey time reduction and is the approach suggested by DfT.

4.1.2 Impact on road users

- 18 extra lives lost (full year estimate) plus increase in other casualties (increase of 64 serious and 363 slight casualties).
- Emission increase (+1.7% CO₂ and +1.8% NO_x)
- Fuel consumption increase (+1.7%)
- Journey times (an average decrease of 4.1 minutes per hour of journey)

4.1.3 Present values (2002 prices discounted to 2010)

Table 4-1: Present values (800 camera systems)

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Emissions and fuel (net of duty and tax) (£m)	Journey time* (£m)	Duty and tax (not included in NPV) (£m)
	benefit-cost	cost	benefit	benefit	benefit	n/a
10 year	1250.9	167.1	-298	-443	2,159	-356.1
20 year	2483.0	218.5	-510	-887	4,098	-654.0

*Journey 'before' average speed based on 'actual' not a compliant speed

Table 4-2: Fatal casualties and emission/fuel quantities

Sum over:	Fatal casualty reductions	NO _x (1000 Tonnes)	CO ₂ (1000 Tonnes)	PM (1000 Tonnes)	Petrol (1000 Tonnes)	Diesel (1000 Tonnes)
10 year	-143	-9.0	-2,615	-1.6	-162,484	-675,255
20 year	-252	-19.5	-5,675	-3.4	-352,630	-1,465,467
	increase	increase	increase	increase	increase	increase

Note: Increases in emissions or fuel are shown as negative because they are negative benefits and then have the same 'sign' as the associated values

4.1.4 Observations

The net present value is positive which is due to large off-set for the decrease in journey time even though previous illegal journey time is not included, i.e. some previous illegal

journey time becomes legal but this is not included in the estimate. However there is an increase in casualties which make this proposal unacceptable to DfT as part of a road safety strategy.

4.2 Reduce the motorway speed limit to 60mph and improve compliance using average speed cameras

The Steering Group asked TRL to estimate the impact of reducing the National motorway speed limit to 60mph and make as fully compliant as possible by using average speed cameras.

4.2.1 Implementation requirements and assumptions

Similar implementation considerations apply as for the option discussed in section 3.2. It would also require changes to the legal speed limit since all vehicles will be limited to 60 mph or less and those vehicles currently restricted to 60mph (HGVs, PSVs, trailers etc.) are assumed to remain restricted to 60mph or less.

4.2.2 Impact on road users

- 94 fewer lives lost per year plus decrease in other casualties (a decrease of 371 serious and 2376 slight).
- Emission reduction (-7.3% CO₂ and -10% NO_x)
- Fuel consumption reduction (-7.3%)
- Journey times (an average increase of 6.8 minutes per hour of journey and this effect is included in the calculation)

4.2.3 Present values (2002 prices discounted to 2010)

Table 4-3: Present values (800 camera systems)

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Emissions and fuel (net of duty and tax) (£m)	Journey time (£m)	Duty and tax (not included in NPV) (£m)
	benefit-cost	cost	benefit	benefit	benefit	n/a
10 year	-7576.6	167.1	1,849	2,281	-11,539	1,798.5
20 year	-14359.6	218.5	3,172	4,569	-21,881	3,302.8

Table 4-4: Fatal casualties and emission/fuel quantities

Sum over:	Fatal casualty reductions	NO _x (1000 Tonnes)	CO ₂ (1000 Tonnes)	PM (1000 Tonnes)	Petrol (1000 Tonnes)	Diesel (1000 Tonnes)
10 year	726	51.0	13,067	9.2	907,467	3,277,889
20 year	1,283	110.7	28,358	20.1	1,969,424	7,113,819
	decrease	decrease	decrease	decrease	decrease	decrease

Note: Increases in emissions or fuel are shown as negative because they are negative benefits and then have the same 'sign' as the associated values

4.2.4 Observations

The net present value is negative which is due to large off-set for the increase in travel time. There is a decrease in casualties but the increase in travel time results in a negative net present value, and so suggests that it is unacceptable.

4.3 Undertake mass action programmes: IHIE guidelines for motorcycles

The Steering Group asked TRL to estimate the impact of a mass action⁶ programmes to reduce motorcycle accidents through introduction of IHIE⁷ guidelines for motorcycle safety (IHIE, 2008).

The IHIE guidelines suggest the introduction and consideration of approximately twenty potential improvements to highway design and infrastructure which could reduce the number of motorcyclist injured and killed on roads in the UK. These include improvements such as increasing visibility at junctions and enabling motorcyclists to use dedicated bus lanes in urban environments.

Some measures, such as the removal of debris from road surfaces, are primary safety measures, which may prevent some accidents altogether; others, such as the use of frangible barriers, are secondary safety measures in that they will not prevent an accident but could reduce the severity of injuries to motorcyclists involved in accidents.

On The Spot files were analysed by accident investigators who offered an opinion on the contribution of different causative factors, as shown in Table 4-5.

Table 4-5 Features considered as causative from 372 OTS accident records involving motorcycles

Feature	Present	Present %	Causative	Causative %
Reduced Friction at Junctions	137	36.8%	45-90	12.1%-24.2
Sightlines at junctions	37	9.9%	16	4.3%
Debris	12	3.2%	11	3.0%
Friction changes on bends	6	1.6%	6	1.6%
Roundabout design	25	6.7%	5	1.3%
Bends: double apex	19	5.1%	3	0.8%
Clearer signing	3	0.8%	3	0.8%
Manhole covers	2	0.5%	2	0.5%
Sightlines: A pillar	4	1.1%	2	0.5%
Changes in surface friction on straight roads	1	0.3%	1	0.3%

High-friction surfaces at junctions on the 'main arm' of urban roads was taken forward as a case study to understand the impact of a measure proposed to improve the safety of motorcyclists.

4.3.1 Implementation requirements and assumptions

Resurfacing of junctions areas on major arm assuming that entry from minor arm is not a problem. The resurfacing would be scheduled over a period. The programme could take 2-5 years to complete (3 years have been assumed). It is necessary to know how many such junctions exist and current status of the road surface, and an estimate has been made based on data from one Local Authority.

4.3.2 Costs

The main cost is in the resurfacing work required (cost of £4,800 per junction) and the maintenance (replacement every six years)

⁶ Transport Scotland suggest the following definition of mass action: Mass Action programmes are a means to address a significant number of common type accidents that, while potentially occurring across a wide area, have a common cause, theme or pattern. The implementation of such a programme involves the use of known engineering solutions to negate the actual hazards or mitigate their impact, thereby raising the overall safety performance of the route.

⁷ Institute of Highway Incorporated Engineers

4.3.3 Impact on road users

There is an estimated benefit in terms of reduced numbers of motorcyclists being collision involved.

4.3.4 Calculations

- It is estimated from detailed data available from the DfT/TRL OTS study (On The Spot) project that between 12% and 24% of powered two wheeler accidents could be prevented. This translates into a casualty saving of between 71-143 fatal injuries, 744-1488 serious injuries and 2023-4047 slight injuries.
- Assume that each junction will be surfaced on the major-arm only and that an area of 400sq/m is required for each, i.e. 50m by 8m area.
- Pytlik (2006) suggests that high friction surfaces last for about six years and the cost per sq/m to maintain/build is about £12. Hence, assuming a junction requires about 400 sq/m it will cost about £4,800 every six years. (Solihull has about 40,000 sq/m of high grip in 2006 and is increasing this by 1,700sq/m pa – Solihull represents about a 400th of the PU+PU2 network of GB roads).
- The number of urban junctions is not known. However an estimate has been calculated from the total length of urban A road (11,139km) and assuming 10 junctions per km (based on a small survey of urban A roads). This is an uncertain estimate, but all that was possible to calculate from available data. Hence, the implementation of high-friction urban junctions is being considered for just junctions involving an A class urban road.
- It has been calculated that there are about 111,390 urban A road junctions which should become high grip surfaces under this proposal.
- High grip junctions have a six year life expectancy before needing renewal and this fact was incorporated into the spreadsheet by assuming a six year renewal cycle strategy.
- The exact number of existing high-friction junctions is not known. However, it was assumed that, initially, there are 20,000 high grip surfaced junctions in 2006 and that this has increased to 30,000 by 2010. This is a rough estimate but provides a base figure (which equates to half the prorated figure using Solihull as an example, Pytlik (2006)). It results in a further 83,190 junctions being treated to high grip surfacing from 2010 over a 3-year period.

4.3.5 Present value – casualty saving (2002 prices discounted to 2010)

The calculations under the assumptions stated produced the following minimum and maximum casualty savings with associated net present values.

Table 4-6: Present value - minimum casualty saving (12%)

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Fatal casualty reductions
10 year	1194.4	651.8	1,846.2	593
20 year	2135.6	1,150.8	3,286.3	1,084

Table 4-7: Present value - maximum casualty saving (24%)

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Fatal casualty reductions
10 year	3051.4	651.8	3,703.2	1,194
20 year	5441.2	1,150.8	6,592.0	2,183

4.3.6 Observations

It is assumed that other factors associated with junction design and layout do not impact on the extra benefit provided by high grip surfaces, i.e. sight lines etc. The casualty savings result from the motorcyclist being able to stop or avoid an emerging vehicle into their path. The net present values indicate that this proposal would produce a positive overall benefit.

4.4 Undertake mass action programmes: barriers

The Steering Group asked TRL to estimate the impact of a mass action programme to introduce CEN standard side barriers to motorways and dual carriageways.

4.4.1 Implementation requirements and assumptions

Add or change all side barriers on motorway and dual carriageways to meet CEN standard. The length of existing side barrier has been estimated by extrapolating from HA survey sources to the whole network. The costs presented assume that all sides would receive a CEN standard barrier. However it is possible that installing barriers may not be necessary on some roads because of a safe 'run-off' area. Hence the net value could be greater than suggested if they were only fitted when necessary.

4.4.2 Costs

The main cost is in the implementation of CEN standard barriers or in the replacement of existing barriers with a CEN standard. It has been estimated that the cost is £50k per km for the right and left sides of the road (virtually all central reservations on motorways and dual carriageways have CEN standard barriers).

4.4.3 Impact on road users

Casualty reductions use HEN figures for motorway (or non-built-up) casualty costs. Casualty figures are pro-rated from 2010 to take into account the projected decrease in casualties. It is difficult to assess what casualty severity reductions there are as a result of the CEN barriers. The approach has been to estimate accident savings based on HA network data. The casualty savings are estimated from the reduced numbers of accidents resulting from having a CEN standard safety barrier.

4.4.4 Calculations

- Figures from HA survey suggest that 50% of motorways and about 26% of dual-carriageways have a roadside safety fence (which will be to a CEN standard).
- The estimated accident savings are based on the differences between the lower accident rate for 4* CEN barriers as compared to non-CEN barriers, based on HA network data.
- The length of the whole network has been used when calculating the length of network to be fitted with a CEN barrier. However, it is possible that only slightly reduced casualty savings would be achieved by just selecting higher risk roads.
- It is assumed that barrier construction would involve both sides. Hence the length for installation will be twice the estimated length (1760km for motorways).
- It is assumed that the installation / replacement process would be spread over a 3-year period.
- The estimate of the KSI accidents saved was translated into casualties by pro-rating using accident and casualty data by road type.

4.4.5 Present value – motorway (2002 prices discounted to 2010)

The calculations under the assumptions stated produced the following net present values. The whole year 2006 estimated casualty savings were for 24 fatal, 138 serious and 1495 slight injuries.

Table 4-8: Present value - motorway

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Fatal casualty reductions
10 year	460.77	77.7	538.4	185
20 year	876.68	77.7	954.3	327

4.4.6 Observations -motorway

The whole motorway network length has been used in the calculation, and 50% would have CEN standard side barrier installed. The accident reduction is based on the assumption that the lower accident CEN rate for 4* rated HA motorways (Castle *et al*, 2007) would apply to the whole motorway network. There are non-CEN standard sections of motorway which have a higher accident rate, so in theory, making it all CEN should generate accident reductions. The approach may lead to an over optimistic estimate of accident savings, because if a motorway has >10m side run-off areas these may be safer than a CEN barrier, which could 'bounce' vehicles back onto the carriageway. It is not known quite how a barrier would change the severity of the accident and so it is suggested that the accident savings, and hence the net value, should be treated with some caution. However, the net present values are positive after 10 years installation which suggests that it may be worth considering for motorways.

4.4.7 Present value – dual carriageway (2002 prices discounted to 2010)

The calculations under the assumptions stated produced the following net present values. The whole year 2006 estimated casualty savings were for 33 fatal, 261 serious and 1999 slight injuries.

Table 4-9: Present value - dual carriageway

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Fatal casualty reductions
10 year	-453.86	1,259.1	805.2	255
20 year	156.75	1,259.1	1,415.8	450

4.4.8 Observations – dual carriageway

The whole A road dual carriageway network length has been used in the calculation, and 74% would have CEN standard side barrier installed. The accident reduction is based on the assumption that the lower accident 4* CEN rate for HA dual carriageways applies to the whole network. The 4* rate was estimated from a plot of HA data of accident rates by star ratings. The basic approach may lead to an over optimistic estimate of accident savings because of the underlying assumptions. It is also not known how a barrier would change the severity of the accident and it is suggested that the accident savings, and hence the net value, should be treated with some caution. The 'break even' point lies between 10 and 20 years after the installation.

4.5 Get younger drivers into newer cars so that they benefit from improved safety features

The Steering Group asked TRL to estimate the impact of getting younger drivers into newer cars.

This section describes the process of reaching an estimate through addressing the question of how much money could be used to subsidise each newly qualified driver to allow them to purchase cars which are 18 months or less old, to achieve a benefit/cost ratio (BCR) of 2.5.

The benefit calculation is based upon the number of car occupant casualties in 2006. The approach estimates casualty benefits under the scenario that all drivers aged 17-22 who were actually driving cars registered before 2004/5 had instead been driving cars registered in 2004/5. (The existing secondary safety analysis takes pairs of registration years, so this gives the best approximation to the '18 months or less old' of the question.) The estimated casualty saving in 2006 with this scenario is shown in Table 4-10.

Table 4-10: Estimated casualty savings arising from younger drivers having been in cars 18 months or less old

		actual casualties	reduction	%
Killed	17-19	271	80	30%
	20-22	222	61	27%
	other	1098	0	0%
	all ages	1591	141	9%
KSI	17-19	2190	420	19%
	20-22	1673	306	18%
	other	10055	0	0%
	all ages	13918	725	5%

The basis of the estimation of the benefits of secondary safety is the assumption that the overall number of casualties will not change, but the injury severity will tend to be reduced, so these benefits will be partially offset by an increase of 725 slight casualties. The net value of the casualty changes is £330m p.a.

It will be assumed that the newly qualified drivers will keep their newish cars for five years, and the discounted value of this benefit is £1543m over five years. This may be a slight overestimate since occupant casualty rates are likely to fall over this period.

773 thousand drivers passed the driving test in the 2006/7 financial year (Department for Transport, 2007f), so to achieve a BCR of 2.5 the subsidy per newly qualified driver is $1543 / (0.773 * 2.5) = £799$.

4.5.1 Observations

This calculation assumes that all the young drivers involved in these accidents were driving their own cars, whereas in fact a proportion will have been driving cars owned by their parents, friends etc. Stats 19 cannot be used to get a figure for which of the drivers recorded were driving their own cars and which were driving 'other' cars. However, dividing the national number of registered cars by the number of drivers with full licences shows about 0.83 registered cars per driver. Applying this factor, only 83% of the casualty savings would be realised since these other cars would probably not have been replaced under the subsidy scheme. This reduces the subsidy to £659 per newly qualified driver.

4.6 Introduce single double summer time (SDST)

The Steering Group asked TRL to estimate the impact of introducing Single Double Summer Time (SDST). Single/Double Summertime in Britain would mean that the time would be GMT + 1 hour from October to March and GMT + 2 hours from March to October. This would mean that Britain was in the Central European Time Zone.

Broughton and Stone (1998) estimated the national change in the number of fatal and serious casualties if clocks had been set to SDST between 1991 and 1994. There were two estimates for fatal casualties: reductions of 104 or 138 per year. The only estimate for serious casualties was a reduction of 339 per year.

Annual casualty totals have fallen since this period, so these estimates have been scaled down pro rata in the analysis presented here. Based on the 2003-07 totals, it is estimated that adopting SDST would have reduced the number of fatal casualties by 82 per year (based on the lower estimate for 1991-94) and the number of serious casualties by 212 per year.

4.6.1 Implementation requirements and assumptions

This would be implemented at an appropriate time, i.e. when a change to BST / GMT was about to occur, and would only require a media campaign. There are political reasons for this proposal not being implemented, which may result in it not being considered for implementation.

4.6.2 Costs

The only cost taken into account is that of a media campaign. It has been suggested that there may be associated industry costs in agriculture and retail, media and other industries relying on early morning working.

4.6.3 Impact on road users

An estimated 82 fatal casualties and 212 serious casualties would be avoided per year (also a pro-rated number of slight casualties, 1487) at 2006 levels. Other claimed benefits are reduction in energy costs, reduction in carbon emissions and an increase in tourism opportunities.

4.6.4 Calculations

The calculations only include the costs of a media campaign and the benefit from casualty savings. The numbers of casualties are adjusted from the estimated 2006 numbers to 2010 taking into account the projected decrease in overall casualties. Other claimed benefits and disbenefits are thought to be small relative to the casualty savings.

4.6.5 Present value (2002 prices discounted to 2010)

The calculations under the assumptions stated produced the following benefit cost ratios.

Table 4-11: Present value

Sum over:	Net present value (£m)	Implement ⁿ cost (£m)	Casualty (£m)	Fatal casualty reductions
10 year	1378.62	5.0	1,383.6	782
20 year	2451.71	5.0	2,456.7	1,549

4.6.6 Observations

The calculations indicate a clear positive benefit cost ratio.

RoSPA (1998) suggests that changing to SDST would also have the following quantified benefits:

- reduce peak evening demand by 2.78 MWhs pa
- reduce carbon emissions by 1.2 million tonnes pa
- boost inbound tourist industry by £1Bn pa
- boost overall spending in UK leisure sector by £2Bn.

It would also reduce fuel bills, help reduce fuel poverty, increase participation in sport with the consequent health benefit. There may be similar campaign figures for the agriculture, media and retail industries, albeit negative benefits. No such estimates have been included in the calculations.

5 Options with quantitative casualty benefit estimates

For this group of measures, the Steering Group considered that an evaluation of the casualty benefits was sufficient. These measures were:

- Reduce the drink drive limit to 50mg or 20 mg
- Introduce programmes to fit alcolocks

5.1 Reduce the drink drive limit to 50mg or 20 mg

The Steering Group asked TRL to estimate the impact of reducing the drink drive limit to 50 milligrammes or 20 milligrammes of alcohol per 100 millilitres of blood.

The current drink-drive limit in Great Britain is 80 milligrammes of alcohol per 100 millilitres of blood, equivalent to 35 microgrammes of alcohol per 100 millilitres of breath. The limit was set in 1967, and is now the highest in Europe, although penalty regimes for offenders differ greatly between nations, with GB's being among the most stringent. The limits in the EU member states in 2007 are shown in Table 5-1, which is based on data from the website of the European Road Safety Observatory.

Table 5-1: Drink-drive limits in the EU member states (2007)

Country	Limit	Country	Limit
Luxemburg	80	Latvia	50
Malta	80	Netherlands	50
Rep. of Ireland	80	Portugal	50
United Kingdom	80	Slovenia	50
Austria	50	Spain	50
Belgium	50	Lithuania	40
Cyprus	50	Poland	20
Denmark	50	Sweden	20
Finland	50	Czech Republic	0
France	50	Estonia	0
Germany	50	Hungary	0
Greece	50	Slovakia	0
Italy	50		

5.1.1 Approach to estimation of casualty reductions

The approach adopted here in order to estimate casualty reduction impacts of reducing the drink-drive limit uses information about numbers killed and injured in road traffic accidents, the distribution of BACs of drivers killed in road traffic accidents and of drivers involved in road traffic accidents that result in personal injury, estimated relationships between accident risk and driver's BAC, and assumptions about the effect of changes in the drink-drive limit upon the numbers of accident-involved drivers with various levels of BAC⁸.

Because of the many relevant differences between countries, only information about drivers and accidents in Great Britain and relationships derived from such information are used. The assumptions about possible effects of changes in the legal BAC limit upon numbers of accident-involved drivers are developed by the author from a more limited set of similar assumptions made by him in an earlier study which has been in the public domain since 2005.

⁸ All references to alcohol levels are to blood alcohol concentration (BAC) in units of mg/100ml without mention of the units.

5.1.2 Sources of information

The Department for Transport (2007c) provides estimates of numbers of casualties in recent years in accidents in which at least one driver had a BAC over 80 (Table 3a on page 29).

Pending widespread use of new technology in screening breath tests and in testing accident-involved drivers, and the possible conduct of a fresh roadside survey of the BACs of drivers in general, information about distributions of BACs of drivers killed and drivers involved in injury accidents and estimated relationships between accident risk and driver's BAC are drawn from Maycock (1997) review. Confidence in the continued relevance of this information is drawn from the general consistency between the unpublished results of the 1998-99 roadside surveys (Tunbridge *et al* 2003) and those of earlier surveys used by Maycock, and the broad stability over time, and consistency with the data used by Maycock, of the distribution of BACs of killed drivers reported in Department for Transport (2007c) (Table 3h) and corresponding tables in earlier years. The author's earlier thinking about possible effects of changes in the legal BAC limit upon numbers of accident-involved drivers, which started from the corresponding discussion in the consultation paper *Combating drink driving: next steps*, is recorded elsewhere (Allsop, 2005).

5.1.3 The process of estimation

The Department for Transport (2007c) shows accidents in which at least one driver's BAC exceeds 80 accounting, in round figures, for about 550 killed, 2,000 seriously injured and 12,000 slightly injured per year (Table 3a). The annual number killed has been broadly steady for a decade, during which the number seriously injured has fallen by about one-third and the number slightly injured has fluctuated between about 12,000 and 17,000. Estimates of reductions made here will be based on there being 550 killed and 2000 seriously injured per year in such accidents with the present BAC limit and, as a conservative estimate, six slightly injured for every one seriously injured. The recent downward trend in serious injuries in such accidents of about four per cent per year should be borne in mind when using the estimates of effect on numbers injured. Estimated reductions corresponding to other current annual numbers killed or injured in accidents in which at least one driver's BAC exceeds 80 can be obtained by pro-rating the estimates made here.

Assumptions which are described here as conservative are so in the sense that they are likely to err on the side of underestimating the casualty reductions to be expected from reducing the legal limit. Other assumptions are made on the basis of being neutral in this respect.

It is assumed that behaviour of those now driving well over the existing limit of 80 is unlikely to be affected by lowering the limit. It is therefore assumed that casualty reductions resulting in the short term from reducing the limit will arise from reduction in accident involvement of drivers below or only somewhat above the current limit. (This is not to say that lowering the limit will never affect the amount of driving at higher BACs, but recognises that appreciable effects on such driving will come mainly through longer term changes in the culture of drinking and driving, leading to fewer people developing the habit of driving after heavy drinking). The following four ranges of BAC are therefore considered: 80-110, 50-80, 20-50, and below 20 but not effectively zero (in that they are so low that they are not necessarily related to drinking behaviour, and in any case there is no reason in terms of accident risk for seeking to change them).

For these four ranges, numbers killed per year in accidents in which a driver's BAC lies in each range are estimated from the total of 550 for which the BAC is over 80 using the distribution of BACs in car drivers killed in 1990-94 in Table 10 of Maycock (1997). It is assumed that the distribution of BACs of drinking drivers involved in fatal accidents is estimated by that of the drinking drivers who were themselves killed. With access to the

data on which Department for Transport (2007c) (Table 3h) and its predecessor tables are based, Maycock's Table 10 could be updated and replaced in the analysis reported here.

Because the numbers of drivers in the BAC intervals 41-80 and 81-120 in Table 10 are so nearly equal, it is assumed that drivers' BACs are uniformly distributed over the range 40-120. It is further assumed for purposes of calculation that BACs that are not effectively zero are uniformly distributed over the range 0-40 with the same density as between 40 and 120 – a conservative estimate because more drivers would be expected at these lower BACs. It follows that the annual numbers of deaths in fatal accidents with a drinking driver in each of the four BAC ranges being considered are estimated to be as shown in Table 5-2.

The corresponding numbers seriously injured are estimated similarly from the total of 2000 for which the drinking driver's BAC is over 80 using the distribution of breath alcohol concentrations in drivers involved in injury accidents in Table 8 of Maycock (1997), after conversion to BACs. Whilst it is less clear than for Table 10 (relating to drivers killed) how representative the distribution in Table 8 is, it is the best available and was used by Maycock as such. Its use in relation to serious injuries is conservative in that it relates to all injury accidents, whereas the proportions of drivers with higher BACs would be expected to be greater among those involved in serious accidents only. The resulting estimates of the annual numbers seriously injured in accidents with a drinking driver in each of the four BAC ranges being considered are estimated to be as shown in Table 5-2.

Table 5-2: Estimated annual numbers killed and seriously injured in accidents where a driver has a BAC of up to 110

BAC of drinking driver	Number killed	Number seriously injured
80-110	65	557
50-80	65	557
20-50	65	557
0-20 but not effectively zero	43	371

If drivers' BACs are influenced by reducing the legal limit, the effect on numbers killed or injured will be determined by the resulting changes in risk of accident involvement. Maycock estimated from his Tables 8 and 10 and the results of roadside surveys in 1988 and 1990 of BACs of drivers in Britain that the risks of being killed and of involvement in an injury accident at a BAC of b were proportional to $\exp(0.032b)$ and $\exp(0.021b)$ respectively (after conversion from units of breath alcohol concentration). In line with previous assumptions, these relationships will be applied here to estimate changes in numbers killed and seriously injured respectively

In doing so, two sets of assumptions, respectively pessimistic and optimistic in terms of casualty reduction, are made about how drivers will change their behaviour in response to reduction in the limit, in order to obtain lower and higher estimates of casualty reduction. These assumptions, set out in Table 5-3, are new to this process of estimation.

The effects of these assumptions, together with the previous assumption that drivers are currently distributed uniformly over each of the four ranges being considered, upon numbers of deaths and seriously injured in accidents involving drivers currently in these four ranges can be derived by integration in the form of factors by which the numbers killed or seriously injured would be reduced, as set out in the Appendix C.

Table 5-3: Assumptions defining optimistic and pessimistic scenarios

Drivers' current BACs	Assumption about altered BACs	
	Pessimistic	Optimistic
Limit reduced to 50		
80-110	Redistributed over 50-110 in the same order	All reduced by 30
50-80	Redistributed over 20-80 in the same order	All reduced by 30
20-50	Redistributed over 0-50 in the same order	Redistributed over 0-20 in the same order
0-20	Unchanged	Unchanged
Limit reduced to 20		
80-110	Redistributed over 20-110 in the same order	All reduced by 60
50-80	Redistributed over 0-50 in the same order	Those over 60 reduced by 60; those 50-60 reduced to 0
20-50	Redistributed over 0-20 in the same order	Those over 30 reduced by 30; those 20-30 reduced to 0
0-20	Unchanged	Reduced to zero

5.1.4 Estimated reductions in casualties

Applying the factors derived in Appendix C to the numbers in Table 5-2 yields the optimistic and pessimistic estimates of reductions in annual numbers killed or seriously injured set out in Table 3. The estimates shown of the reduction in the number slightly injured are simply conservative estimates obtained by multiplying by six the estimated reductions in the number seriously injured.

These estimates are of reductions from an existing situation in which the 550 are killed, 2000 seriously injured and 12,000 slightly injured annually in accidents in which at least one driver's BAC exceeds 80. Estimated reductions corresponding to other current annual numbers killed or injured in such accidents can be obtained by pro-rating the estimates in Table 5-4. For example, estimated reductions of the year 2007, in which an estimated 460 were killed, 1,760 seriously injured and 12,260 slightly injured in such accidents can be obtained by multiplying the reductions in numbers killed by $440/550 = 0.84$, the reductions in numbers seriously injured by $1,760/2,000 = 0.88$, and the reductions in numbers slightly injured by $12,260/12,000 = 1.02$.

Table 5-4: Estimated annual reductions in casualties resulting from reducing the drink-drive limit to 50 or 20 mg/100ml

Drivers' current BACs	Assumption about altered BACs			
	Pessimistic		Optimistic	
	Killed	Seriously injured	Killed	Seriously injured
<i>Limit Reduced to 50</i>				
80-110	23	144	40	260
50-80	23	144	40	260
20-50	17	102	36	227
0-20	0	0	0	0
Total	63	390	116	747
Slightly injured		2340		4492
<i>Limit reduced to 20</i>				
80-110	36	240	55	399
50-80	47	315	55	393
20-50	36	227	39	249
0-20	0	0	9	68
Total	119	782	159	1109
Slightly injured		4692		6654

5.2 Introduce programmes to fit alcolocks

The Steering Group asked TRL to estimate the impact of different scenarios of introducing alcolocks. The scenarios initially proposed for consideration were:

- The casualty reduction achievable through:
 - programmes to fit alcolocks in the case of persistent drink-drive offenders (recidivist drivers);
 - use of alcolocks in company car fleets (commercial drivers);
 - standard fitment to new cars of alcolocks

The Steering Group also requested estimates on the standard fitment to new cars of seat belt ignition interlocks. It was felt that this request was sufficiently discrete as to be taken forward independently as part of other technology impact evaluations within the Department for Transport.

A literature review was carried out by VSRC to understand the current state of knowledge with respect to alcolocks. Its aim was to establish whether sufficient evidence existed to allow the estimation of casualty benefits that might arise through the above options.

The application of casualty reduction estimates from other countries suggests that of the order of 180 fatalities might be saved in the UK. However, further work testing and refining equipment as well as understanding the efficacy in the various target groups would be required before robust estimates of casualty reductions could be generated.

5.2.1 Introduction

This section summarises the current knowledge available within academic, governmental and commercial forums, relating to the effectiveness and implementation of Alcolock devices among various target groups within the driving population. These target groups are recidivist drivers and commercial drivers. Literature was also found relating to young/novice drivers.

Field studies within the EU have shown that an Alcolock device can be seen as a useful tool within drink driving strategies but that the device should form part of a package of measures including rehabilitation and education programmes in order to be most effective and to minimise the likelihood of repeat offences once the period of use has come to an end.

Studies also show that Alcolock devices are well accepted within the commercial driver population and that in this instance they can be used as primary intervention devices to prevent unintentional drink driving due to residual high BAC following alcohol intake the previous evening. Implementation within the commercial fleet is being positively encouraged by governments and fleet operators. In this context the use of the Alcolock is much more out of the discretion of the driver; companies seem keen to make use of the device as part of ongoing drink driving policies and out of an awareness of social responsibility.

The literature shows that, though effectiveness studies have been undertaken in other EU countries and in other continents, there is no measure of the anticipated benefit on accident and casualty numbers in Great Britain.

The objective of the review was to establish from the available literature;

- The target groups where Alcolock would be expected to have some benefit
- What the anticipated benefit within these target groups would be
- The road safety outcomes that would result from the use of Alcolocks amongst these target groups
- The range of deployment modes and potential effectiveness
- What other barriers to implementation exist

The aim of the review will be to prepare the ground for future effectiveness estimates where quantitative information from the literature can be applied to the target groups. These target groups would need to be carefully identified through the data sources available in the UK.

The information in this section is based solely on the available literature; no new qualitative or quantitative studies have been undertaken.

The ETSC drink drive monitors and the ETSC recent report on young drivers and recidivist drivers have been used extensively in this review as they provide an ongoing and up to date commentary on the EU perspective on drink driving, including advances in the acceptance of Alcolocks as a primary and secondary intervention technology. In addition, various other sources of information have been reviewed including;

- DfT reports
- PACTS research
- European Commission funded projects
- Academic Publications
- Other European projects
- Web search for relevant articles
- Alcolock suppliers
- Road safety organisations

It is clear from the review that several studies, including recently funded DfT research (Clayton, 2008 and Beirness, 2008) have considered the acceptability and practical issues associated with Alcolock programmes. Some information relating to the effectiveness of such programmes, particularly among recidivist drivers, is available for other EU countries.

5.2.1.1 The drink drive problem

In the EU, 25% of road deaths due to road crashes have alcohol as a factor and drink driving is the second greatest contributory factor of road deaths in the EU after speeding. In the UK 17% of road deaths occur when the driver was over the limit (RCGB 2006). According to Alcolock.org almost 3000 people a year are seriously and permanently injured and around 600 people die through the effects of drink driving on the UK roads. Even at the legal driving limit drivers are still 2.5 times more likely to have a road accident.

PACTS (2005) highlighted concerns that the number of roadside screening tests for alcohol has been declining while the percentage of positive tests have been rising. In 1998 there was a peak of 815,000 tests in which 13% were positive; in 2001 there were 624,000 tests of which 16% were positive.

The Department for Transport (2007c) identified that:

- Fatalities resulting from drink drive accidents fell by 18 per cent from 560 in 2006 to 460 in 2007, whilst seriously injured casualties fell by 11 per cent from 1,970 to 1,760. Slight casualties, however, rose by four per cent from 11,840 to 12,260. Total casualties in drink drive accidents rose by one per cent from 14,370 to 14,480.
- Fatal accidents fell by 16 per cent from 490 to 410, although there was an overall increase of two per cent in drink drive accidents from 9,400 to 9,620.

5.2.1.2 Target populations

An alcohol interlock is a small, hand-held breath-testing device fitted to a vehicle's ignition. The driver must blow into the interlock before attempting to start the vehicle. If the driver's blood alcohol content (BAC) is higher than the pre-set level, the vehicle will not start. In addition to preventing the vehicle from starting, the interlock records data

on the use of the vehicle and any attempts to circumvent the interlock, such as roll starting.

The literature pin points three sections of the drink drive population where alcolock-based counter measures might be expected to give a casualty reduction benefit.;

- Recidivist drivers
- Young/novice drivers
- Fleet and Commercial drivers

With regard to convicted drivers much of the attention is focussed upon repeat offenders but there are some discussion relating to first time offenders. According to the ETSC drink driving monitors (ETSC DDM), around 20-30% of convicted drivers reoffend.

The ETSC report in the drink driving monitors that there were 2,280 20-25 year olds in drink driving accidents in 2005 compared to 2,170 in 1995. Young adults in the age range 17-24 form a disproportionately high amount of offenders and casualties in drink driving accidents. Within the young drivers, male drivers are seen as a particular problem. The UK THINK campaign particularly focussed on young male drivers aged 17-29 whilst for fatal crashes in Ireland, 90% of drivers whose alcohol intake was a factor were male (ETSC DDM). In the Netherlands it is reported that young male drivers, aged 18-24 years, are a high-risk group. While forming less than 5% of the Dutch population, they cause nearly a quarter of all alcohol-related serious road injuries (Mathijssen, 2005).

The third target group that is identified in the literature is the commercial driver. Commercial vehicles include drivers of lorries, buses, taxis and fleet vehicles. Whilst there is no evidence that commercial vehicle drivers are more likely to drink and drive than any other sector, the consequences can be more devastating (BIVV, 2006) and countries within the EU are promoting the use of Alcolock in commercial vehicles in road safety strategies, in particular Sweden, Finland and more recently France (ETSC DDM).

In general the function of Alcolock can be split between into two groups with different purposes (Bax, 2001):

- Prevention of repeat drink driving
 - Convicted drink drivers
- Prevention of drink driving
 - Drivers without convictions who use Alcolock as a preventative measure
 - Professional drivers whose employers want a preventative measure and those whose employers want to protect themselves against employees' drink driving.

For the purposes of the following sections the three target groups are considered:

- Recidivist drivers
- Young/Novice drivers
- Commercial drivers

Additionally the literature makes comments not specific to target groups, these are also summarised.

5.2.2 Recidivist drivers (including first offenders)

5.2.2.1 Anticipated benefit

Alcolock programmes are seen as being more effective than full licence suspension in preventing recidivism during the period of the programme (ETSC, 2008 and Clayton, 2008). The Alcolock prevents the inevitable overlap between driving and drinking for those who rank both driving and drinking as important in their lifestyle (Beirness,2008).

However, in the absence of additional programme features that take into account other factors that contribute to recidivism, such as an inherent alcohol abuse problem, there is a good likelihood that many drink drivers would continue to drink and drive once the Alcolock has been removed (BIVV, 2006, PACTS, 2005, Clayton, 2008 and Bjerre, 2005).

Various pilot studies have quantified the anticipated benefit of an Alcolock among recidivist drivers including the following:

- Experience within the USA and Canada, where Alcolocks are used extensively for offenders, shows that the devices can reduce repeat drink-driving offences by between 40 and 90% for the duration of the installation. According to a study conducted by the International Council on Alcohol, Drugs and Traffic Safety (ICADTS) Alcolock in conjunction with monitoring, led to a 40-95% reduction in the re-conviction rate of previously convicted drink-drivers;
- The European Commission Alcolock implementation study (Bax, 2001) comments that various evaluations have shown reduction of 28-65% during the period of installation compared with control groups;
- Evaluations in the Netherlands predict a potential for 65-90% less repeat offences for Alcolock users than for drivers with a suspended licence or revocation. It is suggested that the benefits of the Alcolock programme are more than 10 times greater than the costs (SWOV, 2005);
- A study in Victoria, Australia, predicts that fatalities and serious injuries due to drink driving could both be halved if all convicted drink drivers could be prevented from drink driving for the five years immediately following their first offence (Arrive alive);
- Beirness (2003) report that the programme completion rates of DWI offenders who were ordered to participate in an Alcolock programme did not differ from those who volunteered for inclusion;
- Commenting on the Swedish Alcolock trials, Bjerre (2005) states that 'During the program, alcohol consumption generally decreased significantly as measured through five biological alcohol markers, and the rate of DWI recidivism fell sharply from a yearly rate of approximately 5% to almost 0. These effects on DWI recidivism are paralleled by reduced rates of police-reported traffic accidents involving injuries and hospital admissions due to road accidents. Successful completion of the program appears to have lasting effects (even 2.5 years later) in terms of far lower rates of DWI recidivism and maybe also lower crash rates. On the other hand those being dismissed from the program appear to rapidly return to previous behaviour. Hard suspension seems almost to have an adverse effect on DWI recidivism, but crashes resulting in injuries may be reduced during revocation';
- Information stored within the Alcolock can be used to provide evidence of a whether or not rehabilitation programmes are being effective in conjunction with the Alcolock in changing behaviour attitudes towards drinking and driving.

There is no evidence available relating to the size of the recidivist group within the UK; knowledge of this is required before estimates for other countries can be applied to the UK.

5.2.2.2 Implementation

ETSC suggest that Alcolocks should be installed in cars for first time offenders who were far in excess of the legal limit (2.5 times) and all recidivists. The Alcolock programme should be combined with driver rehabilitation courses to achieve more permanent behavioural changes (ETSC, 2008, Clayton, 2008 and PACTS, 2005). This is evident in pilot programmes currently in place. Sweden offers a two year voluntary Alcolock programme in lieu of a 12 month licence revocation. The programme includes regular medical check-ups designed to alter alcohol use. The pilot will continue to run until 2009 (ETSC DDM).

5.2.2.3 Acceptance

European field trials showed that Alcolocks were relatively practicable, did not interfere significantly with the driver's task and were evaluated as easy to use. The general acceptance of the Alcolocks was good and remained high throughout the 12 month trial period. It was, however, noted that user acceptance is generally better in the case of voluntary installation rather than mandatory installation and that the cost to the offender is the greatest impediment to acceptance (BIVV, 2006).

A UK field trial that considered the acceptance of Alcolocks for convicted drivers (Beirness, 2008) reports that despite usability issues of the device (warm up time, requirement for re tests), most of the participants found the device to be an acceptable instrument that had a beneficial impact and helped them in their desire to change their drinking patterns. Almost three-quarters of interlock participants claimed that the interlock had helped them change their drinking patterns and prevented them from drink driving (Beirness, 2008).

5.2.2.4 Barriers

The cost of installation

In Alcolock programmes, the convicted driver bears the installation cost and monitoring costs in return for being able to continue to drive. This can result in low take up rates; for example the take up rate in Sweden is 11% (SWOV, 2005) where participants have to pay between €4,000 and €5,000 for the programme. A trial in France charges offenders €1,260. This excludes many less well-off drivers (PACTS, 2005).

Enforcement of the programme

In California for example, where Alcolock can be mandated by the judicial system, a sentence is imposed in only 10% of eligible cases (SWOV, 2005), of these 80% ignore the sentence. There is some reported opposition to Alcolock programmes by the criminal justice system (BIVV, 2006) where there is a lack of belief that the programme is effective. To increase participation it is suggested (VOAS, 2003) that courts would have to threaten more severe sanctions for those offenders who reject Alcolock programmes.

Technical Difficulties

In a field study carried out in the UK (Beirness, 2008) a number of technical difficulties associated with use of the Alcolock were reported by participants. These included;

- Faulty equipment complaints
- The frequent number of retests that were required
- The inability of the participant to provide an adequate breath sample
- The long warm up time required by the device

The report concludes that these difficulties, on the whole, can be overcome by making suitable adjustments in the software of the device.

Circumvention

Requirements incorporated within the Alcolock recognition are designed to reduce the ability of the driver to circumvent the technology by for example having someone else perform the test. One such requirement is for the driver to hum whilst blowing in to the device. This requires a lot of practice which helps prevent an untrained bystander from providing a breath sample. In a recent field trial in the UK (Beirness, 2008), where this requirement was removed, several participants admitted to circumventing the device. The report (Beirness, 2008) recommends that this hum-blow requirement be included as a feature in any future Antilock programme. Alternatively, Alcolock devices with photo-ID could be employed. Enforcing a prosecutable offence for soliciting or providing a breath sample on behalf of a driver would also help to reduce incidences of circumvention.

5.2.3 Young / novice drivers

There is no specific information in the literature review relating to the benefit or other issues concerned with Alcolock implementation among young or novice drivers. It is commented that a benefit would be expected (Regan *et al*) but there is no quantitative evidence.

Many of the comments in the literature concerning young and novice drivers are in relation to the appropriate legal BAC that should be applied to this target group. It is recommended (ETSC, 2008) that EU member states should be working towards setting a legal BAC limit of no more than 0.5 mg/ml for all drivers with a lower limit of 0.2 mg/ml for young/novice drivers. According to research in the Netherlands (Mathijssen, 2005) existing legislation and programs are neither very effective in further decreasing the number of hardcore drinking drivers nor in improving the drink driving habits of young males. The Netherlands adopted this lower BAC for novice drivers in 2006. SWOV estimates this could result in a 5% reduction of the total alcohol crashes in the Netherlands. A zero BAC for young drivers came in to force in August 2007.

It is feasible to see how the enforcement of lower BAC limits for young/novice drivers through the mandatory fitment of an Alcolock would have a benefit in terms of accident and casualty reduction though this benefit needs to be quantified in a further effectiveness study.

5.2.4 Commercial drivers

5.2.4.1 Anticipated benefit

There is little quantitative data relating to the benefit of Alcolocks within the commercial driver fleet. There is no evidence to suggest that commercial drivers are more likely to drink and drive than any other drivers (BIVV, 2006). Alcolocks would possibly be aimed at those unaware that alcohol consumed the night before can result in elevated BAC and impaired driving performance the following morning. Volvo is adding Alcolock to its UK options list and is reported as confident that the device has the potential to save lives (Volvo, 2007). In this instance Alcolocks are generally seen as a primary preventative measure rather than for repeat offenders.

According to the European Road Safety Observatory (ERSO) Alcolocks have been successful in preventing heavy goods vehicle drivers from driving whilst over the limit. SWOV reports that around 4,700 drink driving attempts per year have been prevented by Alcolocks voluntarily installed in 3000 commercial vehicles (SWOV, 2005). Bjerre (2008) estimates that about half a million drink driving trips would be prevented per year provided that all Swedish trucks, buses and taxis had installed Alcolocks.

5.2.4.2 Implementation

It is estimated (ETSC DDM) that 30,000 Alcolocks are in use in a commercial context in Sweden out of a potential 200,000 vehicles and the Swedish government's strategy recommends that Alcolocks should be fitted to all new commercial busses and trucks. In France there is a requirement for all school buses to have Alcolocks fitted from the start of the 2009 school year.

As an alternative to fitting costly devices in entire fleets, in 2007 the Swedish Post service (2500 vehicles) use the device to access the vehicle keys rather than have the device in-vehicle.

5.2.4.3 Acceptance

European field trials (Norway, Spain and Germany) have shown that Alcolocks are generally acceptable well among commercial drivers (BIVV, 2006) and the acceptability

remained high during the 12 month trial period. As with the recidivist trial, using the device did not interfere significantly with the driver's tasks and the use was generally evaluated as easy. For example, in the Norwegian trial of bus drivers, out of 23 drivers, 17 said they were 'very satisfied' with the Alcolock, two were 'satisfied', three were 'indifferent' and just one reported being 'very dissatisfied'. 87% were happy to use the Alcolock provided that the company bought and installed the device.

Bjerre (2008) reports results from a questionnaire based interview to 118 transport companies with Alcolocks and 230 companies without Alcolocks. 98% of the companies with Alcolocks recommended other transport companies to install Alcolocks. Reported reasons for introducing Alcolocks were in order to improve the quality of the transport and that the introduction was in line with the company alcohol policy. However 25% of companies felt there was no reason for the devices as they had not observed alcohol problems amongst their drivers.

5.2.4.4 Barriers

In the study by Bjerre (2008), the greatest potential barrier to the implementation of Alcolocks in the commercial fleet was given as the cost. The report suggests that the typical cost for installation is €1,700 with a further €225 annual service cost. This barrier could be overcome in part by using a system similar to that employed by the Swedish Post service (above) but would not be a practical solution for all commercial drivers such as those who drive their own vehicle for work purposes.

Other reported problems include the time taken to perform the test (particularly for bus drivers) and the device 'being troublesome to handle'.

5.2.5 The general population

Other comments from the literature that are not specific to the target groups listed above are summarised in this section.

5.2.5.1 Anticipated benefit

Alcolocks could be perceived as a means for helping drivers in general comply with the law and reduce the need for enforcement strategies. They are seen as being particularly useful for 'morning after' cases where drivers may not realise that they are still over the limit (PACTS. 2005).

Within PISa (Powered two wheeler Integrated Safety) a process was used to identify and prioritise safety functions which would contribute to crash avoidance and injury prevention/reduction. This process used 60 in-depth cases (OTS=48) and 70 UK Fatal cases. 'Alcolock' was one of 43 functions assessed but was not found to be one of the top 10 important safety functions using any of the ranking methods. It is acknowledged that the sample of cases analysed is small and a larger study of fatal cases would allow more comprehensive analysis.

5.2.5.2 Implementation

Further studies would be required to consider the benefit of mandatory fitment to new vehicles, though the Swedish government are considering Alcolocks as standard in all new cars from 2012. Away from legislation, Saab for example have developed an Alcokey which requires the driver to breathe into a small mouthpiece on the car's key fob which is fitted with a breathalyser. The intention is to offer the device as an optional extra in the Swedish market in the first instance with extension to other EU member states there after (typical cost £225). Further public awareness campaigns such as those promoted by the ETSC could help initiate the uptake of voluntary Alcolock installation.

5.2.5.3 *Acceptance*

SWOV (2005) shows that 34% of drivers in the EU would be in favour of the introduction of Alcolocks, the highest acceptance rate was for Sweden at 65%. According to the SARTRE3 (2004) project, 40% of UK drivers stated they would find it useful to have 'technical systems' fitted in their cars to prevent drink driving.

5.2.5.4 *Barriers*

The European Road Safety Observatory (ERSO) makes the following comment:

'It is tempting to see the installation of alcohol ignition interlocks in all cars as the panacea for the drink-driving problem. Unfortunately there are still some technical drawbacks and inconveniences. The overwhelming majority of drivers never drive over the legal limit. These drivers also have to install such a still costly device which needs to be calibrated and controlled regularly. Especially when it is cold, first performing a breath test before one can start a car; will mean that it will take several minutes before one can drive off''

5.2.6 **Observations**

From this brief review of the literature it is apparent that the greatest knowledge gap in relation to Alcolocks in the UK is any measure of the accident or casualty reduction benefit of the devices.

Recent studies in the UK (Clayton, 2008 and Beirness, 2008) have built upon the experience of previous work in other member states and give information relating to the implementation of an Alcolock programme aimed at repeat offenders in the UK and also the acceptance and impact of such programmes upon the offender. However, no quantitative data relating to the potential benefit for the UK is reported on in the literature.

A previous European project, TRACE, has made broad estimates of the effect that an Alcolock programme would have. If there were 100% fitment rates then TRACE predicts that 6% of fatalities and 3% of serious injuries would be mitigated. Similarly benefits have been calculated by SWOV for the Netherlands where, based upon given DUI inclusion rates, an effective Alcolock programme is predicted to give a casualty reduction of 5%.

Similar work could be undertaken for the UK under appropriate assumptions and hypotheses and with knowledge of the size of the target populations within the UK. For example, for the UK 6% of fatalities equates to 180 fatalities; this figure also represents a third of all drink driving fatalities. Estimates relating to the likelihood of circumvention within the groups should be applied to the effectiveness estimates. This should be undertaken in order to fully appreciate the life saving and injury mitigating potential of the Alcolock.

In addition to the broad target groups identified in this document, casualty reduction predictions could be made for other groups such as new licensees, and for the different types of commercial driver within that generic grouping. A review of the accident statistics in conjunction with offence history/accident causation data could potentially highlight other target populations. Such analyses would be dependent upon the available data and a review of the current resources would be pertinent.

A further study could assess, based upon the known accident risk for different BAC thresholds, what benefit would be seen for a lowering of the legal BAC limit among various target populations. This would help to set appropriate BAC acceptance levels in the Alcolock software.

6 Options with qualitative casualty benefit estimates

For some measures or areas of activity, no further work into more detailed evaluation of the costs and benefits was undertaken beyond the initial estimates. In some cases this was because the approach to achieving casualty reductions was not clear and/or availability of data was poor. These measures were:

- Apply Manual for Streets design standards on all new residential roads
- Undertake an intensified and extended road safety education programme
- Introduce fiscal incentives for improving driving
- Increase enforcement for speeding, seat belt and drink / drug drive offences and consider random versus intelligence led enforcement
- Focus enforcement on gross speeding
- Reduce pedestrian drunkenness and increase driver awareness
- Provide more pedestrian crossings

6.1 Apply Manual for Streets design standards on all new residential roads

6.1.1 Option definition

The Steering Group asked TRL to estimate the impact of the application of the Manual for Streets (MfS) (Department for Transport, 2007b) design standards being applied to all new residential roads in the period to 2020 and 2030.

6.1.2 Assumptions and approach

In order to address this question, the approach needed to consider the likely growth in new residential roads and understand the safety benefit that these might deliver using MfS design standards rather than any other design standards.

Government Actuaries Department (GAD) data projections for Great Britain⁹ suggest a population growth of 5.20 million to 2020 and 9.19 million to 2030 as shown in Figure 6-1.

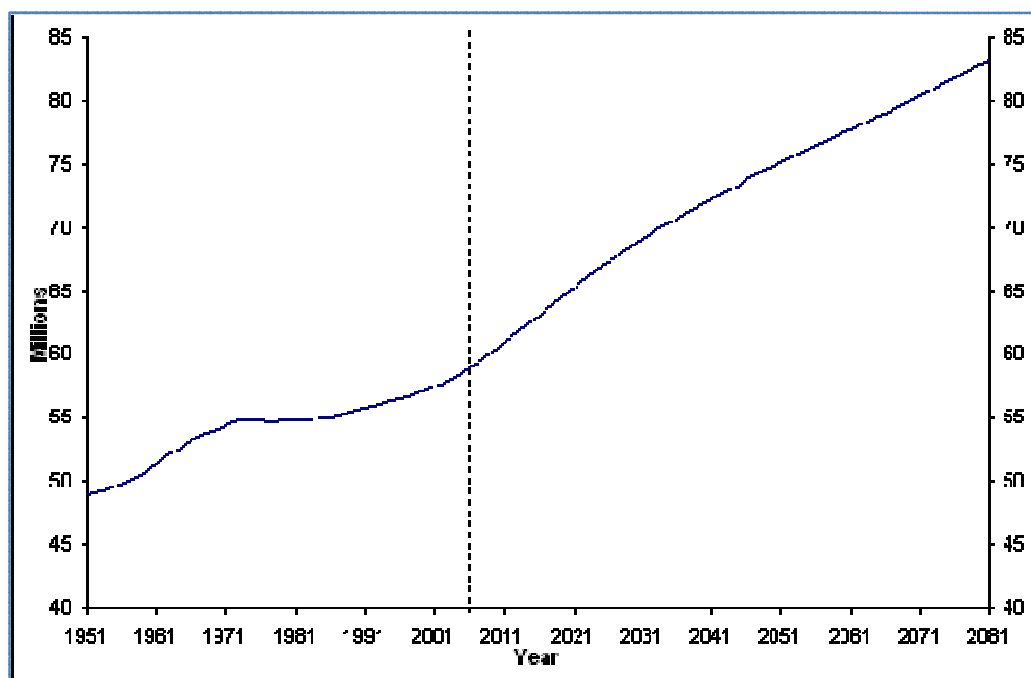


Figure 6-1 Great Britain population 1951-2081, GAD

This is net growth in population which accounts for births, deaths, emigration and immigration. We have assumed that new residential roads are required to house this increase in population and that the population density of these roads is similar to London, this would mean that 9,293 km (5.2 million people / 560 people per km) of new residential roads would need to be constructed by 2020 and 16,284 km by 2030 (increases from 2006).

In the absence of robust proxies for the safety performance of MfS designed roads, it has been assumed that the fatality rates of MfS roads per km are similar to the fatality rates for self-enforced 20mph zones per km. London data in terms of residential population densities is used as a model from which to extrapolate.

There were 154 fatalities on around 13,500km of roads controlled by Boroughs in London in 2007 (a coarse proxy for residential roads) (Transport for London, 2008). London has a population of 7.56 million people (Greater London Authority, 2008). This

⁹ Available from <http://www.gad.gov.uk/Demography%5FData/>

means that, for London, there are 560 people per km of residential road and 0.0114 fatalities per km per year.

If fatal casualties were to arise on the roads of any new residential development at this rate (0.0114 fatalities per km per year) then we might expect this growth in population to result in a further 106 deaths per year in 2020 ($0.0114 * 9293$) and 186 deaths per year in 2030. Assuming that MfS design standards are approximately as effective as self enforced 20 mph zones, we might expect to reduce the number of fatalities by somewhere between 30% and 50% (see section 3.3). This would mean that fatal casualties might be reduced by between 32 (assuming 30% casualty reduction under baseline) and 53 (assuming 50% casualty reduction under baseline) in 2020 and between 53 and 93 in 2030.

There would also be serious and slight injury reductions. Using RCGB 2006 severity ratios for urban non A roads, these might be expected to be as shown in Table 6-3.

Table 6-1: Estimated casualty savings by severity arising from new residential roads complying with Manual for Streets design guidance

Casualty Severity	Low Estimate (2020)	High Estimate (2020)
Fatal	32	53
Serious	555	920
Slight	4336	7181
All Casualties	4923	8154

6.1.3 Observations

The results here are indicative and represent the number of casualty savings per year across Great Britain that the application of MfS design standards might be expected to yield. Clearly the approach relies on a number of untested assumptions and as such should be treated with some caution. The application of Manual for Streets design guidance might, in any case, be expected to be followed in general for new residential developments and as such casualty savings from this are likely to be realised in any case.

Using London roads as a proxy does not account for the fact that a certain proportion of these roads are already 20 mph zones. However, the estimate is indicative and so this fact is unlikely to affect the result in a significant way.

6.2 Undertake an intensified and extended road safety education programme

6.2.1 Option definition

The Steering Group asked TRL to estimate the impact of an intensified and extended road safety education programme.

To fully answer this question, a number of definitions would need to be addressed. For example, who the target audience of the education programme would be (ages, sexes, modes), what education activities are included and excluded (i.e. what specific programmes would any additional effort be targeted at) etc.

A full evaluation of the effectiveness of road safety education effort is beyond the scope of this work. The estimates presented here were directed towards understanding the size of the potential casualty savings for age groups 5 to 18 years of age, with a focus on what could be delivered to school age children.

6.2.2 Assumptions and approach

To understand the likely impact in terms of casualty savings from the an extended road safety education programme aimed at those between 5 and 18 years old, Table 6-2 presents fatal casualty counts by age and mode averaged for 2005-7.

Table 6-2: Fatal casualty counts by age and mode averaged for 2005-7

Age	Car driver	Car passenger	Motorcyclist	Other	Pedal cyclist	Pedestrian	All modes
5	0.0	0.3	0.0	0.3	0.0	2.0	2.7
6	0.0	2.0	0.0	0.0	1.0	2.0	5.0
7	0.0	2.0	0.0	0.3	1.0	3.7	7.0
8	0.0	2.7	0.0	0.3	1.3	2.0	6.3
9	0.0	2.0	0.3	0.0	1.3	2.0	5.7
10	0.0	0.7	0.0	0.0	1.3	4.0	6.0
11	0.0	3.0	0.3	0.0	1.7	4.3	9.3
12	0.3	2.7	0.3	0.3	1.0	7.3	12.0
13	0.0	3.7	1.0	0.0	4.7	5.3	14.7
14	0.7	5.7	0.7	0.0	4.3	7.7	19.0
15	2.3	11.3	2.0	0.0	3.0	10.0	28.7
16	2.7	32.0	9.3	0.7	3.7	12.3	60.7
17	33.7	41.0	19.0	2.3	0.7	12.3	109.0
18	58.3	35.3	12.0	1.3	0.7	10.3	118.0
All Ages	98.0	144.3	45.0	5.7	25.7	85.3	404.0

This shows that on average there were 404.0 fatal casualties per year between 2005 and 2007. The largest single group of these fatalities are car passengers (144.3 of 404.0) and more than half of the fatal casualties (227.0 of 404.0) were aged 17 or 18.

Particularly to address the passenger casualties aged 16 or under, road safety education would perhaps best be targeted at the drivers of these vehicles, rather than the child passengers.

A number of the fatalities involve young drivers who are not authorised to drive the vehicles they are associated with in the accident data. For example 5.0 deaths per year

are ascribed to car drivers aged 15 and 16. These drivers are likely to be driving illegally and so specific and highly targeted educational programmes would be needed to address this small number of casualties.

To some degree, education and improvements to training and testing might be expected to yield results in driver and passenger groups. For groups aged 5-16, the biggest impact is likely to be achieved in the other modes, particularly pedal cyclists and pedestrians. Educational initiatives aimed at addressing the vulnerable road user groups, particularly pedestrians and pedal cyclists, might influence the attitudes and behaviour of around a quarter of the fatalities (111.0 of 404.0).

If we assume a generous 10-30% sustained fatal casualty reduction effect from an extended road safety education programme aimed at pedestrians and pedal cyclists aged 5-16, then the fatal casualties saved might be expected to be between around 10 and 30 per year.

6.2.3 Observations

Assessment of the potential savings from extending road safety education to 5-16 year old children in the context of a road safety strategy suggests that car passengers and pedestrian groups are where the biggest savings might be made. However, the effectiveness of educational initiatives targeted at young passengers might be expected to be of limited value. Education programmes aimed at reducing the numbers of casualties in this group are likely to be best targeted at the drivers of the vehicles. Further work is recommended in this area.

Programmes currently being developed by DfT, to be rolled out from 2009, will initially address 3-5 and 9-11 year old groups. Overall, the programme is aimed at 4-16 year olds over three years and is expected to include some form of evaluation, although this is unlikely to include evaluation of casualty reduction impact.

The impact of education delivered to these younger road users on their risk as they become older has not been considered. Evaluation of the effectiveness of specific educational interventions at these groups is encouraged as this will allow for any future increases in funding to be most cost-effectively prioritised.

6.3 Introduce fiscal incentives for improving driving

6.3.1 Option definition

The Steering Group asked TRL to estimate the impact of fiscal incentives for improving driving.

There is a wide variety of ways in which fiscal incentives might be used. Such incentives could be delivered through a number of mechanisms and agencies, for example commercial or governmental routes.

A literature review was undertaken to understand the evidence in this broad field. Estimating casualty reductions through the application of specific interventions or technologies in Great Britain was beyond the scope of this work.

6.3.2 Assumptions and approach

A number of papers relevant to this question have been identified. There are links between this question and new technologies, particularly ISA. Some of the more relevant findings of one particular study are presented below.

6.3.2.1 *Belonitor*

A Dutch trial ('Belonitor'¹⁰) offers perhaps the most striking example of fiscal incentives being used to reward driver behaviour. Mazureck and Hattem (2006) describe how a fleet of 62 leased vehicles were fitted with an In Vehicle Data Recorder (IVDR) system and in-vehicle display to indicate driving within legal speed limits (i.e. advisory ISA) and driving with safe headway (a minimum of 1.3 seconds to the vehicle in front). Speed limit data was contained in a digital map of the Netherlands that was stored within each IVDR system and updated via a telematic link (to register temporary or new speed limits). On-board GPS provided vehicle speed and position and referenced it against the digital speed map. Drivers were shown a green symbol on the in-vehicle display when they were within the speed limit and a yellow symbol when they exceeded the limit. Different symbols separately indicated when drivers were travelling with more or less than 1.3 seconds headway (measured using a radar device mounted on the front of the vehicle).

Feedback to drivers was continuous. All data were uploaded via a telematic link. Drivers earned points (one for every 15 seconds of driving both within the speed limit and maintaining a safe distance) to purchase rewards. Each point was initially worth €0.04 although the value was halved twice during the study. Participants could monitor their points accumulation online. The system of rewards yielded substantial improvements in driver behaviour: the proportion of mileage travelled within the legal speed limit increased by 18% on average (to 86%) and the proportion travelled at a safe distance increased by 19% (to 77%). Subjectively, 84% of participants reported that the system encouraged them to adhere to speed limits at least a little more often than before, whilst 81% said the same of maintaining a safe headway.

The Dutch 'Belonitor' trial provides several points for consideration when assessing the use of fiscal incentives as a method of improving driver behaviour:

- Mazureck and Hattem estimated that national usage of Belonitor would reduce the Dutch KSI rate by 15% and all injuries by 9% (using the achieved decrease in average speed of 3.14km/h).
- Some 13% maintained the combination of desirable speed and headway after feedback and rewards ceased (for a further four weeks, at least). None of the participants reverted to behaviour that was below the baseline at the start.

¹⁰ 'Belonitor' was coined from the Dutch word for rewarding (*belonen*) and the English 'monitor'.

- Reducing the reward during the study did not have a substantial effect on the extent of behavioural change. This suggests that long-term rewards could be minimal but still stimulate improved behaviour. It also indicates that partial reinforcement programmes may be worthy of further study as a way of managing costs of fiscal incentives and improving the ratio with associated rewards.
- Some participants perceived the reward system as a 'game' (the challenge being to maintain 'safe' feedback); this suggests that fiscal incentives could indeed have a role to play in changing the motivations of some drivers in a safer direction. It is recognised that some drivers are motivated by the challenge of driving fast or dangerously by providing such drivers with a reason to be motivated towards safe driving, the prevalence of violational behaviours that contribute towards collisions may be reduced. This type of approach is embedded in theories of goal-setting.
- Drivers may be demotivated if they do not have sufficient, realistic and equal opportunity to demonstrate the behaviours that earn rewards. In Belonitor, maintaining the required headway was difficult in heavy traffic as other drivers often cut in front to fill the gap. Safe practice would be to drop back to reinstate the gap; however, drivers still found it difficult to maintain safe headway for 15 seconds to earn a point. There is a strong argument for smaller headways in dense, slow-moving traffic to maintain momentum and capacity. Fiscal incentives should be based on behaviours that are realistic within the existing road environment and that are not detrimental to road operation in other ways.
- On average, fuel consumption was reduced by 5.5% — enough for participants to yield desirable financial benefits that could potentially help maintain safer behaviours after any official reward is withdrawn. The associated environmental benefits may also help justify expenditure on a reward system.
- Participants were intolerant of faults in the reward system — any fiscal incentive programme would potentially underperform if it was not reliable and accurate.
- Participant frustration did occur in Belonitor for those who were unable to achieve the same level of rewards as their peers. This suggests that the motivation to perform safe behaviours may be present but is somehow not transformed into appropriate action. This phenomenon has been reported in other studies (e.g. Elliott and Armitage, 2006). If the behaviours required for fiscal incentives are not achievable by all drivers then support and guidance should be available to provide a mechanism to those who are motivated to respond appropriately but are unable to do so.

6.3.2.2 *How do rewards modify behaviour?*

Psychological theories of punishment and reward receive strong support from behavioural psychologists. It is suggested that certain behaviours can be reinforced with rewards (e.g. Skinner, 1953). Minden (1982) claims that "Any behaviour followed immediately by a positive reinforcer is 'strengthened.' That is, such behaviour is more likely to occur again than a behaviour which has not been strengthened. A positive reinforcer is, in essence, a reward." Research has indicated that reward programmes will have greater effect if they are:

- Issued by a reputable, trustworthy source (Hagenzieker, 1999; Steg *et al*, 2000)
- Delivered with an intensity and frequency that makes it clear which behaviours are being rewarded (Hagenzieker, 1999)
- Delivered with appropriate speed, strength and relevance (Tertoolen, 1994)

Rewards issued in a driving context should consider how to appropriately tailor these features to achieve the greatest positive behavioural change. Over a longer term, it may be desirable to vary the regularity of rewards so that positive behaviours become habitual and so that drivers do not expect a reward each time they comply. The concept of partial reinforcement (Nevin, 1988) may yield stronger long-term behavioural changes.

6.3.2.3 *How can drivers be rewarded for safe behaviours?*

The opportunity to improve road safety by providing fiscal incentives to drivers is contingent on correctly identifying and rewarding those behaviours that are strongly associated with safety. Current approaches focus on penalising unsafe behaviour—this is arguably easier to identify as it is typically a response to legal violations. Rewarding safe driver behaviour is complex since not all legal behaviour is safe or would benefit from being reinforced. Rewards also require behaviours to be continuously measured so that systematic, regular rewards can be delivered. IVDR systems can combine inputs from sensors such as accelerometers and from the Global Positioning System (GPS) to accurately record vehicle activity. However, a reward system must find robust ways of selecting and categorising behaviours so that only those that genuinely enhance safety are rewarded.

Types of safety-related behaviour that would be relatively easy to identify and quantify are speed limit compliance and exposure (duration, location and time of day). Safety-related behaviours that might be more complex to measure and categorise could include acceleration (in a straight line and around corners), braking, fuel consumption and headway. Estimating the safety benefits of a reward scheme would depend on which behaviours were targeted. Focusing on a particular behaviour may only reduce the number of casualties associated with that behaviour—although reducing speed through rewards, for example, may have a corresponding effect on other driver actions. Safety benefits could be enhanced if the incentive system was able to recognise and reward a range of behaviours, with the caveat that the driver would need to be aware of how their performance was directly associated with the reward so as to know which behaviours to repeat.

There are practical and ethical considerations for fiscal incentives. A system that effectively pays drivers for not breaking the law may not be justifiable. In essence, fiscal incentives that promote safer driving would be reducing the 'external' costs of driving (e.g. those associated with collisions rather than 'internal' costs such as fuel). Therefore, one route to initiating a fiscal reward would be to allow drivers a rebate on road tax or fuel tax, which would be maintained by 'safe' driving behaviour and eroded by behaviour that was outside the accepted parameters of the reward system.

6.3.2.4 *ISA-related incentives*

Intelligent Speed Adaptation (ISA) offers one of the more obvious routes to fiscal rewards for safer driving. ISA provides drivers with feedback on whether the current speed limit is being exceeded with some systems actually limiting speed voluntarily or mandating the speed limit (Carsten and Tate, 2005). It has been claimed that universal use of mandatory ISA in the UK could reduce injury accidents by 20% and fatal accidents by 37% (Carsten and Tate, 2005). However, research has shown that those drivers who would benefit most from ISA—i.e. those who break speed limits—are least likely to voluntarily use it (Jamson, 2005). Fiscal incentives can be used to both encourage the population to adopt technologies such as ISA which can provide a demonstrable improvement in safety and also to encourage people who do adopt the technology to continue to comply with the action that is recommended (e.g. speed limit compliance).

Lindberg *et al* (2006) introduced monetary incentives when recruiting for an ISA trial in Sweden. The study produced two key findings. The first was that a significantly greater proportion of the population (of a Swedish town) were agreed to install ISA equipment if a monetary incentive was offered (equivalent to £10 each month) when compared to

those who were not offered an incentive¹¹. This indicates that voluntary adoption of safety-related equipment will be more likely if it is linked to monetary gains—the authors claim that financial benefits can induce approximately 5% of the young driver population into adopting safety-related technology (who would otherwise be uninterested if there was no payment).

The second finding was that associating ISA with financial bonuses and penalties generated greater behavioural change. In their study of 'Intelligent Economic Speed Adaptation', Lindberg *et al* explored the behavioural effects of low and high bonus payments that were either reduced by low or high penalties for exceeding speed limits. Speeding behaviour during the bonus scheme was compared with prior behaviour whilst using ISA without any related bonuses. Overall, speed-related penalties that reduced the bonus payments were associated with significantly greater speed limit compliance, particularly amongst those drivers who were receiving only a low bonus to begin with (presumably because each penalty took a larger bite out of their potential earnings). Similar findings emerged from a Danish study that offered an insurance discount for ISA usage and compliance, with the discount being reduced every time participants broke speed limits (Harms *et al*, 2007). This study also identified a reduction in speeding associated with fiscal incentives.

For such models to have real-world applicability it is likely that the incentive would need to be linked with insurance premiums; however, insurance companies may be unable to recover the cost of the technology if adoption is voluntary since Lindberg *et al* noted that typical volunteers were medium–low risk drivers. Such drivers would provide marginal scope for insurers to reduce their costs—they would gain greater financial benefit from targeting high-risk drivers (who are the least likely to volunteer). A feasible concept may require government intervention to coordinate stakeholders and ensure substantial uptake. Lindberg *et al* suggest that if such a system was adopted by the majority of medium–low risk drivers, the groups not self-selecting into the scheme would be notably distinguishable from other drivers as an even greater risk and may find that their insurance premiums are loaded accordingly. This process may subsequently encourage full migration to the ISA system.

There are also ethical considerations. It may not be appropriate to issue rewards for complying with a legal requirement, even if it is demonstrated to be more effective than either no action or penalties alone.

6.3.2.5 *Driver remuneration*

Those who drive for a living already participate in a reward model where salary is the fiscal incentive. For truck drivers, low salary has been associated with higher collision involvement (Belzer *et al*, 2002) and frequency (Rodriguez *et al*, 2003). This has been attributed to the link between mileage and pay; Rodriguez *et al* (2006) report that drivers may exceed safe operating hours to increase pay, or may drive to cover the greatest distance possible in a given time, irrespective of the safety consequences of their behaviour. Rodriguez *et al* (2006) conducted a longitudinal study of truck driver collision involvement in a large USA-based trucking firm. Following a pay increase, drivers were involved in significantly fewer collisions: for every 1% increase in pay, collision involvement reduced by 1.33%. The study did not explore which behaviours had changed to improve safety. The authors suggest that the increase in pay increased the perceived cost of losing employment and reduced the effort required to reach target earnings (based on mileage) which, collectively, may have been the stimulus for safer driving behaviour.

¹¹ If remuneration was offered, 10–17% agreed to participate; without remuneration, 6–12% agreed to participate.

This study emphasises how there is a fine balance between a fiscal incentive that encourages unsafe behaviour and one that encourages safe behaviour. Indeed, Rodriguez et al. report a U-shaped relationship between pay and crash involvement, with extreme pay at either end leading to unsafe adjustments in behaviour. It is important to recognise that any remuneration linked to driving can lead to goals that are based on unsafe behaviours (e.g. speeding or driving long hours to cover greater distances); such behaviours need to be managed by capping minimum or maximum incentives at sensible levels and/or using other methods to restrict extreme behavioural reactions (e.g. speed governors on vehicles).

Similar observations from a German incentive programme where some 1000 commercial drivers received a bi-annual bonus if they avoided having any collisions for which they were at fault. The costs of collisions where the driver was at fault correspondingly reduced by about two-thirds. This was greater than the drop in collision frequency indicating that the incentive programme was particularly effective in reducing collision severity. The organisation issuing the incentive was able to cover the costs of the programme and still save on collision payouts (Gros, 1989).

6.3.2.6 *Eco-driving*

There is an opportunity to tap into increased desire for lower vehicle running costs as a way of motivating some drivers to change their behaviour (with an expected safety benefit). There is much debate over the optimum speed for minimal fuel consumption (Haworth and Symmons, 2001). A fiscal incentive programme would need to deliver accurate, effective and realisable guidance and feedback if drivers were to be encouraged to change their behaviour based upon fuel savings alone. An IVDR and feedback device (similar in concept to Belonitor) is one approach to implementing such a programme, with fuel savings calculated automatically for drivers and perhaps feedback on which changes to driving style and exposure would yield greater savings.

6.3.3 **Observations**

There are several potential routes to delivering incentives to drivers to improve safety performance. One option is to introduce a system that measures specific behaviours and offers related rewards—such a system could be ISA or it could be based on other measures. Another option is to use the salaries of those who drive professionally as a way of encouraging safer driving. A further option is not to explicitly provide rewards but to encourage safe driving that is also efficient, thus replacing direct fiscal incentives with savings made on running costs. Examples of these options are discussed in this section.

Some of the evidence from trials overlaps with ISA-type technology. Evaluation of the expected casualty impacts and other costs and benefits of ISA has been reported on elsewhere (Carsten *et al*, 2008).

Fiscal incentives appear to have merit in general terms. Casualty reduction as well as improved compliance and environmental benefits can be achieved. Studies trialling and evaluating specific examples of technology or other approaches involving the impact assessment of fiscal incentives to improve driving would facilitate improved cost-benefit evaluation.

6.4 Increase enforcement for speeding, seat belt and drink / drug drive offences and consider random versus intelligence led enforcement

6.4.1 Option definition

The Steering Group asked TRL to estimate the impact of increased enforcement aimed at speeding, seat belt and drink/drug offences. This section also considers random and intelligence led enforcement.

6.4.2 Assumptions and approach

Elliott and Broughton (2005) reviewed the available evidence regarding how methods and levels of policing affect road casualty rates. The report concludes that "The great majority of studies in the literature have found that increasing the level of traffic policing reduces the number of road accidents and traffic violations". However, "the majority of studies in the literature were conducted outside the UK...Those studies that were conducted in the UK were either small scale, having investigated the effects of policing on a limited number of roads, or were conducted many years ago." The importance of the comment about non-UK studies lies in the possibility that cultural attitudes will affect the relationship between the level of policing and the casualty rate. The availability of UK-based evidence has not changed appreciably in the three years since the report was compiled.

The report presents clear evidence of the effectiveness of low intensity random enforcement, largely based on Australian experience. It was found, for example, that the 'Random Road Watch' enforcement programme across the Australian state of Queensland achieved large and statistically significant accident reductions in urban and rural area. The results achieved are summarised below.

Overall, random enforcement appears to be more effective than targeted enforcement, probably because randomisation enhances the deterrent effect because it gives the impression of a large-scale enforcement effort.

One problem recognised in the report is the inconsistency among studies of the measure of police enforcement. One suitable measure would be the number of officer-hours spent enforcing the traffic law, but even the number of traffic officers is unknown for many forces. Thus, the national level of enforcement is unknown and it is unclear how the level has varied in recent years.

The question refers to the benefits that might be expected from increases of 50% and 100% in the level of enforcement. Since the current level is unknown, it is not possible to provide a meaningful answer, especially as most studies (with the possible exception of the Queensland Random Road Watch) appear to involve levels well above current UK levels (e.g. stopping every 6th speeding offender as compared with stopping every 100th offender).

6.4.2.1 Queensland Random Road Watch

The 'Random Road Watch' enforcement programme was introduced progressively across the Australian state of Queensland between 1992 and 1997. Each police station in a participating region (not just stations selected on the basis of accident statistics) operated an individual programme; each programme covered as many routes in the station's territory of operations as possible, not just 'black spots'. Each participating station (279 by the close of the study) selected a number of road segments (typically 40) for enforcement. The hours 6:00-24:00 were divided into 2-hour segments, and a schedule for enforcement activity was devised by randomly selecting a series of sites and 2-hour segments. Enforcement consisted of stationing a marked police vehicle at the selected site for normal traffic enforcement duties, such as issuing tickets for traffic

offences. To illustrate the scope of the study, by its close the RRW programme covered roads that accounted for 55% of the accidents that occurred in the year before the programme began. There was no accompanying publicity campaign.

The level of enforcement achieved in the RRW programme amounted to about four hours (2 deployments) per site per year, and achieved statistically significant accident reductions. Newstead et al (2001) estimated that the number of fatal accidents had decreased by 31% (26% in urban areas), serious accidents requiring hospitalisation by 13% (21% in urban areas), and slight accidents requiring medical treatment or first aid by 9% (13% in urban areas).

More recent reports from Victoria have shown enforcement, in conjunction with other activities, resulting in 27% reductions in fatalities and 10% reductions of other severities.

6.4.3 Observations

Literature appears to show that increased enforcement can be linked to accident reduction. However, these results are not sufficiently robust, and the research methods used are not sufficiently rigorous to be applied to the questions quantitatively. Further work is needed to understand any implications for enforcement activity in Great Britain and a clearer experimental design is needed to be able to measure enforcement effort in order to relate it to accident reduction outputs.

The case study shows that random enforcement also merits further investigation in Great Britain.

6.5 Focus enforcement on gross speeding

6.5.1 Option definition

The Steering Group asked TRL to estimate the impact of focusing enforcement on gross speeding.

6.5.2 Assumptions and approach

The effects on numbers of casualties of full enforcement of speeds beyond a certain limit (the enforcement limit) have been estimated. The estimates are based on:

- Speed distributions for 2007 (Department for Transport, 2008c)
- Published relationships linking casualty numbers with speed (see section 2.5.2)

Table 6-3 shows the estimated reduction in the number of casualties by severity for various types of road. The enforcement limits have been set at various percentage increases above the posted speed limit, so that for example on urban roads with a 30 mph speed limit, an enforcement limit of 33 mph represents a 10% increase. It has been assumed that all vehicles that currently travel faster than the enforcement limit would comply with the limit and travel at it. Vehicles that travel below the enforcement limit would continue to travel at their current speed. The numbers saved are the numbers that occur with current compliance minus the number that would be expected to occur with full compliance with the enforcement limit.

Table 6-3: Estimated casualty reductions by road type and severity under different enforcement scenarios

Road type	Speed limit (mph)	Enforcement at percentage above limit						
		0%	5%	10%	15%	20%	25%	100%
Fatal casualties saved per year								
Urban single c'way	30	241	188	143	106	79	57	0
Rural single c'way	60	55	37	26	18	12	8	0
Rural dual c'way	70	41	26	14	7	3	1	0
Motorway	70	43	29	18	11	6	2	0
Seriously injured casualties saved per year								
Urban single c'way	30	3,012	2,313	1,732	1,277	935	679	0
Rural single c'way	60	187	128	89	61	42	28	0
Rural dual c'way	70	124	76	42	21	9	4	0
Motorway	70	161	106	66	39	20	9	0
Slightly injured casualties saved per year								
Urban single c'way	30	14,300	10,790	7,971	5,813	4,224	3,053	0
Rural single c'way	60	495	336	233	159	110	74	0
Rural Dual c'way	70	464	281	152	75	33	13	0
Motorway	70	961	626	384	223	118	49	0
Total casualties saved per year								
Urban single c'way	30	27,253	20,853	15,578	11,455	8,375	6,081	0
Rural single c'way	60	1,024	739	512	351	244	163	0
Rural Dual c'way	70	950	582	317	158	68	28	0
Motorway	70	1,844	1,215	752	439	233	97	0

6.5.3 Observations

It can be seen that, as expected, the higher the enforcement limit the fewer are the casualty savings. This analysis is linked in with other options. Analysis evaluating compliance under specific scenarios involving average speed cameras is taken forward

more robustly in section 3.1 and section 3.2, where estimates of casualty savings and other impacts are refined and monetised through a fuller cost benefit appraisal.

6.6 Reduce pedestrian drunkenness and increase driver awareness

6.6.1 Option definition

The Steering Group asked TRL to estimate the impact of reducing pedestrian drunkenness and increasing driver awareness of drunken pedestrians.

6.6.2 Assumptions and approach – reducing pedestrian drunkenness

One STATS19 Contributory Factor is 'Impaired by alcohol'. The number of pedestrian casualties to whom this factor was attributed has been calculated, and Table 6-4 shows the 2005-07 averages.

Table 6-4: Average number of pedestrian casualties 'impaired by alcohol'

	'Drunk pedestrian' casualties	Proportion of all pedestrian casualties
Fatal	96	14.5%
Serious	688	10.8%
Slight	1,670	6.8%
Any severity	2,454	7.8%

These results indicate the scope for casualty reduction by preventing drunken pedestrians from entering the road, but what proportion may realistically have been avoided by countermeasures such as education and publicity campaigns? There are two precedents which suggest what can be achieved by effective countermeasures: the drink/drive legislation of the Road Safety Act 1967 which introduced roadside breath-testing on 9 October 1967 and the reduction in the level of drink/drive casualties during the 1980s and early 1990s. Both, however, relate to drivers under the influence of alcohol, and subject to a legal limit on their alcohol level, whereas the issue of drunken pedestrians injured in road accidents is one aspect of the broader issue of social burden of drunkenness in GB, and there is no limit on the alcohol level of pedestrians.

There is no information about the level of drink/drive casualties during the 1960s, but analyses of Stats 19 data showed that in the year beginning October 1967, the number of fatal and serious casualties between 10pm and 4am (recognised as the part of the day when the level of drink/driving is highest) fell by 33% (40% on Saturday night/Sunday morning) compared with 4% during the rest of the day. Not all of the casualties that had previously occurred between 10pm and 4am would have involved drink/driving, so the number of drink/drive casualties could well have been halved during the first year that the Act was in force.

Subsequent editions of 'Road Accidents' show that the effect diminished rapidly, as the public became aware of the risk of being breath-tested was less than had been expected.

RCGB Table 2a presents estimates of the number of drink/drive accidents and casualties since 1979. Table 6-5 is based on the estimates for 1983 (when the level of drink/drive casualties had started to fall but the implementation of the 1981 Transport Act led to a step change in casualties) and 1993 (when the level of drink/drive casualties ceased to fall).

Table 6-5: Estimated number of drink/drive accidents and casualties since 1979

	Killed	Serious injuries	Slight injuries
% of drink/drive accidents in 1983	20.3	9.6	8.0
% of drink/drive accidents in 1993	14.2	5.9	4.6
reduction	30%	39%	43%

These reductions may largely be attributed to the effective campaigns aimed at persuading drivers of the dangers of drinking and driving.

It is difficult to envisage a legislative countermeasure such as the 1967 Road Safety Act to the problem of drunken pedestrian casualties. Really effective publicity and education campaigns aimed at persuading drinkers of the dangers of crossing the road while drunk might achieve results approaching those shown in Table 6-5 above at most. Hence, it appears feasible that the number of drunken pedestrian casualties could be reduced by one quarter which, using the results of the Contributory Factor analyses, suggests pedestrian casualty reductions of approximately 24 killed, 170 seriously injured and 420 slightly injured, i.e. about 610 in total per year.

The highest occurrence of pedestrians killed or seriously injured when impaired by alcohol on Friday and Saturday evenings/nights. These casualties were also more common between October and December, with an especially high number of injuries in December.

Almost 80% of these KSI pedestrians were in urban areas, split approximately equally between A-roads and minor roads.

6.6.3 Assumptions and approach – raising driver awareness

Table 6-6 relates to the questions of raising driver awareness to drunken pedestrians. It presents data for accidents (and casualties arising from them) in which pedestrians impaired by alcohol AND driver failed to look properly or to judge other person's path or speed were contributory factors - 2005-2007 annual averages

Table 6-6: Pedestrians impaired by alcohol AND driver failed to look properly or to judge other 2005-2007 annual averages

	'Drunk pedestrian' accidents	Casualties in 'drunk pedestrian' accidents
Fatal	6	6
Serious	33	34
Slight	69	74
Any severity	108	114

This shows the limited effect on fatalities that raising driver awareness might have – only six fatalities per year arise from accidents where a pedestrian was 'drunk' and a driver failed to look properly or judge the pedestrian path.

A 'drunk pedestrian' accident in this context means an accident in which one (or more) pedestrian(s) impaired by alcohol was (were) recorded as a contributory factor(s), whether or not the drunk pedestrian(s) concerned was (were) injured.

6.6.4 Observations

The scope for casualty reduction through pedestrian education is greater than that for driver education relating to drunken pedestrian accidents. However, the proxies for effectiveness used rely on large scale and therefore costly interventions. Furthermore, the levers realistically available for achieving the reductions in either group (pedestrians themselves, or drivers) are unclear. This analysis would require specific mechanisms of intervention to be established in order to take this option forward to more rigorous cost benefit.

6.7 Provide more pedestrian crossings

6.7.1 Option definition

The Steering Group asked TRL to estimate the impact of increasing the number of pedestrian crossings

6.7.2 Assumptions and approach

There are a wide range of results surrounding the casualty reduction impact of installing pedestrian crossings. For example, Elvik and Vaa (2004) undertook a meta-analysis of the effect on accidents of midblock signalised pedestrian crossings and found that pedestrian accidents were reduced by 12% on average (95% confidence interval from 4% to 18%). By contrast, Summersgill and Layfield (1996) found that the presence of a zebra or pelican crossing increased pedestrian accidents by a factor of 1.6, all other things being equal.

Crossings are often viewed as a facility rather than a safety device. For example, the Department for Transport (1995) states: "It should not be assumed that the provision of a crossing alone will necessarily lead to a reduction in road accidents;" and "It has not yet proved possible to make general predictions about how the accident incidence or rates at a site might change following the introduction or change of type of crossing. It is recommended that a safety audit is completed for the option being considered."

To understand the potential accident and casualty saving of a widespread increase in the provision of pedestrian crossings, it is instructive to consider the number of pedestrians casualties that might be saved by such a programme (i.e. what is the size of the target market in terms of casualty reduction). Table 6-7 presents the location of pedestrians killed and seriously injured averaged over 2005-7.

Table 6-7: location of pedestrians killed and seriously injured averaged over 2005-7

Pedestrian location	Junction		Non Junction		Total
	Urban	Rural	Urban	Rural	
In carriageway crossing at facility	568	22	235	16	842
In carriageway crossing near facility	462	25	210	17	714
In carriageway, crossing elsewhere/centre of carriageway/not crossing	1,786	315	1,743	574	4,417
Footway, verge, refuge	266	47	205	73	592
Other/unknown	196	30	179	64	470
Total	3,278	439	2,573	745	7,035

Total includes unknown rural/urban. Junction means within 20m of a junction. Crossing near facility means within 50m.

Assuming that provision of additional crossings would not save casualties currently occurring at junctions or at crossings, and also that casualties would not be saved in rural settings (where an accident problem might be identified and resolved with the provision of a crossing through standard approaches), this leaves around 2000 KSI per year (the sum of the grey boxes in Table 6-7) that might have been saved from provision of a crossing¹².

¹² On average, there is one non-junction pedestrian KSI away from a crossing facility per year for every 20km of major A-road.

Plotting this category of pedestrian KSI in London (shown in Figure 6-2) and initial cluster analysis suggests that these casualties appear not to be clustered. This means that the casualties saved per newly implemented crossing would not be large.

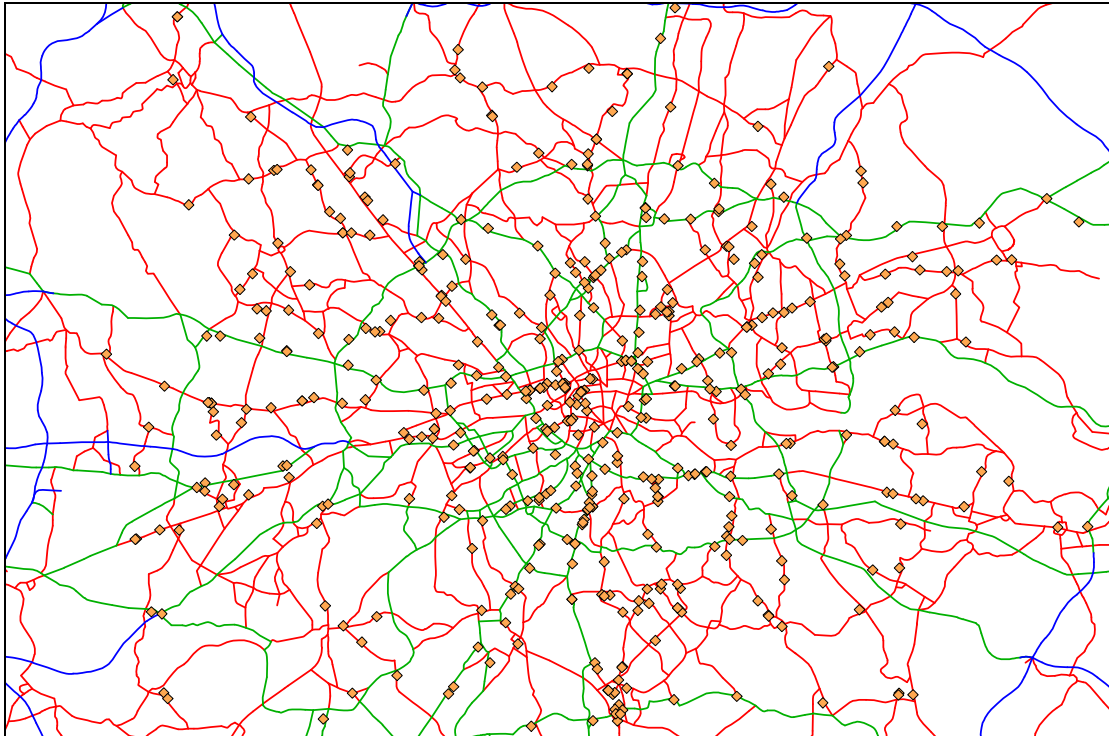


Figure 6-2 Pedestrian KSI locations in London

6.7.3 Observations

Pedestrian crossing provision is not always seen primarily as a safety improvement action. High risk sites that might warrant the provision of a pedestrian crossing on casualty savings ground can be expected to be identified and treated through prevailing approach (e.g. local safety schemes). Providing additional pedestrian crossings above and beyond this is unlikely to prove cost effective because of the distributed nature of the target population of accidents.

7 Summary

This report has described the analytical approaches used to estimate the casualty savings that might be expected to arise from the introduction of a wide variety of road safety measures, or options. The options were proposed by the DfT Steering Group tasked with preparing a road safety strategy post 2010. The level of detail of the evaluation carried out for each option was determined by Steering Group decisions.

Options for which more detailed estimates of impacts were made have been presented in two groups: those for which a full cost benefit analysis was carried out and those for which a partial cost benefit was carried out. The 10 year net present values for these two groups of options are presented in Table 7-1 and

Table 7-2 respectively.

Table 7-1 Net present values for measures taken to full cost benefit analysis

Option¹³	10 year NPV Estimate (£m)
Reduce the national speed limit on single carriageway roads without median barriers to 50mph	-149
Maintain the national motorway speed limit at 70mph and improve compliance using average speed cameras	1,251
Use 20 mph zones in metropolitan residential areas more widely	578 to 2,202
Increase investment in road safety engineering	1,774 to 100,574

Table 7-2 Net present values for measures taken to partial cost benefit analysis¹⁴

Option¹⁵	10 Year NPV Estimate (£m)
Increase the motorway speed limit to 80mph and improve compliance using average speed cameras	1,251
Reduce the motorway speed limit to 60mph and improve compliance using average speed cameras	-7,577
Undertake mass action programmes: IHIE guidelines for motorcycles	1,194 to 3,051
Undertake mass action programmes: barriers	(motorway) 461
	(dual carriageway) -454
Introduce single double summer time (SDST)	1,377

In arriving at these estimates, a wide variety of sources of information and data as well as guidance and advice on the approaches used has been required. It has been necessary to make assumptions in order to be able to quantify the impact of these

¹³ Ranges represent different assumptions / scenarios. Please refer to the relevant section for details

¹⁴ Cost benefit for the intervention of getting younger drivers into newer cars so that they benefit from improved safety features was addressed in a different way, so is not presented in this table.

¹⁵ Ranges represent different assumptions / scenarios. Please refer to the relevant section for details

options. In some cases these assumptions are based on published sources, in other cases expert views, personal communication with practitioners or single data points have been used. The assumptions and analytical approaches have been made explicit where possible.

In some cases, small changes in these assumptions can affect the net present value estimates a surprising amount. Sensitivity analysis has been carried out in a few cases to understand the impact different assumptions would have on the NPV estimates. It would be desirable to extend this and understand the sensitivities to more of the assumptions.

Several areas where the impact of assumptions merits consideration and the application of caution are given below.

- Driver behaviour change: it has been assumed that incidental change to driver behaviours does not occur. For example, where speed limits are reduced it has been assumed that drivers' gap acceptance for overtaking will remain the same. This may not be the case in reality, but it was unclear how to incorporate any changes with confidence. If more overtaking manoeuvres are undertaken, particularly on single carriageway roads, one might expect the casualty benefits from reduced speed to be somewhat negated. However, many of the speed accident relationship models implicitly account for this.
- Journey times: The uncertainty around the journey time changes associated with the wider use of 20 mph zones in residential areas has been discussed earlier. There are also other issues relating to journey times. For example, any journey time benefits arising through a reduction in accidents needs to be considered. Also improved compliance might be expected to result in smaller variance in speeds which can affect journey times.
- Unquantified impacts. There are a number of impacts that have not been incorporated into the cost benefit analysis. The impact of options on damage only accidents and some impacts associated with the introduction of SDST are two examples explained previously. In these cases this was largely because of a lack of readily available robust sources from which estimates could be taken. There are also likely to be unforeseen impacts.
- Reliance on casualty forecasting estimates: The pro-rating of accident and casualty numbers in line with the forecast reductions from Broughton (2009) effectively reduces the potential casualty savings in monetary terms of the options. Forecasts produced as part of the extant strategy have proved reasonably accurate. However, if accident numbers fall more rapidly than the forecasts in the period post 2010 then the casualty benefit pro-rating will have resulted in an overestimate of the savings and vice versa.
- Wider economy: There are several factors in the wider economy which could moderate the impacts of the options in different. For example, the economic climate could act to reduce, for example, car travel. This could be expected to have impacts on the forecasting (because of the use of pro-rated accident numbers) through slower replacement of the older vehicle fleet with newer safer vehicles, as well as the journey time changes. Other issues such as fuel cost changes and changes to the tax regime would affect the magnitude of present value calculations as well as the beneficiary of them.
- Capacity to deliver: several of the options relate to increases in effort in particular areas, for example sections 3.3, 3.4, 4.3, 4.4, 6.2 and 6.4. No evaluation of the availability of expertise or resources has been undertaken. Particularly in the cases of large increases in engineering and enforcement, the availability of capital and human resources may well act to constrain the feasibility of the options.

It should also be noted that the options described are not all additive. For example, increased investment in road safety engineering may be delivered through mass action programmes and/or the wider use of 20 mph zones in residential areas.

Evaluations for some options remained qualitative. In some cases this was because the approach to achieving casualty reductions was not clear and/or availability of data was poor. Some options were taken to a slightly greater level of detail and quantitative estimates of casualty savings were made. In some cases this could be done using well established and robust research and evaluation results. For others, a more novel approach was used. Because of this, these results should be treated with caution.

Acknowledgements

The work described in this report was carried out in the Safety: Statistics and Engineering Group of the Transport Research Laboratory. The authors are grateful to Chris Baughan who carried out the technical review and auditing of this report.

Much of this work has drawn heavily on a wide group of experts within TRL to whom the authors are grateful. Some of the work has also drawn heavily on inputs from experts outside TRL, particularly elements of Chapter 5 for which TRL is grateful for the inputs from Richard Allsop of University College London and Ruth Welsh and colleagues at Loughborough University Vehicle and Road Safety Centre. Also for inputs to section 3.4 for which the authors are grateful for inputs from Peter Whitfield, Lance Fogg and colleagues at Atkins.

Richard Allsop also provided an external peer review of the approach for estimating casualty changes linked to speed, Appendix B, for which the authors are grateful.

References

Aarts L and Van Schagen I (2006). Driving speed and the risk of road crashes: a review. In: *Accident Analysis and Prevention*, vol. 38, nr. 2, p. 215-224.

Allsop R (2005). Some reasons for lowering the legal drink-drive limit in Britain. *CTS Working Paper 2005/1*. London: Centre for Transport Studies, University College London

Alcolock.org Web Link: <http://www.alcolock.org.uk/index.html>

Arrive Alive (2002). Alcohol Interlocks in Victoria 2002. Web Link: www.arrivealive.vic.gov.au/downloads/Alcohol_Interlocks_Report.pdf

Atkins (2008). Post 2010 Road Casualty Reduction Targets: Effects of increasing investment in road safety schemes. Unpublished Atkins document, ref: 50592471/1

Bax, C (2001). Alcohol Interlock Implementation in the European Union; Feasibility study. D-2001-20 SWOV Institute for Road Safety Research, the Netherlands.

Beirness D (2003) The impact of mandatory versus voluntary participation in the Alberta ignition programme. In: *Traffic Injury Prevention 4(3) 2003*

Beirness D (2008) An Investigation of the Usefulness, the Acceptability and Impact Lifestyle of Alcohol Ignition Interlocks in Drink Driving Offenders. Road Safety Research Report No 88. London: Department for Transport.

Bell M, Chen H, Hackman M, McCabe K and Price S (2006). Using ITS to reduce environmental impacts; ITS World Congress, 2006. Web Link: http://road-network-operations.piarc.org/index.php?option=com_docman&task=doc_download&qid=228&language=en

Belzer, M. H., Rodriguez, D. A., and Sedo, S. A. (2002). Paying for Safety: An Economic Analysis of the Effect of Compensation on Truck Driver Safety. Washington, D.C.: Wayne State University
(<http://ai.volpe.dot.gov/CarrierResearchResults/CarrierResearchContent.stm#car2>).

BIVV (2006). Alcolock implementation in the European Union — Deliverable D-3. 2006. 1. Deliverable D-3. Executive summary of the alcolock field trial.

Bjerre B (2005). Primary and secondary prevention of drink driving by the use of alcolock device program: Swedish experiences. In: *Accident Analysis and Prevention 2005 37(6)*

Bjerre B (2008). Primary prevention of drink driving by the large-scale use of alcolocks in commercial vehicles. In: *Accident Analysis and Prevention 40(4) 2008*.

Broughton J, Allsop R E, Lynam D A and McMahon C M (2000). The Numerical Context for Setting National Casualty Reduction Targets. TRL Report TRL382. Crowthorne: Transport Research Laboratory.

Broughton J and Knowles J (2009). Monitoring progress towards the 2010 casualty reduction target – 2007 data. TRL Report TRL671. Crowthorne: Transport Research Laboratory.

Broughton J (2009). Post-2010 Casualty Forecasting. Road Safety Web Publication No.8 London: Department for Transport.

Broughton J and Stone M (1998). A New Assessment of Likely Effects on Road Accidents of Adopting Single Double Summertime. TRL Report TRL368. Crowthorne: Transport Research Laboratory.

Carsten, O.M.J. and Tate, F.N. (2005). Intelligent Speed Adaptation: Accident Savings and Cost-Benefit Analysis. *Accident Analysis & Prevention* 37(3):407-416.

Carsten *et al* (2008). ISA – UK intelligent speed adaptation. Final report. Web Link: <http://www.dft.gov.uk/pgr/roads/vehicles/intelligentspeedadaptation/fullreport.pdf>

Castle J A, Scoons J A and Rillie I M (2007). EuroRAP Road Protection Score, Initial HA network results. TRL Unpublished Project Report UPR SSI/197/08, 3/372-R040. Crowthorne: Transport Research Laboratory.

Clayton A (2008). A Review of International Evidence on the Use of Alcohol Ignition Interlocks in Drink-Drive Offences. Road Safety Research Report No 89. London: Department for Transport.

Curry A, Hodgson T, Kelnar R and Wilson A (2006). Intelligent Infrastructure Futures. The Scenarios – Towards 2055. London: Department of Trade and Industry Web Link: http://www.foresight.gov.uk/Intelligent%20Infrastructure%20Systems/the_scenarios_2055.pdf

Department for Environment, Food and Rural Affairs (2007). The Social Cost of Carbon and the Shadow Price of Carbon: What They Are, and How to Use Them in Economic Appraisal in the UK. Annex 2, p21, Economics Group. London: Defra.

Department for Environment, Food and Rural Affairs (2008a). IGCB: Air quality damage costs. London: Defra. Web Link: <http://www.defra.gov.uk/environment/airquality/panels/igcb/guidance/index.htm>

Department for Environment, Food and Rural Affairs (2008b). Climate change: valuing emissions *Updated* guidance on the Shadow Price of Carbon. London: Defra. Web Link: <http://www.defra.gov.uk/Environment/climatechange/research/carboncost/index.htm>

Department for Transport (1995). The Assessment of Pedestrian Crossings. Local Transport Note 1/95. London: Department for Transport. Web Link: <http://www.dft.gov.uk/pgr/roads/tpm/ltnotes/ssessmentofpedestriancro4033.pdf>

Department for Transport (2000). Tomorrow's Roads: Safer for Everyone. The Government's Road Safety Strategy and Casualty Reduction Targets for 2010. London: Department for Transport. Web Link: <http://www.dft.gov.uk/pgr/roadsafety/strategytargetperformance/tomorrowsroadsaferforeveryone>

Department for Transport (2005). New directions in speed management: a review of policy. London: Department for Transport. Web Link: <http://www.dft.gov.uk/pgr/roadsafety/speedmanagement/newdirectioninspeedmanage4802>

Department for Transport (2006). Cost Benefit Analysis, TAG Unit 3.5.4, DfT, Transport Analysis Guidance (TAG). London. Web Link: http://www.dft.gov.uk/webTAG/webdocuments/3_Expert/5_Economy_Objective/3.5.4.htm

Department for Transport (2007a). Highways Economics Note No. 1. 2005 Valuation of the Benefits of Prevention of Road Accidents and Casualties. London: Department for Transport. Web Link: <http://www.dft.gov.uk/pgr/roadsafety/ea/pdfeconnote105.pdf>

Department for Transport (2007b). Manual for Streets. London: Department for Transport. Web Link: <http://www.dft.gov.uk/pgr/sustainable/manforstreets/pdfmanforstreets.pdf>

Department for Transport (2007c). Road Casualties Great Britain: 2006 - Annual Report. London: Department for Transport. Web Link: <http://www.dft.gov.uk/pgr/statistics/datatablespublications/accidents/casualtiesqbar/roadcasualtiesgreatbritain2006>

Department for Transport (2007d) Road Statistics 2007: Traffic, Speeds and Congestion. London: Department for Transport. Web Link: <http://www.dft.gov.uk/pgr/statistics/datatablespublications/roadstraftic/speedscongestion/roadstatstsc/roadstats07tsc>

Department for Transport (2007e). Road Transport Forecasts for England 2007 – Results from the Department for Transport’s National Transport Model. London: Department for Transport. Web Link: http://www.dft.gov.uk/pgr/economics/ntm/071023_AnnualForecast07.pdf

Department for Transport (2007f). Transport Statistics Great Britain. London: Department for Transport. Web Link: <http://www.dft.gov.uk/pgr/statistics/datatablespublications/tsgb/edition20071.pdf>

Department for Transport (2008a). Road Casualties Great Britain: 2007 - Annual Report. London: Department for Transport. Web Link: <http://www.dft.gov.uk/pgr/statistics/datatablespublications/accidents/casualtiesqbar/roadcasualtiesgreatbritain20071>

Department for Transport (2008b). Road lengths in Great Britain: 2005 - 2007 by Regions/LA - Great Britain. London: Department for Transport. Web Link: <http://www.dft.gov.uk/pgr/statistics/datatablespublications/roadstraftic/roadlengths/>

Department for Transport (2008c). Transport Statistics Great Britain. London: Department for Transport. Web Link: <http://www.dft.gov.uk/pgr/statistics/datatablespublications/tsgb/edition20071.pdf>

Department for Transport (2008d). Free Flow Vehicle Speed Statistics 2007. London: Department for Transport. Web Link: www.dft.gov.uk/excel/173025/221412/221546/227050/261688/vehiclespeeddata07.xls

Department for Transport (2009a). Travel Analysis Guidance (WebTAG). London: Department for Transport. Web Link: <http://www.dft.gov.uk/webTAG>

Department for Transport (2009b). Road Safety Research Report No. 108. Contributions of Local Safety Schemes to casualty reduction. London: Department for Transport.

Ealing Local Implementation Plan (Transport) (2007). London. Web Link: http://www.ealing.gov.uk/services/transport_and_streets/transport_strategy_and_policies/Lip/lip_docs/section_2720113925370.html

Elliott M and Armitage C (2006). Effects of implementation intentions on the self-reported frequency of drivers compliance with speed limits. In: *Journal of Experimental Psychology: Applied*, 12, 108-117.

Elliott M and Broughton J (2005). How Methods and Levels of Policing Affect Road Casualty Rates. TRL Report TRL637. Crowthorne: Transport Research Laboratory.

Elvik R, Christensen P and Amundsen A (2004). Speed and road accidents – an evaluation of the power model TOI Report 740/2004, Institute of Transport Economics, TOI, Norway.

Elvik R and Vaa T (2004). The Handbook of Road Safety Measures. Oxford: Elsevier.

ERSO. Web Link:

http://www.erso.eu/knowledge/content/50_vehicle/heavy_goods_vehicles.htm

ETSC DDM ETSC Drink Drive Monitors 1-5 April 2007 - July 2008

Web Link: <http://www.etsc.be/documents.php?did=2>

ETSC (2008). Drink Driving: Young drivers and recidivist drivers.

Web Link: http://www.etsc.be/documents/ETS_004-08.pdf

Finch D, Kompfner P, Lockwood C and Maycock G (1994). Speed, Speed Limits and Accidents. TRL Project Report 58. Crowthorne: Transport Research Laboratory.

Greater London Authority (2008). London's Changing Population. DMAG update: GLA Demography Update 16-2008. London: Greater London Authority. Web Link:

<http://www.london.gov.uk/gla/publications/factsandfigures/dmag-update-16-2008.pdf>

Gros, J. (1989). Das Kraft-Fahr-Sicherheitsprogramm. Personalführung, 3,246-249.

Hagenzieker, M.P. (1999). Rewards and road user behaviour: an investigation of the effects of reward programs on safety belt use, Leiden.

Harms, L.; Klarborg, B.; Agerholm, N.; Tradisauskas, N. and Lahrman H.; (2007) Effects of ISA on the driving speed of young volunteers - A controlled study of the impact information and incentives on speed; Proposal for paper on the 6th European Congress on Intelligent Transport Systems and Services, 18th -20th June 2007 in Aalborg, Denmark

Haworth, N., Symmons, M. (2001). The Relationship between Fuel Economy and Safety Outcomes, Monash University Accident Research Centre, Report No 188.

Highways Agency. The Design Manual for Roads and Bridges. London: Highways Agency

Web Link: <http://www.standardsforhighways.co.uk/dmrb/index.htm>

HM Treasury (2003). The Green Book. Appraisal and Evaluation in Central Government. London: TSO.

ICADTS. Web Link: <http://www.ignitioninterlockdevice.org/uslegislationstudies.html>

IHIE (2008). Guidelines for Motorcycling. London: IHIE. Web Link:

<http://www.motorcycleguidelines.org.uk/home.htm>

Jamson, S. (2005). Would those who need ISA, use it? Investigating the relationship between drivers' speed choice and their use of a voluntary ISA system. Transportation Research Part F 9 195-206.

Joumard, R, Jost, P, and Hickman J (1995). Influence of instantaneous speed and acceleration on hot passenger car emissions and fuel consumption. SAE Paper 950928

Lawton, B, Broughton, J, and Johnson, B (in press). Foresight: Intelligent Infrastructure Futures – Implications for Road Safety.

Lindberg, G., Hultkrantz, L., Nilsson, J. E., and Fridtjof, T. (2006). Pay-as-you-speed: two field experiments on controlling adverse selection and moral hazard in traffic insurance. Working paper, Vaeg-och Transportforskningsinstitutet.

Lisbeth, H., Klarborg, B., Lahrmann, H., Agerholm, N., Jensen, E., and Tradisauskas, N. (2007). Proceedings from 6th European Congress on Intelligent Transport Systems and Services, Time to Intelligent Move, 18th - 20th June 2007.

Mathijssen M (2005). Drink driving policy and road safety in the Netherlands: a retrospective analysis. In: *Transportation Research E Logistics Transp Rev 2005 41(5)*.

Maycock G (1997). Drinking and Driving in Great Britain – a Review. TRL Report TRL232
Crowthorne: Transport Research Laboratory

Mazureck, U. and Hattem, J. van (2006). Rewards for safe driving behaviour; influence on following distance and speed. Transportation research record. 1980, 31–38.
Rotterdam: Rijkwaterstaat.

Minden, H. (1982). Two Hugs for Survival. Toronto, ON: McClelland and Stewart Limited.

Nevin, J.A. (1988). Behavioral momentum and the partial reinforcement effect. *Psychological Bulletin*, 103, 44-56.

Newstead S, Cameron M and Leggett M. (2001) 'The crash reduction effectiveness of a network-wide traffic police deployment system' *Accident Analysis and Prevention*, 33 (2001), pp393-406.

Nilsson G (2004). Traffic Safety Dimensions and the Power Model to Describe the Effect of Speed on Safety. Bulletin 221. Lund Institute of Technology, Department of Technology and Society, Traffic Engineering, Lund.

PACTS (2005). Policing Road Risk: Enforcement, Technologies and Road Safety. March 2005. Web Link: <http://www.pacts.org.uk/research.php?id=2>

Pytlik (2006). Development of a Process for Assessing Skidding Resistance of Roads and a Policy for High Friction Surfaces on Roads. Report to Cabinet Member for Transport and Highways: Report of Corporate Director of Community Services. Solihull Metropolitan Borough Council.

Regan M, Oxley J, Godley S and Tingvall C. Intelligent Transport Systems: Safety and Human Factors Issues. Royal Automobile Club of Victoria (RACV) Ltd - Report 01/01. Monash University. Web Link: <http://www.monash.edu.au/muarc/reports/Other/racv0101.html>

Rodriguez DA, Targa F, Belzer MH. Pay Incentives and Truck Driver Safety: A Case Study. *Industrial and Labor Relations Review*, Vol. 59, No. 2, 2006, pp. 205-225.

RoSPA (1998) The Campaign for Lighter Evenings. Web Link: http://www.rospace.com/news/releases/1998/prx10_24_09_98_road.htm

SARTRE3 Consortium (2004). European drivers and road risk: SARTRE3 reports. European Commission: Brussels.

Skinner, B.F. (1953). Science and Human Behavior, New York: Macmillian.

Steg, L. & Kalfs, N. (2000). Altijd weer die auto!, in opdracht van Sociaal Cultureel Planbureau, Adviesdienst Verkeer en Vervoer, Den Haag.

SWOV (2005). Web Link:

<http://www.swov.nl/UK/Research/Publicaties/inhoud/factsheets.htm>

Taylor M, Lynam D and Baruya A (2000). The Effects of Drivers' Speed on the Frequency of Road Accidents TRL Report TRL421. Crowthorne: Transport Research Laboratory.

Taylor M, Baruya A and Kennedy J (2002). The Relationship between Speed and Accidents on Rural Single Carriageway Roads. TRL Report TRL511. Crowthorne: Transport Research Laboratory.

Tertoolen, G. (1994). Uit eigen beweging ...?! Een veldexperiment over beïnvloedingspogingen van het autogebruik en de daardoor opgeroepen psychologische weerstanden, Utrecht.

TRACE conference. Web Link: <http://www.trace-project.org/publication/publications.html>

Transport for London (2004). A Business Case and Evaluation of the Impacts of Cycling in London. London: Transport for London.

Transport for London (2008). Towards the year 2010: monitoring casualties in Greater London (Issue 8). London: Transport for London. Web Link: <http://www.tfl.gov.uk/assets/downloads/towards-2010-monitoring-casualties-issue-8.pdf>

Tunbridge R J, Keigan M and James F J (2003). The Distribution of Breath Alcohol Levels in Drivers. TRL Unpublished Report PR SE/735/03. Crowthorne: Transport Research Laboratory.

VOAS R (2003). Barriers to Alcolock Implementation. In: *Traffic Injury Prevention 4(3) 2003*

Volvo (2007) Web Link: <http://www.roadtransport.com/Articles/2007/12/14/129372/mt-tests-volvo-alcolock.html>

Webster D C and Layfield R E (2003). Review of 20mph Zones in London Boroughs. TRL Published Project Report PPR243. Crowthorne: Transport Research Laboratory.

Webster D C and Mackie A M (1996). Review of Traffic Calming Schemes in 20mph Zones. TRL Report TRL215. Crowthorne: Transport Research Laboratory.

Appendix A Initial list of options

Options taken to full cost benefit analysis

- Reducing the national speed limit for rural single carriageways to 50mph
- 20 mph zones/limits in urban areas
- Full compliance with the 70mph speed limit on motorways
- 25% increase in investment in local safety engineering schemes

Options taken to partial cost benefit analysis

- Increasing investment in local authority and Highways Agency road safety engineering schemes by 25%/50%/100%
- Mass action programmes including. These might have degree of targeting
 - PTW-friendly infrastructure as set out in chapter 4 of the IHIE Guidelines for Motorcycling
 - those to improve the secondary safety of highway infrastructure e.g. side barriers, centre barriers, frangible sign posts etc.
- The potential contribution of measures to get vulnerable young drivers into newer, safer cars
- The casualty impacts of introducing Single Double Summer Time -little robust evidence besides road safety

Options with quantitative casualty benefit estimates

- Raising the national speed limit for motorways to 80mph
- The casualty reduction impacts of reducing the drink-drive limit to 50mg and 20mg;
- The casualty reduction achievable through:
 - programmes to fit alcolocks in the case of persistent drink-drive offenders;
 - use of alcolocks in company car fleets;
- standard fitment to new cars of
 - seatbelt-ignition interlocks and
 - alcolocks

Options with qualitative casualty benefit estimates

- What would be the casualty-reduction effect of Manual for Streets design standards being applied to all new residential roads in the period to 2020 and 2030?
- The potential impacts of an intensified and extended road safety education programme
- Research into the effectiveness of fiscal incentives in improving driving.
- A 50% and 100% increase in police enforcement against speeding offences, seatbelt offences and drink/drug-driving offences
- Impact of random enforcement and intelligence-led enforcement in reducing casualties
- Focussing enforcement effort on gross speeding
- Pedestrian drunkenness - reducing pedestrian drunkenness and increasing awareness among drivers of the potential for encountering drunken pedestrians
- A programme of providing more pedestrian crossings

Appendix B Review of approach in estimating casualty changes

TOI REPORT 740/2004 – OPINION ON THE QUALITY OF THE WORK IT DESCRIBES AND ON ITS RELEVANCE TO SCENARIOS FOR REDUCING SPEEDS ON 60 AND 70 miles/h ROADS IN BRITAIN

Richard E Allsop
Centre for Transport Studies
UCL

January 2009

This opinion is offered in response to a request by DfT Road User Safety Division in January 2009 in the context of TRL Ltd's use of results from TOI Report 740/2004 in estimating the impact of altered speed on high speed roads on casualties under four scenarios for speed management.

B.1.1 TOI Report 740/2004

This report, entitled *Speed and road accidents – an evaluation of the power model*, by Rune Elvik, Peter Christensen and Astrid Amundsen, was published in December 2004 by the Institute of Transport Economics in Oslo, and will be referred to here as '*the Report*'. It describes and presents results of a meta-analysis based on numerous studies relevant to the representation by the power model of the influence upon road accident occurrence of changes in the speed of traffic on sections of road. The central outcome is a set of preferred values of power to be used in the power model to estimate the effects of changes in mean speed upon numbers of accidents or casualties of different severities.

B.1.2 Quality of the Report

The Institute of Transport Economics (TOI) is a respected research institute with a strong internal system for quality control of reporting. The research leading to the Report was funded jointly by the Norwegian and Swedish National Roads Administrations, and the latter is known for its rigorous approach to the application of research. The Report is endorsed in the Preface by the Acting Managing Director of TOI and by the Head of the relevant Department of TOI.

The Report deals exclusively with the power model, in which the number of accidents or casualties on a section of road in a given period at a given level of traffic is represented as being proportional to a certain power of the mean speed of traffic. This model has a long history, is well-supported by theory and empirical evidence, and is widely accepted. The report points out that the model should ideally be applied to accidents or casualties disaggregated by level of severity but is often also applied to aggregate numbers of accidents or casualties of different severities, and provides preferred values of power for both kinds of application, but does not otherwise discuss variants on or alternatives to the power model. This is sensible because although the model can be refined to reflect other factors affecting numbers of accidents and casualties, and alternative algebraic formulations can be used in place of the power function, there is no body of evidence supporting any alternative form of model that would be likely to provide substantially different estimates of the effect on accident or casualty numbers of modest changes in mean speed.

The model does not represent, nor therefore does the Report discuss, the effects of changes in the distribution of speeds of individual vehicles about the mean speed.

After a wide trawl for relevant research reports, a total of 175 previous studies were identified as being relevant to the calibration of the power model, 98 of which were

found to meet strict criteria for inclusion in the meta-analysis. These criteria are set out fully in the Report and are concerned with whether a study provides data to support an estimate of power of mean speed in the power model; there is no sign of inclusion or exclusion of any study being influenced by the value of power that the study might imply.

The meta-analysis is described in some detail and the indications are that the range of studies included give rise to distributions of estimates of power that point reasonably clearly to preferred estimates. The relation between raw numerical estimates given by each study and theoretical considerations concerning the values of power for accidents or casualties of different severities is discussed, and judgement is used in smoothing the raw estimates to yield a mutually consistent set of smoothed estimates from each study before the results from all studies are combined with appropriate weighting to yield preferred values of power. Confidence intervals for these preferred values are derived appropriately from the estimated standard errors of the values given by the individual studies before smoothing. The step in this process that is most open to debate is the smoothing, but it seems unlikely that different approaches to this would have led to substantially different preferred values of power.

In short, the Report describes a thorough, comprehensive and sound analysis which provides strong support from many empirical studies taken together for the values of power that are close to those advanced on the basis of theory and a smaller range of empirical evidence by leading exponents of the power model, notable Nilsson.

B.1.3 The four scenarios for speed management

The four scenarios for speed management on 60 and 70 miles/h roads in Britain are described by TRL Ltd as:

1. Changing the National speed limit on single carriageway roads from 60mph to 50mph
2. Enforcing the 70mph speed limit on motorways
3. Changing motorway speed limits to an enforced 60mph
4. Changing motorway speed limits to an enforced 80mph

B.1.4 Relevance of results from the Report to these scenarios.

Just over half the studies included in the meta-analysis in the Report are of changes in speed limit, and nearly a quarter are of changes in enforcement. The remainder are mainly of traffic engineering measures. The resulting preferred values of power are therefore based to a considerable degree on the measured effects on numbers of accidents and casualties of changes in speed management of the broad kinds envisaged in the scenarios.

The meta-analysis in the Report investigates whether the values of power differ according to the speed management measure giving rise to the change in speed observed in each included study. It finds that only one kind of measure is associated with values of power differing significantly from those associated with changing the speed limit: police enforcement is found to be associated with higher values of power, but no indication is given of how much higher. The Report therefore indicates, without quantification, that reducing mean speed by police enforcement is likely to reduce accidents and casualties more rather than less than would achieving the same reduction in mean speed simply by reducing the speed limit. The Report suggests, plausibly, that this may be because police enforcement encourages safer driver behaviour in other ways in addition to simply moderating speed. The preferred values of power given in the report estimate the effect on numbers of accidents and casualties of changes in mean speed resulting simply from changing the speed limit. The indication is that they provide conservative estimates of the effect on numbers of accidents and casualties of achieving changes in mean speed by police enforcement.

There is little doubt of the general relevance of the findings in the Report to the four scenarios, but there are important differences between the scenarios in this respect.

Scenario 1 is a simple reduction in the speed limit on 60 miles/h roads without reference to enforcement. To apply the power model, it is necessary to make some assumption, on which the Report provides no guidance, about the associated reduction in mean speed. Under this assumption, the preferred values of power from the Report can be applied in the knowledge that this is just the kind of change to which the preferred values relate.

The other three scenarios include enforcement, with or without change in the speed limit. Scenario 2 speaks of enforcing the 70 miles/h limit on motorways, which presumably envisages an appreciably stricter level of enforcement than prevails now. Scenarios 3 and 4 speak of enforced limits, which again presumably envisages an appreciably stricter level of enforcement than prevails now with the current limit. To apply the power model to these scenarios it is necessary to make some assumption, on which the Report provides no guidance, about the reduction in mean speed associated with the stricter level of enforcement. In Scenario 2, the preferred values of power from the Report can then be applied to give a conservative estimate of the effect on accidents and casualties, conservative because the change in mean speed arises from enforcement. In Scenario 3 the assumption needs to extend to a combination of reduction in speed limit and stricter enforcement, and the preferred values of power will then give an estimate of the effect on accidents and casualties which is conservative to the extent that some of the reduction in speed has arisen from enforcement. In Scenario 4 the assumption is about the net effect of raising the limit and stricter enforcement, and the preferred values will give an estimate of effect on accidents and casualties which will tend to underestimate a decrease or overestimate an increase because the estimate of the downward contribution from the enforcement is conservative.

In relation to stricter enforcement it should also be considered whether this form of enforcement may give rise to a change in the distribution of speeds which is appreciably different from any change in distribution which is typically associated with changing the speed limit, and therefore differs from any change in distribution reflected in the preferred values of power. The Report provides no guidance about the effect of any such appreciably different change in speed distribution, or indeed whether such changes might have contributed to the extra effect on accidents and casualties it finds to arise from reduction in mean speed achieved by enforcement over and above the effect arising from the same reduction achieved by changing the speed limit.

The foregoing paragraphs mention a number of matters relevant to the application of the power model on which the Report gives no guidance. In these respects, the application of the model will need to have regard to other research sources. But the power model should be central to the estimation of changes in accident and casualty numbers in the various scenarios, and the Report is therefore relevant to the scenarios in providing the most strongly based available set of values of power and confidence limits for these values.

Appendix C Estimated effects of assumed alterations in drivers' BACs upon casualty numbers

The factors by which numbers of casualties will be multiplied under the assumptions in Table 5-3 are each estimated by use of one or two of the following four expressions, in which $k = 0.032$ for numbers killed and $k = 0.021$ for numbers seriously injured.

1 *All current BACs are reduced by r*

The number of casualties is multiplied by $\exp(-kr)$

2 *BACs in the range (b,c) are redistributed over (a,c) in the same order, where $a < b$*

Each BAC x in this range is reduced by $(c-x)(b-a)/(c-b)$ so the number of casualties is multiplied by $\int_b^c \exp[-k(c-x)(b-a)/(c-b)]/(c-b)dx = \{1 - \exp[-k(b-a)]\}/k(b-a)$

3 *BACs in range (b,c) are redistributed over $(0,b)$ in the same order*

Each BAC x in this range is reduced by $[b^2 + (c-2b)x]/(c-b)$ so the number of casualties is multiplied by

$$\int_b^c \exp\{-k[b^2 + (c-2b)x]/(c-b)\}/(c-b)dx = \{\exp[-k(c-b)] - \exp(-kb)\}/k(2b-c)$$

Note: In the singular case $c = 2b$ this expression reduces to expression (1) .

4 *All BACs in range (b,c) are reduced to zero*

Each BAC x in this range is reduced by x so the number of casualties is multiplied by

$$\int_b^c \exp(-kx)/(c-b)dx = \{\exp(-kb) - \exp(-kc)\}/k(c-b)$$

These expressions yield the values shown in Table A1, which are independent of the numbers killed or injured in accidents in which at least one driver's BAC exceeds 80.

Factors by which numbers of killed or seriously injured are estimated to be multiplied by changes in behaviour assumed in Table 5-3

Drivers' current BACs	Assumption about altered BACs			
	Pessimistic		Optimistic	
	Killed	Seriously injured	Killed	Seriously injured
<i>Limit reduced to 50</i>				
80-110	.6428	.7419	.3829	.5326
50-80	.6428	.7419	.3829	.5326
20-50	.7386	.8166	.4512	.5926
0-20	1.0	1.0	1.0	1.0
<i>Limit reduced to 20</i>				
80-110	.4445	.5685	.1466	.2837
50-80	.2828	.4349	.1553	.2943
20-50	.4512	.5926	.4056	.5526
0-20	1.0	1.0	.7386	.8165

An evaluation of options for road safety beyond 2010



This report describes the methods that have been used to estimate the casualty reductions that might be expected to arise from a number of potential road safety intervention options raised for consideration as part of the work by the Department for Transport in preparation of a road safety strategy post 2010.

The options are presented in four groups defined by the level of detail of the estimation: options taken to full cost benefit analysis; options taken to partial cost benefit analysis; options with quantitative casualty benefit estimates and options with qualitative casualty benefit estimates.

The report describes in detail the analytical methods used to estimate the costs and benefits associated with the list of potential options. Costs and benefits addressed include implementation, casualty savings, journey time, emissions and fuel use.

Net present values have been estimated for four potential road safety options in the first group: reduce the national speed limit on single carriageway roads without median barriers to 50mph; maintain the national motorway speed limit at 70mph and improve compliance using average speed cameras; use 20 mph zones in metropolitan residential areas more widely and increase investment in road safety engineering.

Other titles from this subject area

- PPR096** The Heavy Vehicle Crash Injury Study (HVCIS) Project Report. I Knight, R Minton, P Massie, T Smith and R Gard. 2008
- PPR248** Review of International Road Safety Good Practice. J A Castle and G E Kamyra-Lukoda. 2007
- PPR247** Review of Road Safety Good Practice in English Local Authorities. J A Castle and G E Kamyra-Lukoda. 2007
- PPR223** New and improved accident reconstruction techniques for modern vehicles equipped with ESC systems. R F Lambourn, P W Jennings, I Knight and T Brightman. 2007
- PPR241** Factors influencing pedestrian safety: a literature review. A Martin. 2007
- PPR213** Assessment of current bicycle helmets for the potential to cause rotational injury. V J M St Clair and B P Chinn. 2007

Price code: 3X

ISSN 0968-4093

TRL

Crowthorne House, Nine Mile Ride
Wokingham, Berkshire RG40 3GA
United Kingdom

T: +44 (0) 1344 773131
F: +44 (0) 1344 770356
E: enquiries@trl.co.uk
W: www.trl.co.uk

Published by

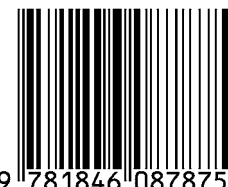


IHS

Willoughby Road, Bracknell
Berkshire RG12 8FB
United Kingdom

T: +44 (0) 1344 328038
F: +44 (0) 1344 328005
E: trl@ihs.com
W: http://emeastore.ihs.com

ISBN 978-1-84608-787-5



9 781846 087875

PPR397