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Post-2010 Casualty Forecasting

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EXECUTIVE SUMMARY

This report presents the outcome of research that has been carried out by the Transport Research Laboratory to assist the Department for Transport to prepare for the post-2010 casualty reduction strategy. It shows how the numbers of casualties in 2020 and 2030 have been forecast, taking account of likely future developments in travel by road and in road safety, and presents the forecasts that have been prepared.

The work has built on the methodology that was developed in the late 1990s to prepare the post-2000 casualty reduction target, as described in the report TRL 382 (Broughton et al, 2000). The TRL 382 methodology provides a series of statistical models that forecast the number of casualties in 2010 under a number of assumptions about the changes in road travel until 2010 and the assumed effects of new road safety measures that might be introduced. An important feature of the methodology is that it can incorporate the effects of existing road safety measures where they can be estimated reliably.

The forecasting models have been updated annually, and the results have shown that the forecasting methodology is broadly reliable. Consequently, the new forecasts presented in this report have followed the same approach, with some minor modifications. The report presents forecasts of the number of people who will be killed and seriously injured in 2020 and 2030. It also uses a slightly simpler approach to forecast the number of children who will be killed and seriously injured in these years.

Few road safety measures affect all road user groups equally, so five groups of road user are treated separately in the modelling: car occupants, motorcyclists, pedestrians, pedal cyclists and others. ‘Transport scenarios’ are defined to allow for uncertainty over the future level of road use by the various transport modes. Each scenario consists of predictions for the target year of the levels of traffic (all motor vehicles, cars, motorcycles) and of pedestrian and pedal cycle activity. These scenarios are largely based on official forecasts.

Casualty forecasts

The casualty forecasts for 2010 that were presented in the report TRL 382 took account of the likely effects of road safety measures that might be introduced between 2000 and 2010 as part of a new road safety strategy. This report is being published as contribution to the Department for Transport’s consultation over the post-2010 casualty reduction target, and only limited information is available at present about the range of potential new measures and their likely effects. Hence, it would be premature at this stage to attempt to prepare final forecasts. The forecasts presented in this report show the casualty reductions that might be expected if

current road safety activities are maintained and current casualty trends continue but no new road safety measures are introduced.

These forecasts suggest that the number of people who will be killed in road accidents in 2020 could well be about one-third less than the 2005–07 average, and the number who are seriously injured could well be a little more than half the 2005–07 average, the exact values depending on various assumptions. The corresponding proportions for 2030 are almost a half and almost two-thirds. The number of children who are killed in road accidents in 2020 could well be little more than one-third of the 2005–07 average, and the number who are seriously injured could well be less than a half. Further reductions are predicted by 2030.

It should be emphasised that the predicted reductions are in no sense predetermined. They will only be achieved by a continuation of current efforts to improve road safety in Great Britain.

Car secondary safety

Secondary safety refers to the protection offered by a vehicle involved in an accident, as distinct from primary safety, which refers to systems such as steering and brakes, which should help to avoid accidents. A statistical model is used to analyse accident data from 1989 to 2007 in order to quantify this effect. Cars are grouped by their year of first registration, and the model demonstrates that newer cars offer substantially better protection than older cars. The results show that the single development over the past 15 years that has had the most significant effect on the national casualty total has probably been the improvement of car secondary safety.

The results of the most recent analyses are presented in the report, and these are then used to assess the likely benefits of future improvements. These predictions depend in part on an assumption about the extent to which recent progress will continue in future. They make a key contribution to predicted reductions for car occupant casualties in 2020 and 2030.

ABSTRACT

This report describes the methods that have been used to forecast in some detail the number of fatal and serious casualties on British roads in 2020 and 2030. These forecasts will help to provide the numerical context when the Government sets the next round of casualty reduction targets. Statistical models are fitted to past casualty and exposure data, taking account, as far as possible, of road safety measures that have been introduced.

The models demonstrate sufficient consistency to be used to forecast casualty rates, which are then combined with predictions about the distances travelled in future to produce casualty forecasts. These forecasts assume that current road safety activities will continue to be undertaken in coming years, but that no new measures will be introduced. Consequently, they provide the basis for the final stage of forecasting in which the assumed effects of new measures can be taken into account.

The improvement of car secondary safety over the past 15 years has probably been the development that has had the most significant effect on the national casualty total. A statistical model is used to quantify this effect by analysis of accident data. The results of the most recent analyses are presented, and used to estimate the future benefits.

1 INTRODUCTION

One of the main tasks in preparing for the post-2010 casualty reduction target has been to forecast the number of casualties in two target years, taking account of likely future developments in road safety. This report summarises the forecasts that have been prepared. The work has built on the methodology that was developed in the late 1990s to prepare the post-2000 casualty reduction target, as described in detail in the report TRL 382 (Broughton et al, 2000).

The TRL 382 methodology provided a series of statistical models that forecast the number of casualties in 2010 under a number of assumptions about the changes in road travel until 2010 and the assumed effects of new road safety measures that might be introduced. The forecasting models have been updated annually in a series of monitoring reports, and the results have confirmed that the forecasting methodology is broadly reliable. Consequently, the post-2010 forecasts have been prepared using the same approach. The most recent monitoring report analysed data to 2007 (Broughton and Knowles, 2009), but a complete set of the relevant results is presented in this report and the reader has no need to consult that report.

It was important that the TRL 382 methodology should incorporate the effects of road safety measures *where they could be estimated reliably*. This was found to be true of only three types of measure:

- improved standards of secondary safety in cars
- measures to reduce the level of drink/driving
- road safety engineering.

These were known as the 'DESS' measures (Drink/driving, Engineering, Secondary Safety) and the remainder were grouped together as the 'core' measures. The road safety measures that might be included in any new road safety strategy can be grouped as follows:

1. The DESS measures, whose level of effect may vary from what has been achieved in the past.
2. The core programme, i.e. a continuation of existing core measures.
3. New measures, including all measures which are either innovatory or a substantial expansion of existing measures.

The distinction between core measures and new measures is crucial to understanding the casualty forecasts that will be presented in Section 3. Core measures already exist and should already be contributing to casualty trends. By contrast, new measures either do not exist or, where they do already exist, have had no appreciable effect on casualty trends to date. Electronic Stability Control for cars is an example of a new measure in terms of the forecasts for 2020 and 2030. It was only fitted to a small minority of cars on the road in 2007 so would not have influenced casualty trends, but by 2020 it is likely to be fitted to a majority of cars and could well be achieving casualty reductions.

Few road safety measures affect all road user groups equally, so five groups of road user were treated separately in the modelling:

- car occupants
- motorcyclists
- pedestrians
- pedal cyclists
- others.

To allow for uncertainty over the future level of road use by the various transport modes, several ‘transport scenarios’ were defined. Each scenario consisted of predictions for the target year of the levels of traffic (all motor vehicles, cars, motorcycles) and of pedestrian and pedal cycle activity. The stages of the procedure for forecasting the consequences of a new road safety strategy for a specific transport scenario were:

1. Estimate casualty rates in the target year to show what would be expected if there were no further DESS measures and only the core road safety activities were undertaken with the current level of effect.
2. Prepare a baseline casualty forecast using these estimated rates together with predictions of the volume of road travel in the target year.
3. Apply the assumed effects of the measures in the new road safety strategy (including any further DESS measures) to the baseline forecast.

The estimates in step 1 were prepared from analyses of casualty rates from 1983–98, adjusted to allow for the effects of the DESS measures. These are referred to as the adjusted casualty rates. The forecasts for the five road user groups were then summed to give overall forecasts, conditional on the assumed change in road travel and the assumed effects of new measures.

The approach followed in this report differs in three important respects from the approach described in TRL 382 as a result of decisions by the Department for Transport:

1. Separate forecasts are prepared for 2020 and 2030.
2. Separate forecasts are prepared for the number of people killed and the number seriously injured (TRL 382 focused on forecasts for the number killed or seriously injured (KSI) and the number slightly injured).

3. This report is being published as part of the Department for Transport's consultation over the post-2010 casualty reduction target, so only limited information is available at present about the range of potential new measures and it would be premature to present final forecasts at this stage, i.e. to complete step 3.

Several more detailed changes have been made to improve the modelling. In addition, analyses originally developed in the monitoring reports are applied to investigate potential targets for reducing the number of injured children.

1.1 Targets and forecasts

The purpose of setting a casualty reduction target is generally accepted to be to provide a common goal for those involved with improving road safety. They can easily understand a *quantitative* target, and later will be able to check progress towards the target and if necessary take action to ensure that the target will be achieved. In order to gain the support of the many people whose co-operation will be needed if the target is to be attained, they need to feel that the goal is *achievable*. On the other hand, the target should also be *challenging* in order to avoid complacency and to focus efforts on the most effective measures. If the target is not challenging then a major opportunity for saving lives will have been lost.

It is important to use a sound methodology to prepare the target for reducing road accidents and casualties. If the methodology is not sound then the target will lack credibility and the efforts for improving safety and saving lives will be jeopardised. Moreover, if, as time passes, key people involved in improving road safety come to realise that a poor methodology has produced a target that is too demanding and which cannot be achieved, they will lose motivation and it will be difficult to make progress.

The final stage of the target setting process is outside the scope of this report. Post-2010 targets will be set by the Government within the context of the Road Safety Strategy, informed by the casualty forecasts. The forecasting methodology provides a means for assessing the likely range of casualty numbers in 2020 and 2030 for a range of policy assumptions. The selection of a suitable target involves judgements about the likelihood of the various scenarios being realised as well as the likelihood of implementation and confidence in the predicted effectiveness of the strategy.

1.2 Statistical background

All the statistical information on which this report is based comes from Government sources. In particular, information about road accident casualties comes from the national STATS19 accident database. Details of the database and a range of results are published annually in the Road Casualties Great Britain series (e.g. Department for Transport, 2008). This section presents a brief overview of the casualty statistics over recent years.

The purpose of this report is to forecast the number of fatal and serious casualties in Great Britain. Figure 1.1 summarises the statistical background, namely the annual national totals between 1983 and 2007. The number of serious casualties has fallen fairly steadily since 1985, with a brief exception in 1994. The number of people killed has varied more erratically, with periods of slow decline in 1983–90 and 1996–2003 separated by a period of more rapid decline between 1991 and 1995.

Figure 1.1 National totals, 1983 2007

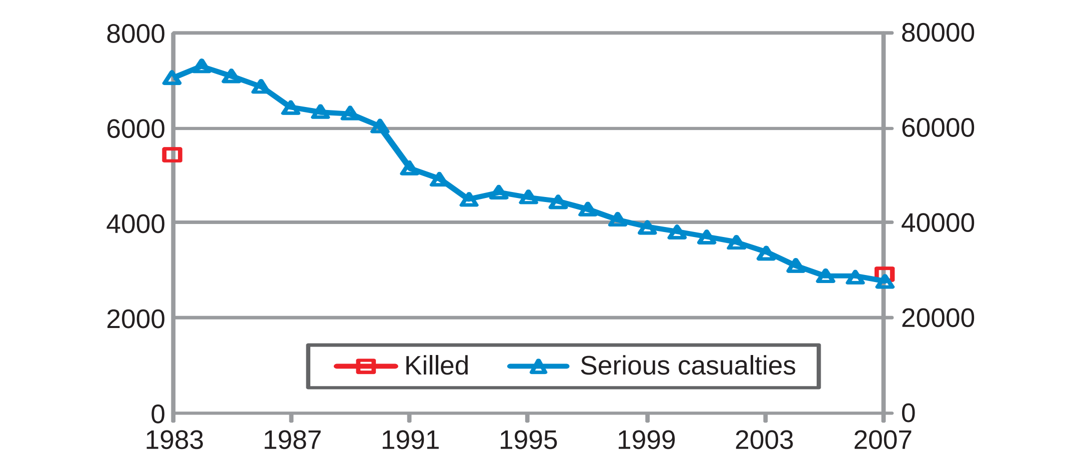


Table 1.1 presents the composition of the national casualty totals at ten-year intervals, using the road user groups shown in the Introduction. Throughout this period, almost half of all casualties were car occupants, although the exact proportion has varied. Pedestrians formed the next largest group, although their proportion of the fatality total has fallen considerably. 'Others' formed the smallest group; this heterogeneous group includes people travelling by bus, coach, van or lorry. Table 1.2 compares casualty numbers in 1987, 1997 and 2007, and shows that progress with casualty reduction over these two decades has varied considerably between groups and over time.

Table 1.1 Distribution of casualties by road user group						
	Year	**Car occupants**	**Pedestrians**	**Motorcyclists**	**Pedal cyclists**	**Others**
Killed	1987	43%	33%	14%	5%	4%
	1997	50%	27%	14%	5%	4%
	2007	49%	22%	20%	5%	5%
Serious casualties	1987	42%	25%	20%	8%	5%
	1997	50%	23%	14%	8%	5%
	2007	42%	23%	22%	9%	5%

Table 1.2 Casualty reductions over succeeding decades							
	Decade	**Car occupants**	**Pedestrians**	**Motorcyclists**	**Pedal cyclists**	**Others**	**All road users**
Killed	1987–1997	19%	43%	30%	35%	35%	30%
	1997–2007	20%	34%	–16%	26%	–4%	18%
Serious casualties	1987–1997	20%	37%	55%	30%	36%	33%
	1997–2007	46%	38%	–4%	29%	37%	35%
Note: A negative reduction denotes an increase.							

2 THE FORECASTING PROCEDURE

The baseline for the post-2000 target was the annual average number of casualties from 1994 to 1998, so the forecasting period was in effect for 14 years from the mid-point of this five-year period. It is likely that the baseline for the post-2010 target will be the 2004–08 annual average. The latest available casualty data are from 2007, so forecasting for 2020 and 2030 based on the annual average number of casualties from 2005 to 2007 casualties is a good approximation to the likely final approach. This section discusses various issues that arise with these forecasts.

TRL 382 presented two main series of forecasts: for the number of people killed or seriously injured (KSI) and for the number of slight casualties. Forecasts for the number of people killed were also prepared, which indicated that the percentage reductions of the number of people killed and KSI to be expected under any particular scenario were similar. This was one of the considerations that led to the decision to have a target for reducing KSI, but no explicit target for reducing the number of people killed.

In fact, the trends for killed and KSI began to diverge about the year 2000, although this did not become clear for two or three years. The reasons have been examined in several monitoring reports, and Broughton and Knowles (2009) presents the most recent evidence.

2.1 The statistical model

The statistical model used to forecast casualties is described in detail in TRL 382, as are the reasons for choosing this form of model. Only a simplified account is presented below.

The Introduction set out the three steps used in TRL 382 to forecast the number of casualties in 2010. These have been revised slightly for the current forecasts:

1. Estimate casualty rates in the target year to show what would be expected if the core road safety activities were undertaken at the current level and the DESS measures have a certain level of effect that will be specified in Section 2.2.
2. Prepare a baseline casualty forecast using these estimated rates together with predictions of the volume of road travel in the target year.
3. Apply the assumed effects of the measures in the new road safety strategy to the baseline forecast.

The statistical model developed in TRL 382 to implement these steps will now be described mathematically. The baseline for the forecasts in Section 3 will be the 2005–07 average, but the description uses the 2006 data for convenience. The example of the year 2020 will be used, but the equations also apply to the year 2030 with simple modifications.

For a particular road user group, let C(y) denote the number of casualties in year y and let T(y) denote the volume of traffic (the volume of car traffic for car occupants, the volume of motorcycle traffic for motorcyclists and the volume of motor traffic for the remaining three groups). Let C′(y) denote the adjusted (increased) number that would have been expected if the DESS measures had had no effect, then C′(y)/T(y) is the adjusted casualty rate for this road user group in year y.

Given time series of data for C(y) and T(y), the task is to forecast C(2020). The first stage in step 1 is to forecast the adjusted casualty rate C′(2020)/T(2020), and the natural equation for this is:

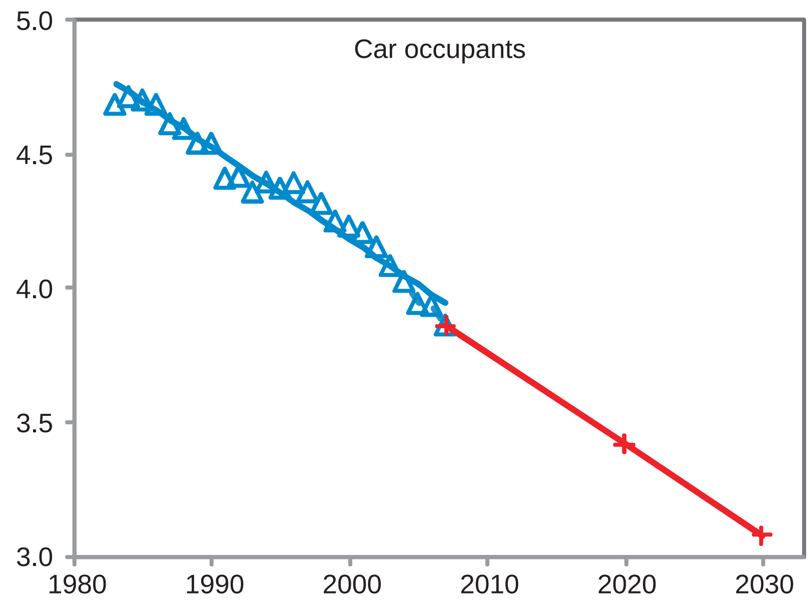
$$C'(2020)/T(2020) = [C'(2006)/T(2006)] \cdot (1 - \alpha)^{14} \quad (1)$$

where α is the average annual rate of reduction predicted for the 14 years 2007–20.

The value of α will be estimated by examining past changes in C′/T.

The process is illustrated in Figure 2.1, using the example of seriously injured car occupants. The triangles show that this particular serious casualty rate fell steadily between 1983 and 2007, and the blue line represents the linear trend fitted to these points; α is estimated from this line and the red line represents the extrapolation of this trend from the baseline year to 2020 and 2030.

Figure 2.1 Log (adjusted serious casualty rate)



To complete step 1, the baseline casualty rate for 2020 is:

$$\begin{aligned} C''(2020)/T(2020) &= (1 - \beta) \cdot C'(2020)/T(2020) \\ &= (1 - \beta) \cdot [C'(2006)/T(2006)] \cdot (1 - \alpha)^{14} \end{aligned} \quad (2)$$

where β represents the expected effect of the DESS measures by 2020, as will be discussed in the next section.

A convenient feature of (2) is that a simple rearrangement of the equation gives:

$$C''(2020) = (1 - \beta) \cdot C'(2006) \cdot [T(2020)/T(2006)] \cdot (1 - \alpha)^{14} \qquad (3)$$

Thus, C″(2020) can be estimated using only the values of α and β, C′(2006) and a prediction of traffic growth between 2006 and 2020. It is helpful that the casualty forecast depends on the relative levels of traffic rather than the absolute levels since errors in past measurements of traffic volume will not affect the casualty forecast.

An extra term is needed in the case of pedestrians and pedal cyclists:

$$C''(2020) = C'(2006) \cdot [T(2020)/T(2006)] \cdot (1 - \alpha)^{14} \cdot \gamma \qquad (4)$$

where γ denotes the volume of pedestrian or pedal cyclist activity in 2020 relative to the 2006 volume. TRL 382 allowed for the possibility that if activity were to grow strongly then casualties may not rise in direct proportion to activity, but this scenario has not been considered likely for the current round of analyses (see Section 2.4) and only a linear term is used in (4).

The values of α for the various casualty groups will be selected in Section 2.3 by examining the past values of C′/T, so confidence in the forecast depends on the regularity of the time series. In principal, an alternative value of α could be used to prepare the forecast for a particular group, but it would be difficult to justify an alternative in cases where the rate had been changing regularly over many years.

This completes step 2. In step 3, the baseline forecast C″(2020) is reduced to take account of the assumed effects of the new road safety strategy. As explained in the Introduction, this step will not be attempted in this report.

2.2 Effects of the DESS measures

Step 1 of the modelling strategy requires the effects of the DESS measures on recent casualty trends to be estimated. The results will then provide the basis for predicting the effects of these measures on future casualty trends. In the case of drink/driving and road safety engineering, the situation has advanced only slightly beyond that described in TRL 382, as discussed by Broughton and Knowles (2009). In the case of improved secondary safety of cars, however, the evidence provided by the STATS19 data from 1999 to 2007 has provided important new information.

Secondary safety for vehicle occupants refers to the protection offered by a vehicle involved in an accident, as distinct from primary safety which refers to systems such as steering and brakes that should help to avoid accidents. The statistical method that had been developed to identify the improvements in car secondary safety was summarised in TRL 382, and Broughton (2003) presents fuller details. Both demonstrated that these improvements had brought substantial benefits, so it is important to examine the more recent data in order to consider how future benefits may affect trends for car occupant casualties. As car occupants account for almost half of all casualties (Table 1.1), this is a central issue in casualty forecasting.

The statistical method starts with the observation that the proportion of driver casualties recorded in the STATS19 data who were killed or seriously injured is lower in more modern cars, i.e. in cars with a more recent year of first registration. This is true whichever accident year is studied and Broughton (2003) shows that the effect can be attributed to developments in car design that have improved their secondary safety.

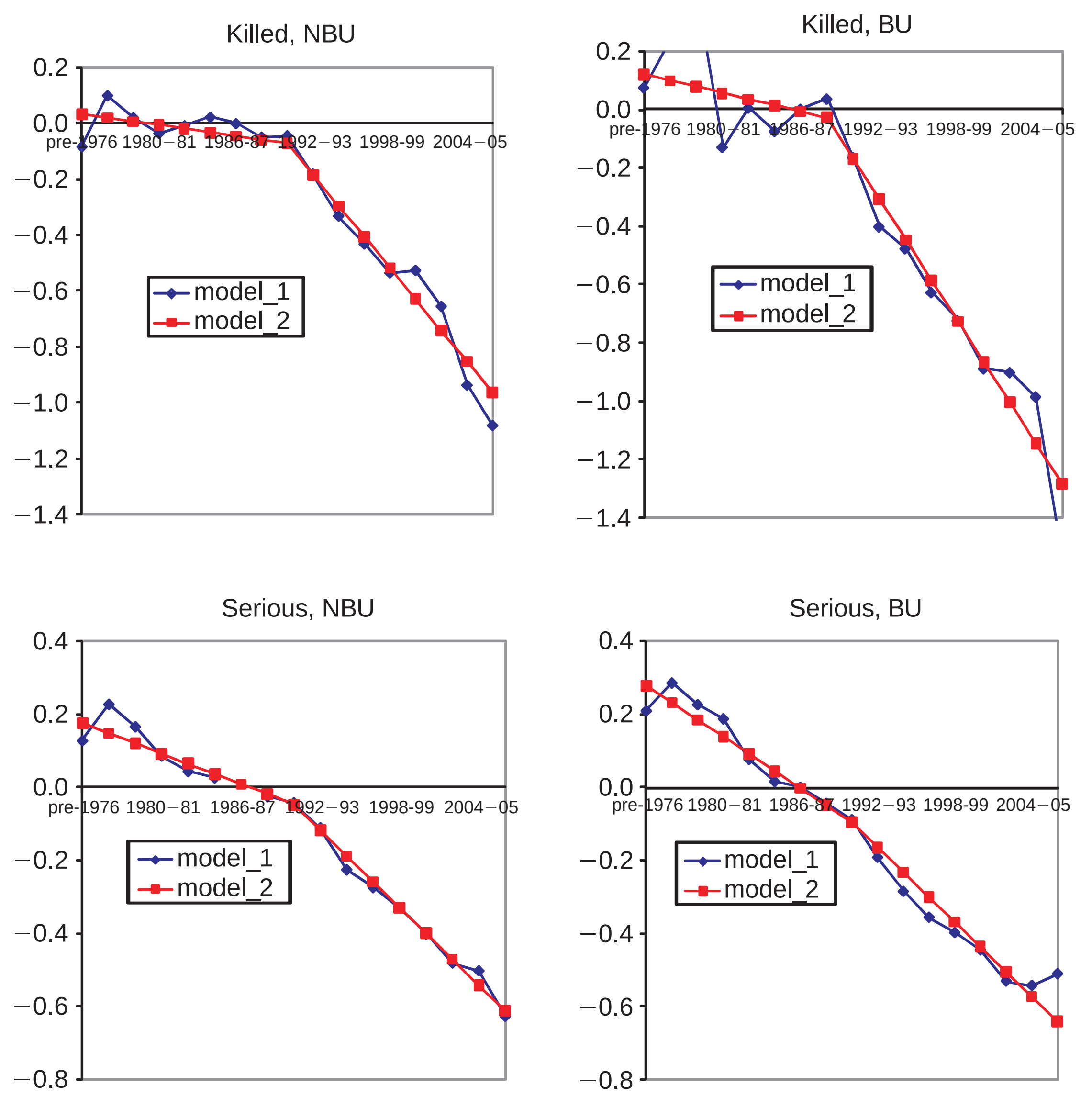
The method that was developed to assess the consequences can be summarised as follows. Cars are grouped according to their year of first registration, and data from the accidents occurring in a series of years are analysed using a Generalised Linear Model (GLM) fitted to the 'severity proportion', i.e. the proportion of driver casualties that are killed or seriously injured. The model takes account of year of accident, year of first registration and age and sex of driver. Driver casualties are analysed rather than occupant casualties since the number of passengers per car is variable, and it is reasonable to assume that secondary safety changes affect driver and passengers equally.

Registration year is the key variable for measuring the improvement in secondary safety, and Figure 2.1 presents results from the analysis of accident data from 1989 to 2007. Fatal and serious casualties in accidents on built-up (BU) and non-built-up (NBU) roads were analysed separately, and registration years were paired. The results shown are the logarithm of the severity proportion, relative to the reference level, which is taken as the severity proportion for cars that were first registered in 1986−87.

Note that cars sharing the same registration year can be at very different stages in the product cycle. At any particular time, some will have just entered production and represent the 'state of the art' of car design, while others entered production several years earlier. Consequently, an advance in design technique will only gradually affect these secondary safety results by registration year. Ideally, the statistical analysis would use design year rather than registration year as the explanatory variable, and this would simplify the discussion in Section 2.2.2 of the likely extent of future progress with improving secondary safety. Unfortunately, this has not proved to be feasible.

Two sets of results are presented in the figure, labelled model_1 and model_2. Model_1 fits a separate value for each registration year, so makes no assumption about the relationship between years. These results have a broadly linear trend, so model_2 is a linear model with a trend change about 1990. On NBU roads, the simpler model_2 fits the data as well as model_1, but this is not true of serious casualties on BU roads. The low value for Killed, BU in 2006−07 cars is based on a small number of casualties, and the value for Serious, BU suggests it may be misleadingly low.

Figure 2.2 Coefficients representing effect of registration year



The model coefficients in each part of the figure measure change relative to the cars that were first registered in 1986–87. A value of y = –1.0 for cars registered in year R, for example, would mean that the severity proportion for these cars was exp(–1.0) = 0.368 times the severity proportion for 1986–87 registered cars, i.e. the proportion of occupant casualties who were killed or seriously injured in year R cars was about 63% less than for occupants of cars registered in 1986–87, so they are about 63% 'safer'. Since the GLM fitted to the casualty data is a logit model, this is true overall but not exactly true for subsets of casualties.

Broughton (2003) presented results based on accident data to 1998. Evidence for the change in trend for cars registered around 1990 was emerging at that time, and the accident data from 1999 to 2007 have demonstrated this change far more clearly. The change has important consequences for predicting the future number of car occupant casualties.

Overall, the linear trend adopted for the original analyses has proved successful, and there is little sign that progress may be slowing. It is unfortunate but inevitable that the newest cars are least well represented in the accident data, so the coefficients estimated to represent their secondary safety are the least precise.

2.2.1 Secondary Safety Forecasts

The results of these analyses have been used to estimate the overall benefit of past improvements in secondary safety. They can also contribute to casualty forecasts, as will now be explained, using 2010 as the example.

The method consists of adjusting the casualty data from the latest year to simulate the number of car driver casualties that would have occurred if the accident-involved cars had been N years newer, where the forecast is for N years ahead (e.g. N = 4 when forecasting for 2010 based on analyses of 2006 casualty data). The casualties are grouped by registration year. The improved secondary safety of newer cars means that the severity of each group of casualties would have been less if the cars had been newer, and the casualty reduction can be estimated using the coefficients from the analysis. The reductions in fatal and serious casualties from the various groups are summed to estimate the overall changes.

The adjustment to allow for newer cars makes use of the most recent model_2 results as illustrated in Figure 2.2. Taking the 2006 example, the calculation using these results is made with the car driver casualty data from 2006. It is applied to casualties grouped by car registration year, and has two parts:

a) Cars registered in year Y ($Y \leqslant 2002$) are replaced by cars registered in year Y + 4, whose improved level of secondary safety is represented by the model_2 line: this represents the replacement of older cars by more modern cars as part of the continuous renewal of the car fleet.

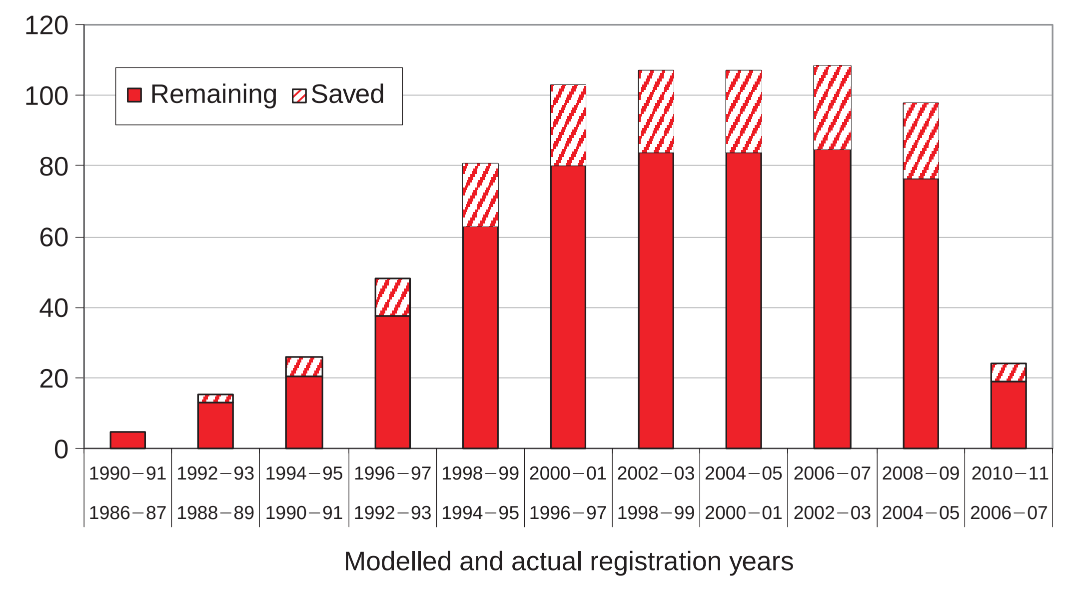
b) Cars registered in year Y ($Y > 2002$) are replaced by cars registered in year Y + 4. These cars do not exist so their collective level of secondary safety is not known and must be estimated from the results of the analysis, and one possibility would be to extrapolate the trend from model_2.

For example, 71 drivers of 1996–97 registered cars died in 2006 in NBU accidents. The modelled value is 74.8, and if the coefficient representing 1996–97 cars is replaced by the coefficient representing 2000–01 cars then this modelled value reduces by 20.6% to 59.4 – part a). The same percentage reduction is found for

2004–05 cars since the coefficient representing 2008–09 cars is estimated by extrapolation – part b). When the calculation is repeated for all driver casualty groups, in BU and NBU accidents, it is estimated that the number of driver fatalities in 2006 would have been 20.5% less if all cars had been four years newer.

The process is illustrated in Figure 2.3. The labels on the x-axis show the actual registration years of the cars being driven (lower) and the registration years of the replacement cars (upper). The solid bars show the number of fatalities expected with the newer, replacement cars and the shaded bars the number saved by the simulated change. The results for pre-1986 cars are not shown, but contribute to the calculation of the overall saving.

Figure 2.3 Modelled effect on driver fatalities in 2006 if all cars had been four years newer



The drivers of cars of unknown registration year are omitted from these results, so the actual numbers of driver fatalities in 2006 are slightly greater than shown in the figure. The registration year is derived from Vehicle Registration Mark (VRM), and there is no reason to think that reporting of VRM varies with registration year, so the percentage changes estimated in this way can be applied to total casualties. They will also be applied to passenger casualties.

The number of fatalities is likely to change by 2010, for various reasons other than developments of secondary safety. This calculation suggests that the number in 2010 will be 20.5% less than it would have been if there were no improvement in secondary safety between 2006 and the target year of 2010. This factor will be referred to as SS(2006, 2010), 2006 referring to the year of the casualty data and 2010 to the year of the forecast. Any forecast for 2010 that takes account of the other influential factors can then be reduced by this factor to obtain an overall forecast.

Part a) of the calculation has assumed that secondary safety will continue to improve at the rate seen over the last 15 years, which may be over optimistic. An alternative assumption is that there will be no improvement beyond the level represented by the 2006–07 coefficient, and this can also be simulated. In this case the part b) reductions are less and the overall fall is 19.5%. The actual improvement of secondary safety is likely to lie between the ‘improvement fully maintained’ and ‘no further improvement’ scenarios, so SS(2006, 2010) for fatality forecasts lies between 18.5% and 20.5%: the choice of value for forecasting depends on the degree of confidence about the development of new cars’ secondary safety between 2007 and 2010. The corresponding factor for serious casualties lies between 10.7% and 12.1%.

2.2.2 Predictions for 2020 and 2030

The analysis has demonstrated that car secondary safety has improved considerably since about the 1990 registration year. The improvement has been rather steady, in part perhaps because the secondary safety features of a car model tend not to change appreciably through its period of production and new models are introduced relatively slowly, so that it takes a number of years before a development in car design has been implemented in the majority of new cars being sold.

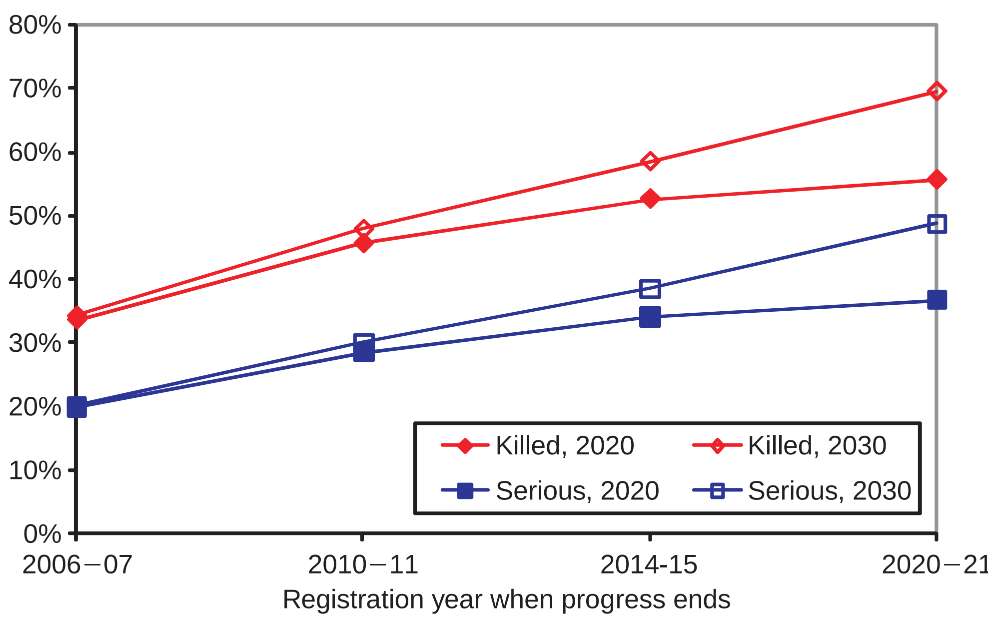
Turning to forecasts for 2020, the statistical approach that was used to prepare forecasts for 2010 can be applied but the assumptions about how secondary safety might develop are critical. Figure 2.1 demonstrated that the linear assumption made ten years ago has been justified, but the point of diminishing returns may be approaching – in which case future progress will be slower. This possibility has been recognised for some years, and more recent concerns over fuel consumption and emissions may have started to limit the scope for improving safety by adding equipment or structure that would raise the overall weight of a car.

On the other hand, there will inevitably be some progress beyond the level of secondary safety found in cars from the 2006–07 registration year. Older models still on the market have on average poorer secondary safety features than the latest models; these will go out of production and their successors will have better secondary safety – even if no better than those of the latest models. Thus, the average level of secondary safety of new cars will improve in future to a limited extent, even if new models entering the market are no better than the best of the current models.

The sensitivity of SS(2006, 2020) to alternative assumptions about the future development of secondary safety has been tested. Each scenario assumes that the model_2 linear development continues until a particular registration year, with no further progress. The most cautious assumption is that there will be no progress beyond the 2006–07 registration year, while the most optimistic assumption that has been made is that progress will continue at the same rate until the 2020 registration year. These scenarios should define the plausible range of outcomes.

The same approach can be applied to prepare forecasts for 2030, although forecasting over 24 years is inevitably more speculative than forecasting over 14 years to 2020. The results for SS(2006, 2020) and SS(2006, 2030) are compared in Figure 2.4.

Figure 2.4 SS(2006, 2020) and SS(2006, 2030) calculated with alternative assumptions



For 2020, a scenario that appears plausible is that progress will continue at the same rate until the 2010–11 registration year. The exact trajectory is relatively unimportant; presumably there would be a gradual slowing of progress before 2010. This scenario will be used for the casualty forecasting, and the precise reductions that will be used in the 2020 forecasts are 45% for killed and 28% for serious casualties. Secondary safety would probably develop a little further between 2020 and 2030, and the reductions that will be used for the 2030 forecasts are 58% for killed and 39% for serious casualties.

The most cautious forecasting scenario is that secondary safety will not improve beyond the level achieved in the 2006–07 registration year. In order to test the sensitivity of the overall forecasts to the assumption about future progress with secondary safety, Section 3 will also present forecasts that are based on this scenario. More precisely, these will assume that the replacement of older cars by new cars with the 2006–07 level of secondary safety will reduce the number of car occupant fatalities by 34% and the number of serious casualties by 20% in both 2020 and 2030.

The ‘certain level of effect’ referred to in step 1 (Section 2.1) includes the benefits of improved secondary safety that have been predicted in this section. Measures to reduce the level of drink/driving formed the second of the DESS measures. The proportion of accidents that involve drink/driving were similar in 1996 and 2006, and the forecasts will assume that the proportion in 2006 will apply in 2020 and 2030. If, following the consultation, it is concluded that the level of drink/driving can be reduced in future then this would be incorporated when the casualty forecasts are finalised, as discussed in Section 3.2.

Road safety engineering is the third of the DESS measures. The first row of Table 6 from TRL 382 shows the expected effect (by 2010, relative to 1994–98 baseline) of the ‘new road safety engineering programme’ outlined in the report. It will be assumed that this level of effect will be maintained in future, so these factors will be applied when forecasting for 2020 and, adjusted *pro rata*, when forecasting for 2030. Again, if the consultation leads to the conclusion that the future level of effect will be different then this would be incorporated when the final casualty forecasts are prepared.

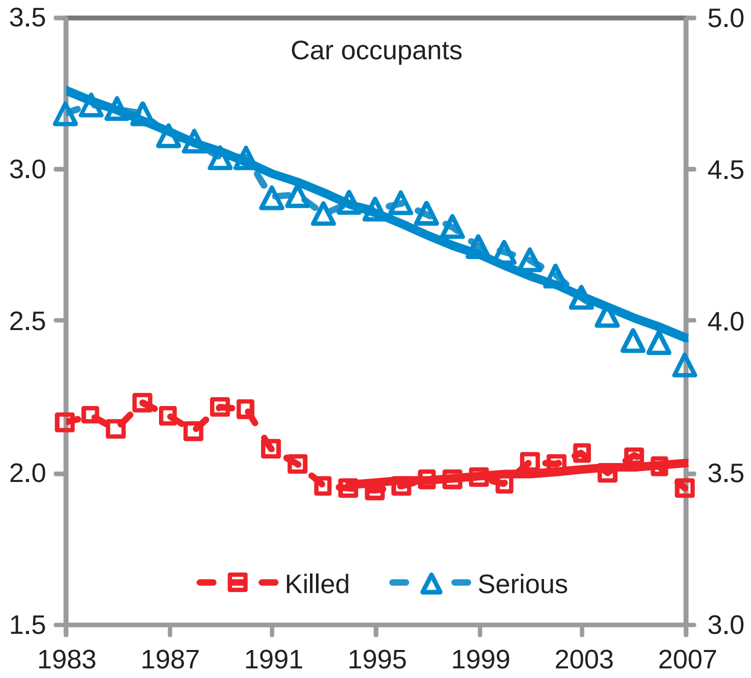
2.3 Adjusted casualty rates

As explained in Section 2.1, the actual casualty rates need to be adjusted to allow for the possibility that the future effects of the DESS measures may differ from the past effects. To calculate the adjusted rates, the actual casualty data from each year are adjusted to reflect the estimated effects of the DESS measures in that year. In step 1 of the forecasting process, these adjusted rates are then extrapolated in order to prepare the baseline forecasts. Ten series of adjusted casualty rates need to be studied: the fatal and serious casualty rates for the five road user groups listed in the Introduction. The average rate of reduction for each series is calculated as the key parameter α for forecasting the disaggregate casualty rate.

It is desirable to base the calculation of the rate of reduction on as long a period as possible. The recent serious casualty series have broadly continued the trends identified in TRL 382 for the KSI rates, so the starting points adopted then have been retained (mostly 1991, but 1983 for car occupants). Several of the fatality trends changed in the 1990s, so more recent starting points have been adopted in these cases.

The first road user group comprises car occupants. The adjusted fatal and serious casualty rates for car occupants are shown in Figure 2.5, the rate calculation using the volume of car traffic as the denominator. A common pattern will be used in this series of figures; the fatal rates are shown in red and use the left-hand scale, the serious rates are shown in blue and use the right-hand scale. The solid lines show the trends that have been chosen to calculate the values of α that will be used for forecasting.

Figure 2.5 Log (adjusted casualty rates), car occupants



The adjusted serious rate has declined steadily over many years, although there is an indication that the rate of reduction has increased since 2000. The adjusted fatal rate has risen since the early 1990s, although the rate fell in 2006 and 2007. If this fall continues in future then forecasts based on the trend line will be too high, but it would be premature to conclude that the rising trend seen between 1993 and 2005 has ended.

The next group comprises pedestrians, and the adjusted fatal and serious casualty rates are shown in Figure 2.6. The rate calculation uses the volume of motor traffic as the denominator, and the two rates have fallen in parallel over many years.

The third group comprises motorcyclists. The approach adopted in TRL382 to prepare forecasts for this group was simpler than for the four other groups, because of the variability of the recent casualty rates. The adjusted fatal and serious casualty rates shown in Figure 2.7, however, have varied with sufficient regularity since 1997 to allow the general approach to be used for motorcyclists as well. The rate calculation uses the volume of motorcycle traffic as the denominator.

The adjusted fatal and serious casualty rates for pedal cyclists are shown in Figure 2.8. The rate calculation uses the volume of motor traffic as the denominator. The fatality rate rose in 2004 and 2005, but the earlier downward trend was resumed in

Figure 2.6 Log (adjusted casualty rates), pedestrians

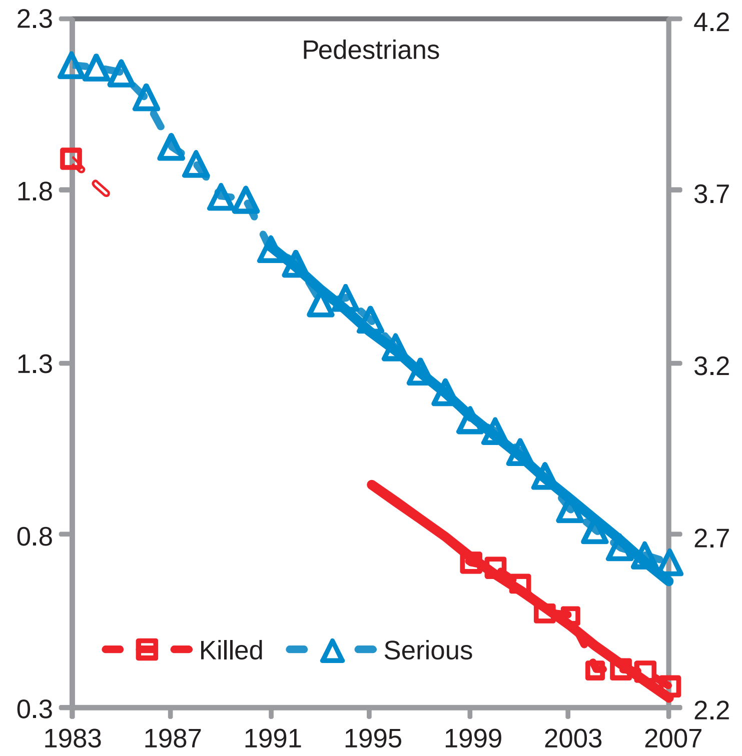


Figure 2.7 Log (adjusted casualty rates), motorcyclists

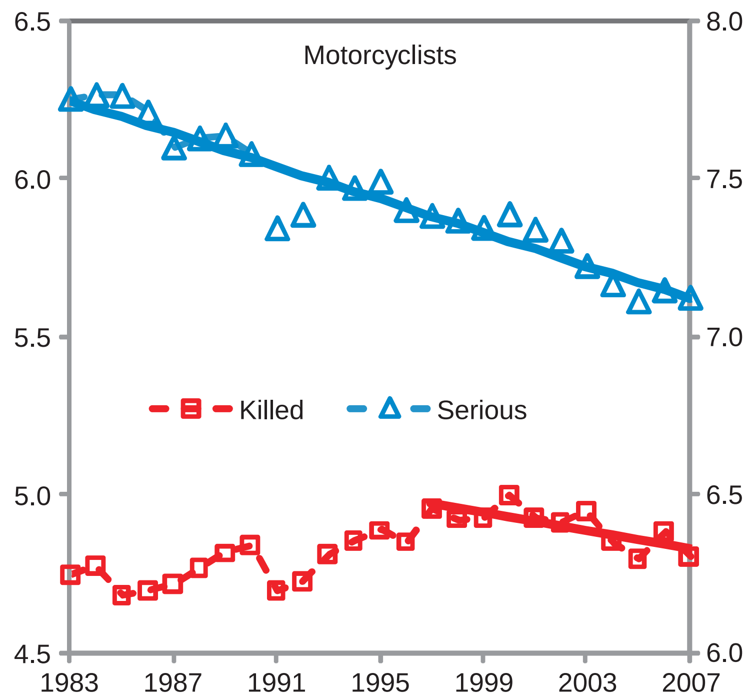
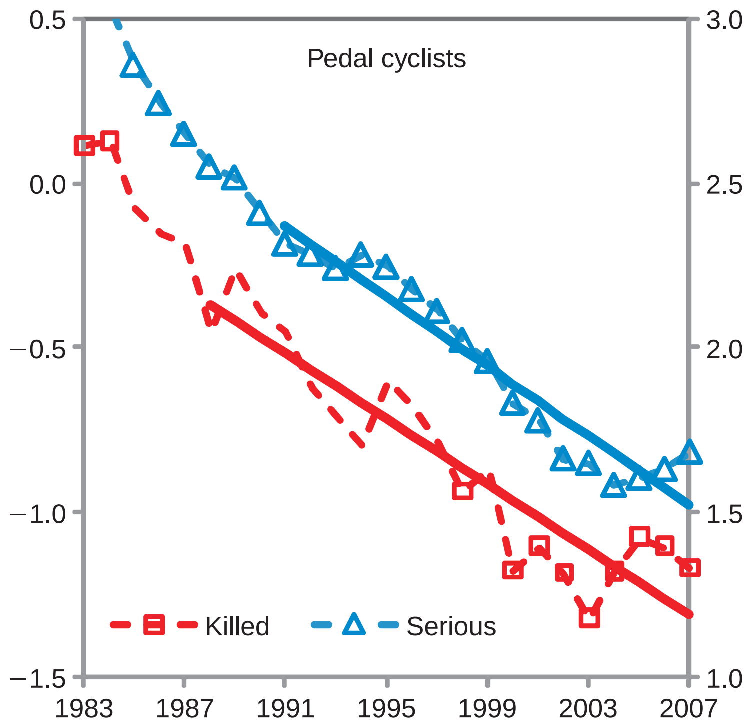


Figure 2.8 Log (adjusted casualty rates), pedal cyclists



2006 and 2007, and it is reasonable to base forecasts on the 1988–2007 trend as shown by the solid red line. The adjusted serious casualty rate has risen since 2005, but the forecasts will be based on the optimistic assumption that the 1991–2007 trend shown by the solid blue line will be resumed.

The final group is the smallest and comprises all casualties not in the four previous groups. The rate calculation uses the volume of motor traffic as the denominator. The relatively small annual casualty numbers would be expected to cause the rates to be more variable than the previous rates, but in fact the adjusted serious casualty rate shown in Figure 2.9 has fallen with great regularity since 1991. The adjusted fatality rate was rather variable in the mid-1990s, but has been more regular in recent years and the trend from 1993 will be used for forecasting.

Table 2.1 brings together the average rates of reduction that have been calculated from the series presented in these figures. These will help to prepare baseline casualty forecasts in Section 3 as the values of α in equations (3) and (4), i.e. to forecast the number of casualties under the assumption that the core road safety programme will retain effectiveness and the DESS measures will have the effects specified in Section 2.2.

The key feature of a scientific approach to forecasting based on past data is to identify consistent relationships among these data which can be projected into the future. The trends highlighted in these figures constitute consistent relationships

Figure 2.9 Log (adjusted casualty rates), others

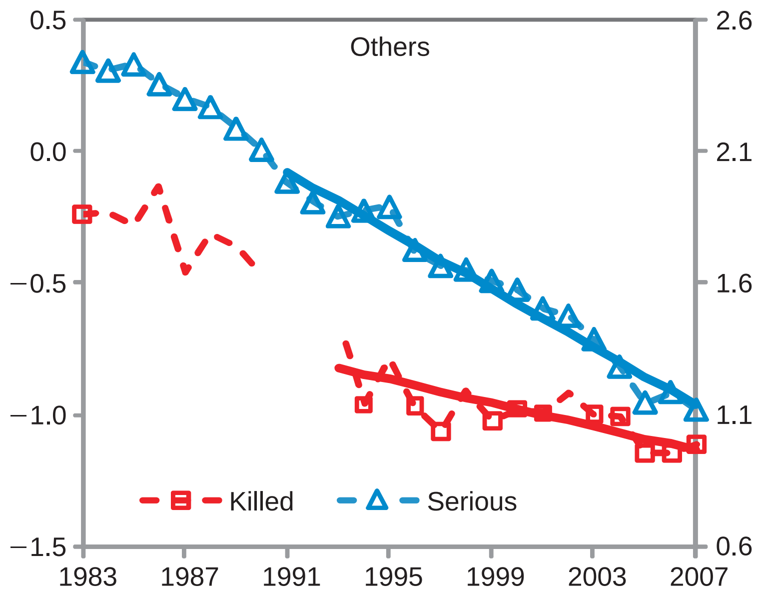


Table 2.1 Rates of reduction of adjusted casualty rates

	Killed		Serious casualties	
	Annual rate of reduction	**Period chosen**	**Annual rate of reduction**	**Period chosen**
Car occupants	−0.56%	1994–2007	3.34%	1983–2007
Motorcyclist	1.42%	1997–2007	2.58%	1983–2007
Pedal cyclist	4.83%	1988–2007	5.17%	1991–2007
Pedestrian	5.00%	1995–2007	5.90%	1991–2007
Others	2.20%	1993–2007	5.33%	1991–2007

which can be used to prepare forecasts. Hence, the credibility of forecasts that rely on these relationships depends on the regularity of the series shown in these figures. For example, Figure 2.9 shows that the serious casualty rate for others has fallen steadily for over 20 years, so it is reasonable to assume that this rate will fall equally steadily over the forecasting period. By contrast, the fatality rate for others has been more variable, so the assumption may prove to be less reliable in this case.

The possibility that these trends could change in future and affect the forecasts should be borne in mind when considering the results that are presented in Section 3. The forecasts represent the best view that is available at present about the future development of casualty trends, but this section has shown at least two changes in the mid-1990s in the trends for Killed that could not have been identified at the time when the forecasts for 2010 were finalised. Nevertheless, in view of the inherent impossibility of predicting individual road accidents, let alone serious or fatal accidents, it is striking that these forecasts can be prepared with any degree of reliability.

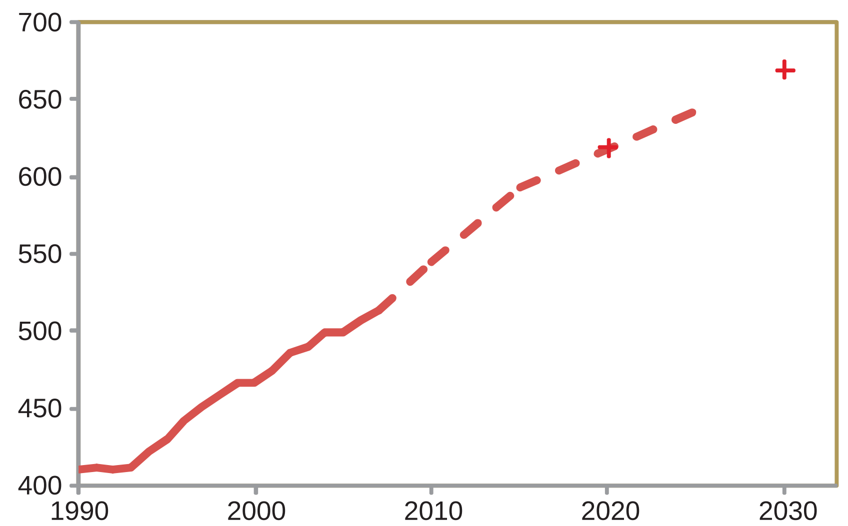
2.4 Transport scenarios

At any time, there is inevitably uncertainty about how the volume of travel may change in future. TRL382 introduced the concept of the transport scenario to accommodate uncertainty about the volume of travel (or activity) by the various road user groups. A recent report provides guidance about the growth in road traffic to 2025 (DfT, 2007), but judgement is required in the case of motorcycling.

The central forecast from the DfT Report 'Road Transport Forecasts for England 2007' is that traffic in England will grow by 11% between 2003 and 2010, by 21% between 2003 and 2015 and by 31% between 2003 and 2025. Traffic volumes are required for 2020 and 2030 to forecast casualties in these years. Interpolation and extrapolation of the DfT data gives traffic growth of 22% between 2006 and 2020 and of 32% between 2006 and 2030. These data are illustrated in Figure 2.10, where the solid line shows the actual data to 2007, the broken line shows the DfT forecasts and the crosses show the derived values for 2020 and 2030.

Ideally, the forecasts for traffic growth would relate to Great Britain as a whole, but traffic in England accounts for about 86% of the total so the use of forecasts based on English data is acceptable. There may be more concern over the forecast of continuing strong traffic growth, given the gloomy economic prospects in 2009 and the likely implications for traffic growth.

Figure 2.10 Actual and forecast traffic volumes, Great Britain



The DfT forecasts exclude motorcycles. The reason is not given but is likely to be that, by comparison with other modes of road transport, the volume of motorcycling depends more on the popularity of motorcycling and less on economic factors. The volume of motorcycling has oscillated since 2003, following 47% growth over the previous seven years. Two scenarios will be examined for motorcycle traffic post-2006: zero growth and 25% growth.

Figures are also required for the volume of walking and cycling in 2020 and 2030. The DfT report provides forecasts for the combined volume: growth of 6% by 2015 and 11% by 2025. It will be assumed that the volumes of walking and of cycling will both grow by 8.5% by between 2006 and 2020, and by 13.5% by between 2006 and 2030.

3 FORECASTS FOR 2020 AND 2030

3.1 Baseline forecasts

This section brings together various baseline forecasts that have been prepared using the methods and data presented above. These forecasts assume that existing road safety measures continue, the DESS measures develop as specified in Section 2.2 but there will be no *new* road safety measures. To reiterate the definition provided in the Introduction, a new measure in this context is either innovatory or a *substantial* expansion of an existing measure. Thus, these forecasts represent a ‘Continuation of trends’ scenario. Some existing measures are likely to lose effectiveness over the forecasting period, however, so the forecasts may well be somewhat optimistic.

It should be emphasised that the predicted reductions will only be achieved by continuing current efforts to improve road safety, they are in no sense predetermined.

The forecasts are presented as reductions from the 2005–07 casualty averages that are shown in Table 3.1. Thus, a value of 0% for a group of casualties in the following tables implies that the future number is predicted to be unchanged from the 2005–07 average, while a value of 25% implies that the number is predicted to fall by one quarter.

Table 3.1 2005 07 average numbers of casualties

	Car occupants	Motorcyclists	Pedal cyclists	Pedestrians	Others	All road users
Killed	1,573	585	143	664	141	3,106
Serious	12,373	5,991	2,312	6,371	1,420	28,467

The first four forecasts are based on what were described in Section 2.2.2 as the ‘most plausible scenarios’ for the development of car secondary safety, namely to the 2010–11 level for the 2020 forecasts and the 2014–15 level for the 2030 forecasts.

Table 3.2 Casualty reduction forecast for 2020, no growth in motorcycling

	Car occupants	Motorcyclists	Pedal cyclists	Pedestrians	Others	All road users
Killed	32%	23%	37%	44%	16%	33%
Serious	49%	35%	40%	51%	47%	46%

These forecasts suggest that, even if no new road safety measures are taken, it should be possible to reduce the number of people killed in road accidents in 2020 by about one-third relative to the 2005–07 average, and to reduce the number seriously injured by almost a half. The corresponding reductions for 2030 are almost a half and almost two-thirds.

Table 3.3 Casualty reduction forecast for 2020, motorcycling grows by 25%						
	Car occupants	**Motorcyclists**	**Pedal cyclists**	**Pedestrians**	**Others**	**All road users**
Killed Serious	32% 49%	4% 18%	37% 40%	44% 51%	16% 47%	29% 42%

Table 3.4 Casualty reduction forecast for 2030, no growth in motorcycling						
	Car occupants	**Motorcyclists**	**Pedal cyclists**	**Pedestrians**	**Others**	**All road users**
Killed Serious	45% 69%	36% 52%	58% 61%	67% 73%	31% 68%	48% 66%

Table 3.5 Casualty reduction forecast for 2030, motorcycling grows by 25%						
	Car occupants	**Motorcyclists**	**Pedal cyclists**	**Pedestrians**	**Others**	**All road users**
Killed Serious	45% 69%	20% 40%	58% 61%	67% 73%	31% 68%	45% 63%

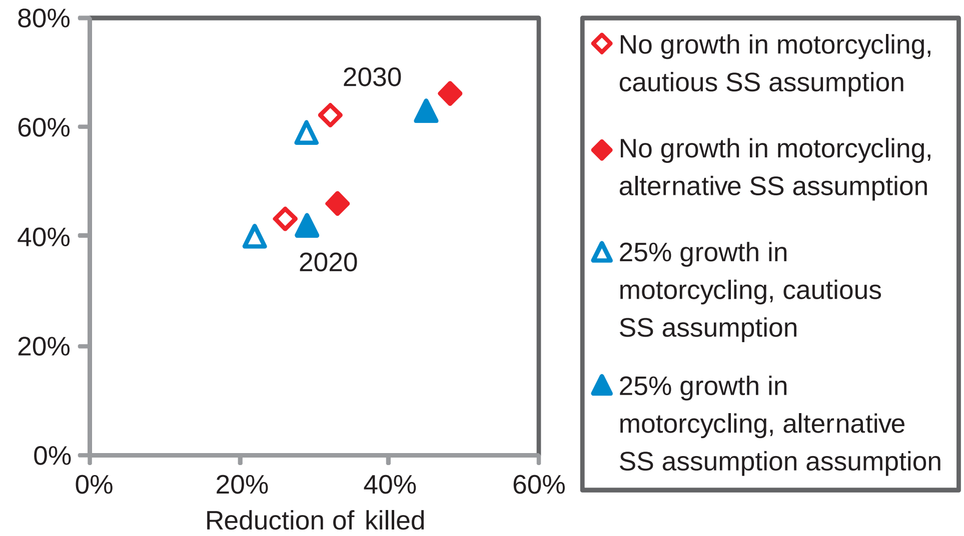
The following forecasts are based on the most cautious scenario for the development of car secondary safety, namely that there will be no progress beyond the 2006–07 level for both the 2020 and the 2030 forecasts. Only the forecasts for car occupants and for all road users are affected by the change of scenario, so only these are shown in Table 3.6. Comparison with the four previous tables shows that basing the forecasts on this scenario reduces the overall reduction by 2020 for Killed by 7% and for Serious casualties by 3%. Naturally, the changes are larger for the 2030 forecasts, 16% for Killed and 4% for Serious casualties.

Table 3.6 Casualty reduction forecast for 2020 with cautious scenario				
	No growth in motorcycling (changes from Table 3.2)		**Motorcycling grows by 25% (changes from Table 3.3)**	
	Car occupants	**All road users**	**Car occupants**	**All road users**
Killed Serious	19% 43%	26% 43%	19% 43%	22% 40%

Table 3.7 Casualty reduction forecast for 2030 with cautious scenario				
	No growth in motorcycling (changes from Table 3.4)		**Motorcycling grows by 25% (changes from Table 3.5)**	
	Car occupants	**All road users**	**Car occupants**	**All road users**
Killed Serious	13% 59%	32% 62%	13% 59%	29% 59%

The overall forecasts for 2020 and 2030 are combined in Figure 3.1. The forecast reductions for serious casualties are plotted against the y-axis and the forecast reductions for fatalities are plotted against the x-axis. The cautious assumption for the development of car secondary safety (SS) is that there will be no progress beyond the 2006–07 level; the alternative assumptions are that there will be progress to the 2010–11 level for the 2020 forecasts and to the 2014–15 level for the 2030 forecasts.

Figure 3.1 Summary of forecasts



Section 2.4 raised the possibility that traffic growth may be less than was forecast in 2007. To test the sensitivity of the casualty forecasts to the traffic growth assumption, the following tables incorporate traffic growth that is half of the growth predicted by the DfT report, namely 11% between 2006 and 2020 and 16% between 2006 and 2030. The forecasts from the Tables 3.2–3.5 appear in the columns headed 22% and 32% traffic growth. The effect of halving the assumed traffic growth is shown to be equivalent to assuming that motorcycling will grow by 0% rather than 25%.

Table 3.8 Casualty reduction forecast for 2020, all road users

	No growth in motorcycling		25% growth in motorcycling	
	11% traffic growth	22% traffic growth	11% traffic growth	22% traffic growth
Killed Serious	37% 49%	33% 46%	33% 46%	29% 42%

3.2 Assumed effects of new road safety measures

In principle, these initial forecasts could now be adjusted to take account of new measures that might be introduced over the coming years. TRL382 describes how

Table 3.9 Casualty reduction forecast for 2030, all road users				
	No growth in motorcycling		**25% growth in motorcycling**	
	16% traffic growth	**32% traffic growth**	**16% traffic growth**	**32% traffic growth**
Killed	52%	48%	49%	45%
Serious	68%	66%	66%	63%

the DfT's 'Safety Targets and Accident Reduction Group' helped to prepare the current target for 2010 by developing a list of possible new measures. Their effectiveness was then estimated, using whatever evidence was available, and the results appeared as Table 6 in TRL382.

This report is being published as part of the Department for Transport's consultation over the post-2010 casualty reduction target, so only limited information is available at present about the range of potential new measures. It would be premature to present final forecasts in this report. The DfT consultation document discusses potential new measures, while Sexton and Johnson (2009) provide supplementary information.

To illustrate the process by which final forecasts can be prepared from the baseline forecasts presented in the previous section, consider Table 3.2. This forecasts that, under certain circumstance, for every 100 car occupants killed in 2005–07 there would 68 killed in 2020. Various new measures could be taken to reduce the number of car occupant fatalities by 2020, such as reducing speed limits. Moreover, changes to the car fleet by 2020 are also likely to reduce the number, such as the introduction of Electronic Stability Control. Suppose that the combination of these changes was predicted to reduce this group of fatalities by 10%, then the forecast would reduce to $68 \times (1 - 0.10) = 61$, i.e. a 39% reduction from the 2005–07 baseline. Once effectiveness estimates have been prepared for each road user group, each table of baseline forecasts can be adjusted in the same way.

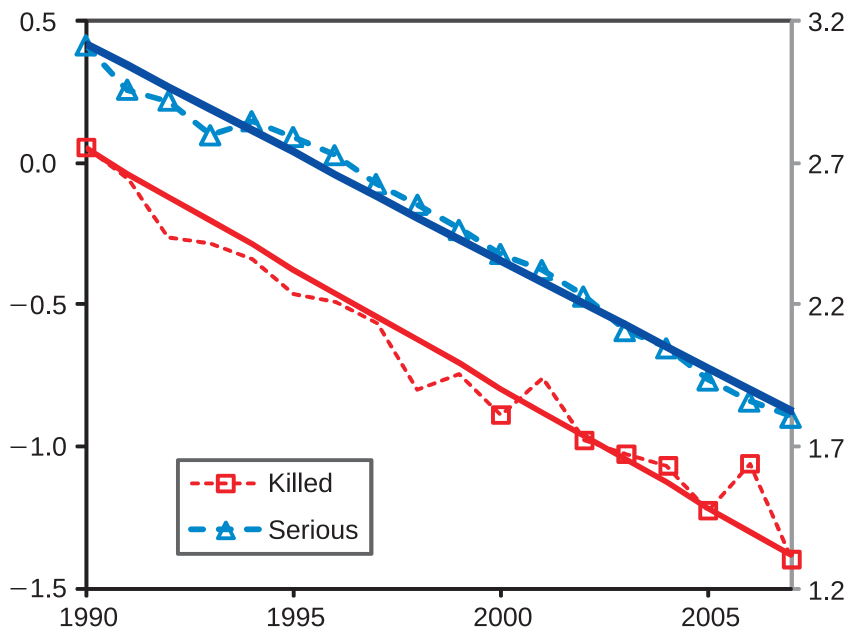
It is envisaged that, once the consultation has been completed, conclusions will be reached about which measures are likely to be introduced as part of a new road safety programme, and their likely level of effect. At that point, the casualty forecasts can be finalised, taking account of the effectiveness of these new measures in this way.

4 CHILD CASUALTY FORECASTS

The casualty reduction target for children announced in 2000 was not based on statistical analysis. The target that was about to be adopted of reducing the overall KSI total by 40% was simply boosted by 10% to make clear the priority that was attached to improving the safety of children.

Nevertheless, a suitable statistical basis exists for forecasting child casualties (children are taken to be 0–15 years old). The approach is a simplified version of the approach that has been used for the main post-2010 casualty forecasts, and is based on the rate of child casualties per billion veh-km of motor traffic. The rate calculation is identical to that used for the main casualty forecasts except for one point: the rates are adjusted to allow for changes in the population of children, which has been much more variable than the size of the full population. Figure 4.1 displays the rates. With the exception of the fatality rate increases in 2001 and 2006, the relation between casualties and traffic has been as regular as that observed for all road users.

Figure 4.1 Logarithm of child casualty rates



The solid lines are fitted to the casualty rates from 1983–2007, and in 2007 both rates returned to the trends represented by these lines.

The number of casualties of each severity in 2020 and 2030 can be forecast by extrapolating the relevant trend, applying a minor adjustment based on the population forecast for that year, then multiplying by the national traffic forecast. This assumes that the child casualty rates will continue to fall in future as they have since 1983, and makes no assumption about possible new measures to improve the safety of children. The traffic forecasts presented in Section 2.4 are again used, together with official population forecasts.

Table 4.1 presents the forecasts, and they are also expressed as reductions from the 2005–07 average.

Table 4.1 Child casualty reduction forecasts

	Forecasts		Reduction from 2005–07 average	
	Killed	**Serious**	**Killed**	**Serious**
2005–07 average	144	3,211		
2020	54	1,481	63%	54%
2030	25	760	82%	76%

These forecasts suggest that the number of children who are killed in road accidents in 2020 could well be little more than one-third of the 2005–07 average, and the number who are seriously injured could well be less than one half.

The reductions predicted for 2020 may appear ambitious, but they are actually similar to the reductions that have been achieved in the recent past. Consider reductions over the corresponding period prior to 2007, i.e. between the 1992–94 average and 2007. The number of children killed fell by 60% over this period, and the number of serious casualties by 58%. Thus, the forecast reductions are broadly in line with the progress that has already been made in reducing child casualties.

5 CONCLUSIONS

Forecasting the future is generally an uncertain and difficult process. The timescale required for improving road safety, however, means that it is important to prepare long-term plans that are soundly based on current knowledge and that take account of likely future developments. This report describes the methods that have been used to forecast the number of fatal and serious casualties in 2020 and 2030 in some detail. These forecasts will provide the numerical context for setting future casualty reduction targets, although estimates of the effectiveness of likely new road safety measures are needed to finalise the forecasts.

The main casualty forecasts are prepared in several stages, while the forecasts for child casualties are rather simpler. In both cases, statistical models are first fitted to past casualty and exposure data; the main forecasts take account as far as possible of road safety measures that have been introduced, but the child forecasts do not.

Both sets of models demonstrate sufficient consistency to be used to forecast the casualty rates in 2020 and 2030. The forecast rates are then combined with predictions about the distances that will be travelled by road in those years to produce casualty forecasts. These forecasts assume that current road safety activities will be undertaken in coming years, and that the secondary safety of the car fleet will continue to improve. Once the likely effects of potential new road safety measures have been assessed, these baseline forecasts will provide the basis for the final stage of forecasting in which these effects are taken into account.

These forecasts cannot make allowance for unforeseen future developments, so they may not prove to be correct in all respects. They do, however, provide a framework for examining the inherent uncertainties about future developments and for making full use of available knowledge. Hence, they play a valuable role in formulating a new road safety strategy and in setting casualty reduction targets that will provide continuing motivation for the effective implementation of the strategy. The forecasting methods have provided the basis for monitoring the development of road safety since 2000, and will in future allow the likelihood of achieving the new casualty reduction target to be assessed regularly. They will show whether it may be necessary take action to ensure that the target will be achieved

The improvement of car secondary safety over the past 15 years is likely to have been the development that has had the most significant effect on casualties nationally. It is fortunate that a method has been developed that can quantify this effect by analysis of STATS19 data. This report has presented the results of the most recent analyses and has shown how these can be used to predict future benefits.

ACKNOWLEDGEMENTS

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