Updated post–2010 casualty forecasts

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Transport Research Laboratory

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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 upon the methodology that was developed in the late 1990's 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 forecast 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.
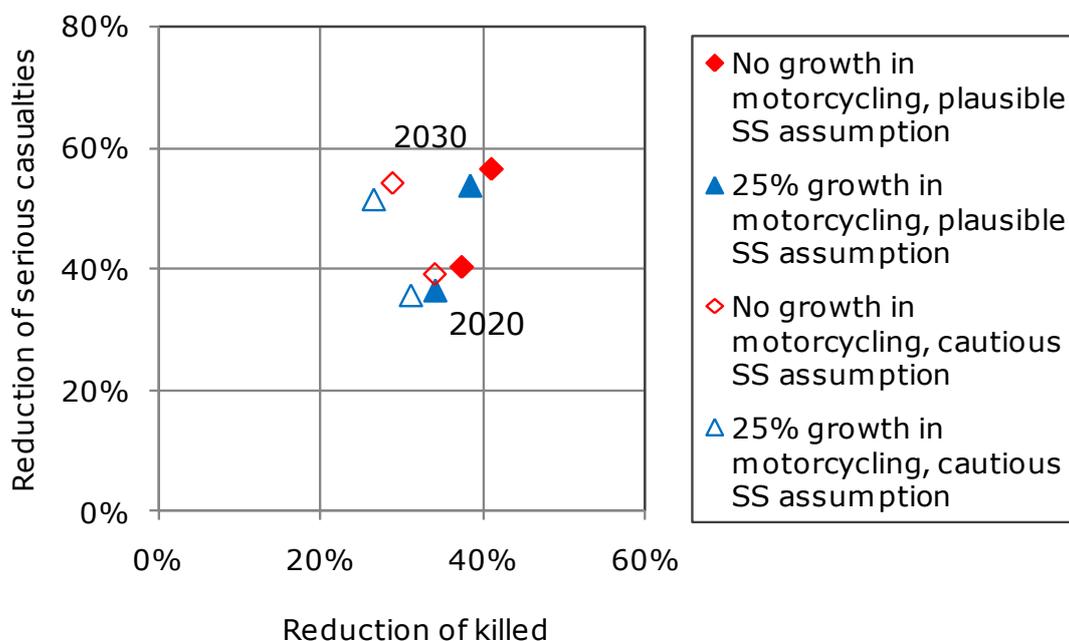
Casualty forecasts

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. The forecasts presented in this report simply show the casualty reductions that might be expected if current road safety programme continues to develop and current casualty trends continue but no new road safety measures are introduced.

Fourteen per cent fewer people were killed in road accidents in 2008 than in 2007, and this was followed by a further 12% reduction in 2009. The scale of these reductions is unprecedented, and the potential implications for the forecasting process have been examined in detail. The number of fatalities fell sharply in 2008 and 2009 for two road user groups, following the pattern seen during the previous economic recession of 1990-91: the changes in the other casualty groups were broadly in line with existing trends. The new forecasts for these two groups differ from previous forecasts (Broughton, 2010) as they incorporate the lower 2009 data, but the approach to forecasting has not been changed. The parallels with the fatality trends of these two groups during the economic recession of 1990-91, however, may suggest that the recession of 2008-09 has contributed to the falls seen in 2008 and 2009. The result of assuming that over the next few years these two trends will follow the pattern seen after the previous recession is to reduce these two forecasts slightly.

The main forecasts suggest that the number of people who will be killed in road accidents in 2020 could well be more than one third below the 2005-09 average, and the number who are seriously injured could fall slightly more. The exact values depend upon various assumptions, and no allowance has been made for the effectiveness of any new road safety measures. The corresponding proportions for 2030 are about two fifths and more than one half. The number of children who are killed in road accidents in 2020

could well be little more than one third of the 2005-09 average, and the number who are seriously injured could well be less than one half of the corresponding 2005-09 average. Further reductions are predicted by 2030.

The range of the main casualty reduction forecasts for 2020 and 2030 is illustrated below. The forecast reductions for serious casualties are plotted against the y-axis and the forecast reductions for fatalities are plotted against the x-axis. Two assumptions for the development of car secondary safety (SS) are assessed, and two assumptions about the future growth of motorcycling.

Summary of casualty reduction forecasts for 2020 and 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. Equally, if new measures are introduced (for example, significant development of vehicle safety measures) then the forecasts, particularly those for fatalities to 2030, could well prove to be conservative.

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 2009 in order to quantify this effect for cars. 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 suggest that the single development over the past 15 years that has had the most significant effect on the national casualty total has been the improvement of car secondary safety.

The results of the most recent analyses suggest that there may be no further casualty reductions on roads with speed limits up to 40mph, but that on higher speed roads there will continue to be additional reductions. These results are used to assess the likely benefits of future improvements to car secondary safety, but the predictions depend in part upon an assumption about the extent to which recent progress on higher speed roads will continue in future. They make a key contribution to predicted car occupant casualty reductions in 2020 and 2030.

New vehicles have begun to be fitted with advanced primary safety equipment such as Electronic Stability Control, and the proportion of equipped vehicles is likely to rise

markedly in future. The forecasts make no allowance for new road safety measures, so do not take account of this development.

N.B. This is an updated version of an earlier report (Broughton, 2010). It includes data from 2009 as well as revised official traffic growth forecasts and an improved method for forecasting pedal cyclist casualties.

References

Broughton J (2010). *Post-2010 Casualty Forecasting.* TRL Report PPR444. Crowthorne: Transport Research Laboratory.

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.

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 prepares the next road safety strategy. 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 the current road safety programme will continue to develop in coming years, but that no major new measures will be introduced. The forecasts take account of the implications of the major reduction in road accident fatalities that occurred in 2009.

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 road safety strategy has been to forecast the number of casualties in 2020 and 2030, taking account of likely future developments in road safety. This report summarises the forecasts that have been prepared. The work has built upon the methodology that was developed in the late 1990's to prepare the post-2000 casualty reduction target, as described in detail in the report TRL 382 (Broughton et al, 2000).

This is a revised version of an earlier report (Broughton, 2010) and all analyses have been updated to include data from 2009. Fourteen per cent fewer people were killed in road accidents in 2008 than in 2007, and this was followed by a further 12% reduction in 2009. The scale of these reductions is unprecedented, exceeding the reduction that occurred in 1991. The potential implications for the forecasting process of this reduction have been examined carefully. Official traffic growth forecasts have been revised, and the new casualty forecasts take account of these.

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 2008 (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:

 (a)   measures to reduce the level of drink/driving,

(b)   road safety engineering,

(c)   improved standards of secondary safety in cars.

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:

(i)   the DESS measures, whose level of effect may vary from what has been achieved in the past,

(ii)   the core programme, i.e. a continuation of existing core measures,

(iii)   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 2009 so would not have influenced casualty trends to an appreciable degree. By 2020, however, 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 5 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 forecast year of the levels of traffic (all motor vehicles, cars, motorcycles) and of pedestrian and pedal cycle activity. The casualty forecasts in TRL 382 incorporated the most recent STATS19 data, for 1998. 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 selected future year 2010 to show what would be expected if the DESS measures stayed at their 1998 level of effect and the core road safety programme continued to develop as it had up to 1998 during the period from 1999 to 2010,

2. Prepare a Baseline casualty forecast using these estimated rates together with predictions of the volume of road travel in 2010, to show what would be expected with DESS measures at the 1998 level of effect plus the continuing development of the core activities,

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 5 road user groups were then summed to give overall forecasts, conditional upon the assumed change in road travel and the assumed effects of new measures.

The approach that is 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:

• Separate forecasts are prepared for 2020 and 2030,

• 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),

• No attempt has been made to predict the effectiveness of potential new measures, 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 child casualty trends.

1.1   Statistical background

All of the statistical information upon which this report is based comes from Government sources. In particular, the information about road accident casualties comes from the national STATS19 database which holds details of road accidents involving personal injury that are reported to and by the police. Details of the database and a range of results are published annually, e.g. Department for Transport (2010a) which also considers the degree of underreporting in the database. This section presents a brief overview of the STATS19 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 2009. 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 1983-1990 and 1996-2003 separated by a period of more rapid decline between 1991 and 1995. The number fell by 14% in 2008 and a further 12% in 2009.
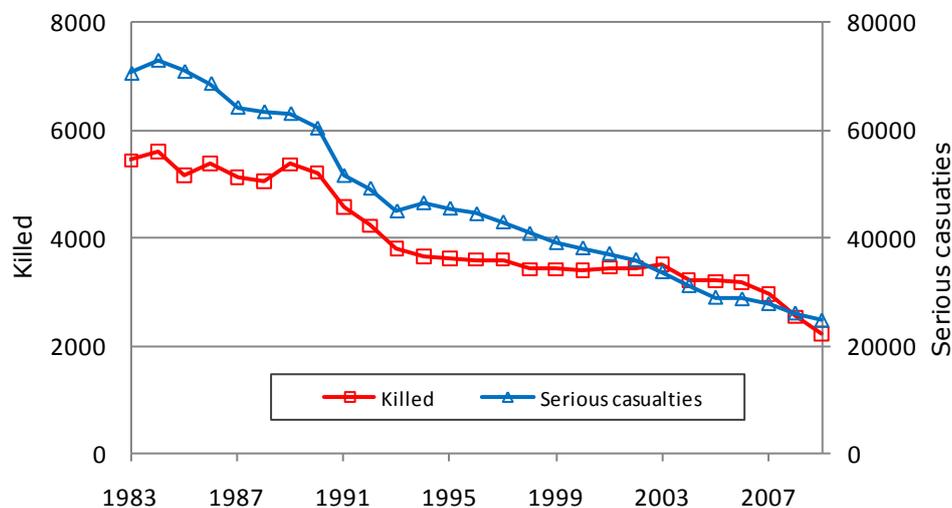

Figure 1.1 National totals, 1983-2009

Table 1.1 presents the composition of the national casualty totals at 10-year intervals, using the road user groups shown in the Introduction. Throughout this period, almost one half of 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 1989, 1999 and 2009, 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	Motor-cyclists	Pedal cyclists	Others
Killed	1989	45%	32%	13%	5%	5%
	1999	49%	25%	16%	5%	4%
	2009	48%	23%	21%	5%	4%
Serious casualties	1989	43%	25%	19%	8%	6%
	1999	48%	23%	16%	8%	5%
	2009	41%	22%	22%	11%	5%

Table 1.2 Casualty reductions over succeeding decades

	Decade	Car occupants	Pedestrians	Motor-cyclists	Pedal cyclists	Others	All road users
Killed	1989-1999	30%	49%	20%	41%	44%	36%
	1999-2009	37%	43%	14%	40%	41%	35%
Serious casualties	1989-1999	31%	43%	46%	38%	39%	38%
	1999-2009	46%	38%	16%	13%	47%	37%

2   The forecasting procedure

The baseline for the post-2000 forecasts was the annual average number of casualties from 1994 to 1998, in order to minimise any bias that might arise if a single year were selected for the baseline and there were to be unusually many or unusually few casualties in that year. Following this precedent, the baseline for the post-2010 casualty forecasts will be the 2005-09 annual average. The latest available casualty data are from 2009, so the forecasts for 2020 and 2030 will be based on the number of casualties in 2009. This section discusses various issues that arise with these forecasts. In particular, the fact that the number of people killed in road accidents fell markedly in 2008 and 2009 poses real questions over the forecasting procedure.

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. 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 future casualty rates (2020 and 2030 are the selected years) to show what would be expected if the core road safety programme continued to develop as it has up to 2009 and the DESS measures have the level of effect that is expected in 2020 and 2030, as estimated in section 2.2,

2. prepare a Baseline casualty forecast using these estimated rates together with predictions of the volume of road travel in 2020 and 2030,

3. apply the assumed effects of the measures in the new road safety strategy to the baseline forecast (if required).

The Baseline forecast from step 2 shows the number of casualties to be expected in the forecast year if the core road safety programme develops until then as it has in recent years, the benefits of the DESS measures predicted for that year are achieved and the volume of road travel changes as predicted.

The statistical model developed in TRL 382 to implement these steps will now be described mathematically. The forecasts presented in section 3 will be based on the latest casualty data, i.e. for 2009. The example of the forecast 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 actual 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 the same level of effect in year y as they had in 2009, then $C'(y)/T(y)$ is the adjusted casualty rate for this road user group in year y. Note that $C'(2009)=C(2009)$ by definition.

Given time series of data for $C(y)$ and $T(y)$, the task is to forecast the number of casualties in 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:

$$C'(2020)/T(2020) = [C'(2009)/T(2009)].(1-\alpha)^{11} \qquad (1)$$

where α is the average annual rate of reduction predicted for the 11 years 2010-2020.

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 left hand graphic shows $\log(C'/T)$, and if the annual rate of change was constant then the transformed rate would change by the same amount each year. The triangles show that this particular serious casualty rate fell steadily between 1991 and 2009, and the blue line represents the linear trend fitted to these points. α is calculated from the gradient

this line, and the red line represents the extrapolation of this trend from the baseline year to 2020 and 2030 as defined by (1). The right hand graphic shows the untransformed data, to illustrate the exponential decline that occurred in the past and is expected to continue in future.
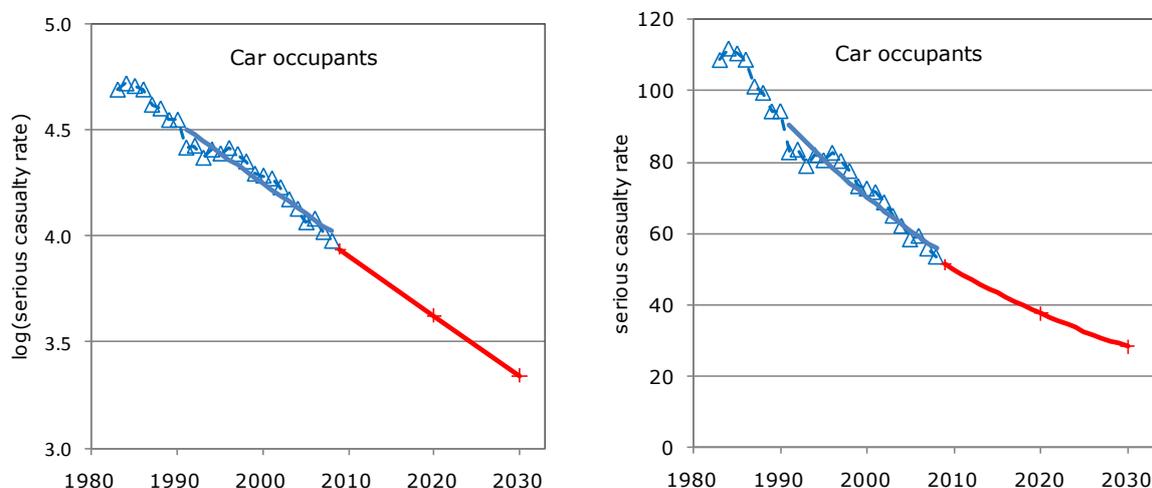

Figure 2.1 Example of an adjusted serious casualty rate

The outcome of step 2 is the baseline casualty forecast, which will be denoted by C''(2020). The outcome of step 1 is the baseline casualty rate for 2020:

$$C''(2020)/T(2020) \quad = (1-β) . C'(2020)/T(2020)$$

$$= (1-β) . [C(2009)/T(2009)].(1-α)^{11} \qquad (2)$$

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

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

$$C''(2020) = (1-β) . C(2009) . [T(2020) / T(2009)].(1-α)^{11} \qquad (3)$$

Thus, C''(2020) can be estimated using only the values of α and β, C(2009) and a prediction of traffic growth between 2009 and 2020. It is helpful that the casualty forecast depends upon the relative levels of traffic rather than the absolute levels since any 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:

$$C''(2020) = C(2009) . [T(2020) / T(2009)].(1-α)^{11}. γ \qquad (4)$$

where γ denotes the volume of pedestrian or pedal cyclist activity in 2020 relative to the 2009 volume. TRL 382 allowed for the possibility that if activity were to grow sufficiently strongly then casualties would 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) – it is simply assumed if pedestrian or cyclist activity changes then the number of casualties would change *pro rata*.

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 upon 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 performed 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 2009 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 which 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 reduced the number of car occupant casualties substantially, so it is important to examine the more recent data in order to consider how future improvements may affect casualty numbers. As car occupants account for almost half of all casualties (Table 1.1), this is a central issue in casualty forecasting.

The analysis of the benefits of improved car secondary safety and the related technical issues are relatively complex. Appendix A presents the details, including results based on analyses of car accidents between 1989 and 2009. Appendix A.1 shows how these results can be used to predict the benefits in future years, based upon an assumption about the extent to which secondary safety might continue to improve among new cars, i.e. those first registered in or after 2010.

The Appendix presents the latest evidence which suggests that there may be no further casualty reductions on Built-Up[1] (BU) roads, but that on Non Built-Up (NBU) roads there will continue to be additional reductions. Broughton (2010) had shown weak signs that progress had ceased on BU roads, based upon analyses of accident data to 2008; the addition of data from 2009 has strengthened the evidence to the point where the more natural assumption for casualty forecasting is that there will be no further progress on BU roads. The assumption, then, concerns when the improvement that has occurred over almost two decades *on NBU roads* might end. Appendix A.2 presents the results of calculations for two scenarios:

- for the 2020 forecasts, that progress will continue at the same rate until the 2012-13 registration year, with a little further progress for the 2030 forecasts
- alternatively, that secondary safety will not improve beyond the current level, i.e. the level achieved in the 2008-09 registration year.

In recent years, new vehicles have begun to be marketed with advanced primary safety equipment such as Electronic Stability Control which is claimed to reduce their risk of being involved in an accident. Relatively few of the vehicles on British roads in 2009 had such equipment, however, so the casualty trends are unlikely to have been affected appreciably. Hence "advanced primary safety equipment" counts collectively as a new road safety measure.

The proportion of vehicles with advanced primary safety equipment is likely to rise markedly in future. The forecasts presented in section 3 make no allowance for new measures, so take no account of this development. Assessments of the likely market penetration of this equipment by 2020 and 2030 and of its effectiveness in reducing

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[1] Built-Up roads have speed limits up to 40mph, Non Built-Up roads have higher limits

casualties would be required to complete step 3 of the forecasting procedure for this measure.

The "certain level of effect" referred to in step 1 (section 2.1) includes these benefits of improved secondary safety. Another DESS measure comprises activities to reduce the level of drink/driving. If it is expected that further activities will be undertaken in future to reduce this level then the predicted effects would be modelled in step 3. For the moment, the forecasts will assume that the proportion in 2009 will apply in 2020 and 2030, and it may be noted that the proportions of accidents that involve drink/driving were similar in 1999 and 2009.

Road safety engineering is the final DESS measure. The first row of Table 6 from TRL 382 shows the expected effect of the "new road safety engineering programme" outlined in the report. The values were based on the economic assessment of schemes at that time: 6.0% reduction of KSI for car occupants, motorcyclists and others, 4.7% for pedal cyclists and 13.7% for pedestrians (by 2010, relative to the 1994-98 baseline). 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. There is limited information about the effectiveness of these schemes in reducing fatal as opposed to serious casualties, so it is assumed that these values apply to fatalities as well as to serious casualties.

The effects of the three measures should be independent, so their combined effectiveness can be estimated by multiplying the separate estimates (as discussed in TRL 382). The results are shown in Table 2.1 and provide the values of β that will be used for forecasting with equations (3) and (4).

Table 2.1 Estimated effectiveness of combined DESS measures

Secondary safety scenario	Year of forecast		Car occupants	Motor-cyclists	Pedal cyclists	Pedest-rians	Others
Progress continues at the current rate until the 2012-13 (2020) or 2014-15 (2030) registration years	2020	Killed	39%	5%	3%	11%	5%
		Serious casualties	24%	5%	3%	11%	5%
	2030	Killed	52%	9%	6%	21%	9%
		Serious casualties	33%	9%	6%	21%	9%
There is no progress beyond the level achieved in the 2008-09 registration year	2020	Killed	33%	5%	3%	11%	5%
		Serious casualties	20%	5%	3%	11%	5%
	2030	Killed	36%	9%	6%	21%	9%
		Serious casualties	24%	9%	6%	21%	9%

In summary, the rate that would be expected if the DESS measures were as effective in 2020 or 2030 as they were in 2009 is estimated by extrapolating the adjusted casualty rate, as illustrated in Figure 2.1. This represents the consequences of the core road safety programme continuing to develop as it has over recent years. The rate is then reduced using the relevant value from Table 2.1 to realise the following scenario:

- the level of drink/driving in 2020 and 2030 will be unchanged from the level seen in 2009,

- the road safety engineering programme will continue in future and its level of effect will be maintained,

- the improvement of car secondary safety as a result of the continuing replacement of scrapped cars by newer cars (with known level of protection) and new (registered after 2009) cars (two scenarios for their level of protection).

The number of casualties is then forecast by evaluating equations (3) or (4) with casualty data from 2009, values of β from Table 2.1, values of α from Table 2.2 (below) and predictions of traffic growth (including walking and pedal cycling).

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 2.2, 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 to be used for forecasting. The modelling of the benefits of improved secondary safety has been improved, which explains certain differences from the corresponding figure in Broughton (2010).
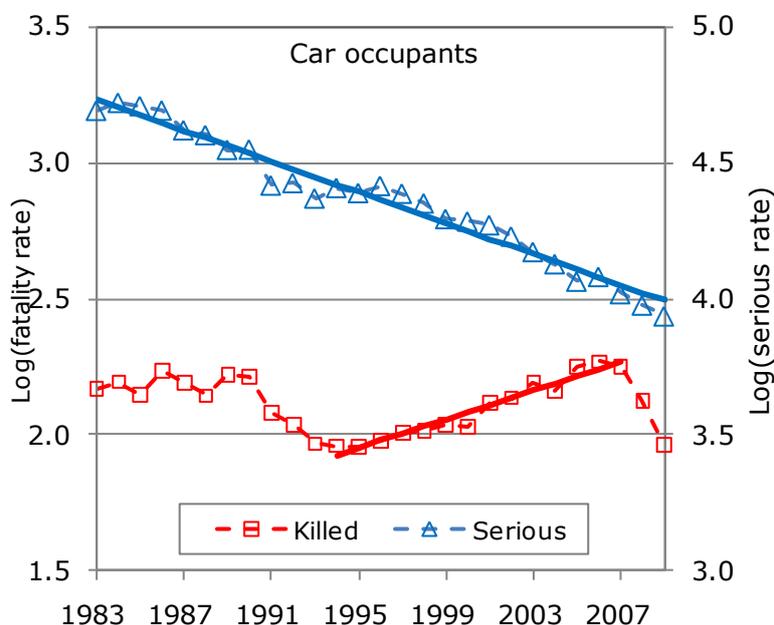

Figure 2.2 Log(adjusted casualty rates), car occupants

The adjusted fatal casualty rate fell substantially in 2008 and 2009. In terms of the implications for forecasting, it is instructive to look back to the rates in the early 1990s and observe that the fall in these two years is similar to the fall from 1990, the year when the previous economic recession began. It is steeper, however, and the 2008-09 recession has been deeper. The similarity of the patterns suggests that the onset of the

recession may have influenced the car occupant fatality rate. It also suggests that this particular rate will stabilise once the recession ends, so that as the economy recovers the rate will develop in line with the trend fitted for the 1994-2007 period and the existing forecasting procedure can again be applied. The forecast is shown by the "Forecast" line in Figure 2.3.
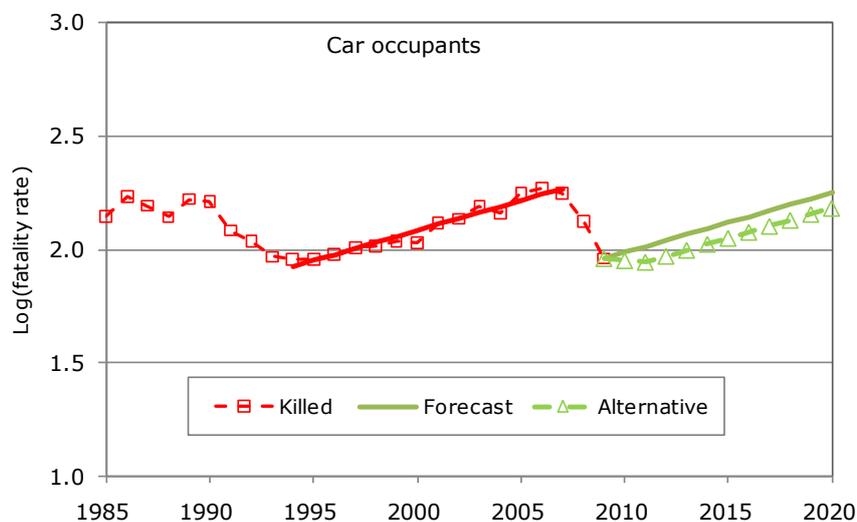

Figure 2.3 Forecast of log(adjusted fatality rate), car occupants

It is not certain that this rate reduction can be attributed to the economic recession, either wholly or in part, although Broughton and Knowles (2009) present supporting evidence. Hence, it would be premature to base the forecast on the assumption that the recession did cause the reduction: the forecast that is illustrated in Figure 2.3 simply applies the existing approach with the latest data.

On the other hand, it is possible to examine the consequences of assuming that the reduction is attributable to the recession, and that the recovery from the previous recession provides a precedent for the development of the rate over the next few years. The result is shown as the "alternative" forecast in Figure 2.3. The gap between the two rates in 2020 is equivalent to a 7% difference between the two fatality forecasts, i.e. if the pattern observed in the 1990s is repeated then the existing approach may overestimate the number of car occupant fatalities in 2020 by 7%. This approach also suggests that if recovery from the current recession is slower than in the 1990s then the overestimation would probably prove to be somewhat greater since there would be a longer transitional period before the rate began to rise once more.

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 rate was scarcely affected by the recession of the early 1990s, and the same is true for 2008 and 2009, so the long term trend will be used for forecasting. The reason for the different responses of the fatal and serious car occupant rates is not clear.

The next road user group comprises pedestrians, and the adjusted fatal and serious casualty rates are shown in Figure 2.4. The rate calculation uses the volume of motor traffic as the denominator, and the two rates have fallen in parallel over many years. The rates in 2008 and 2009 are reasonably consistent with the previous trends.
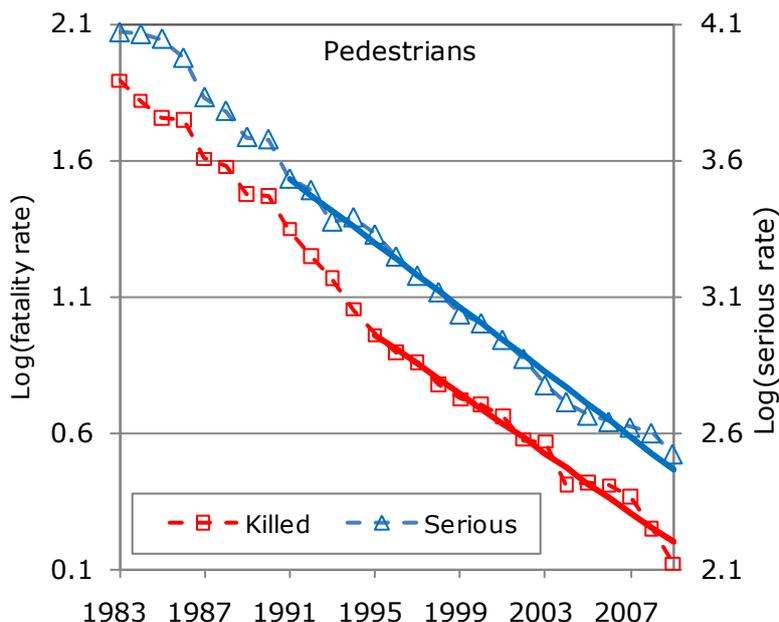
Figure 2.4 Log(adjusted casualty rates), pedestrians

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 2.5, 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. Again, the rates in 2008 and 2009 are consistent with the previous trends.

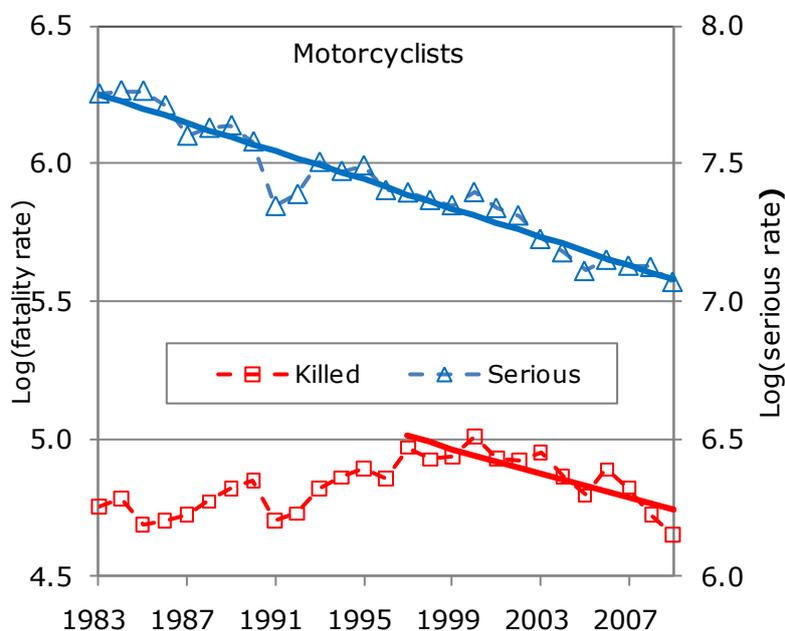**Figure 2.5 Log(adjusted casualty rates), motorcyclists**

The adjusted fatal and serious casualty rates for pedal cyclists are shown in Figure 2.6. The volume of motor traffic is the denominator for the rate calculation, so the rate does not take account of the volume of cycle traffic. The recent pattern of the casualty rates is examined in more detail in section 2.5, in particular the increase of the serious casualty

rate since 2004. Casualty forecasts will be developed to take account of the current trend for increased cycling that is identified in section 2.4.
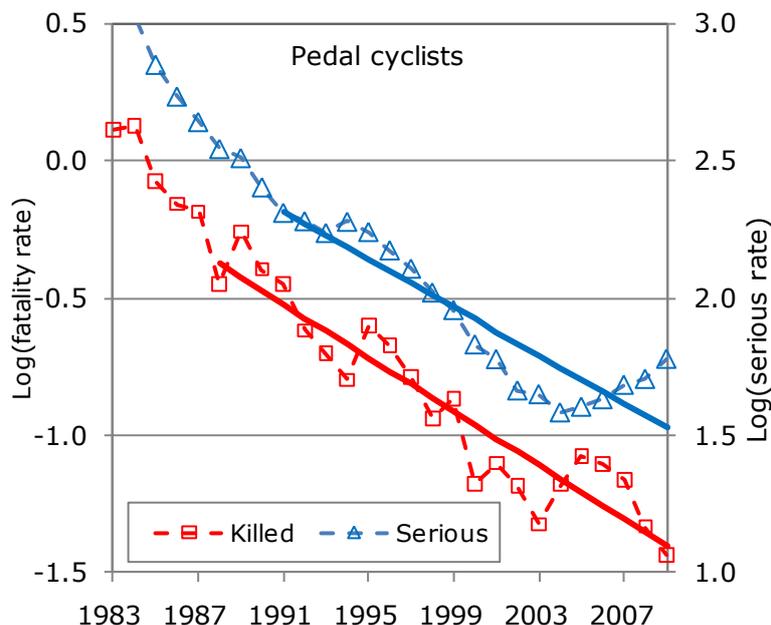
Figure 2.6 Log(adjusted casualty rates), pedal cyclists

The final group of road users 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 2.7 has fallen with great regularity since 1991. The adjusted fatality rate has been more variable, particularly in the mid-1990s. It followed the example of the rate for car occupants in falling rapidly at the onset of the previous recession before stabilising, and the fall in 2008 was even greater than for car occupants. The approach described above to forecast the car occupant fatality rate will be followed in this case, and the fitted trend from 1994-2007 will be used.
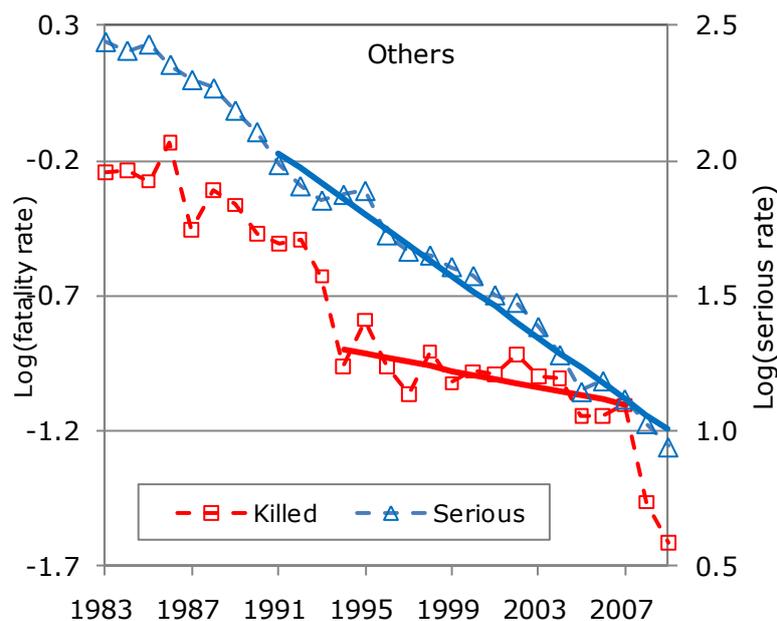
Figure 2.7 Log(adjusted casualty rates), others

There are clear parallels between the rate changes in 2008 and 2009 for others and car occupants: both of the fatality rates fell markedly in these years, but neither of the serious casualty rates. "Others" is a heterogeneous casualty group, with the great majority of casualties travelling by bus, coach, van or lorry. Thus, they have more in common with car occupants than with pedestrians, pedal cyclists or motorcyclists. If the recession has affected car drivers in a way that has reduced the fatal (but not the serious) casualty rate appreciably, the drivers of these larger motor vehicles could well have been influenced in a similar way. The discussion of the possible implications of the recession on the car occupant fatality forecasts applies equally to the fatality forecasts for this group of road users.

Table 2.2 brings together the average rates of reduction that have been calculated from the series presented in these figures. These will contribute to the baseline casualty forecasts in section 3 as the values of a 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.

Table 2.2 Rates of reduction of adjusted casualty rates

	Killed Annual rate of reduction	Period chosen	Serious casualties Annual rate of reduction	Period chosen
Car occupants	-2.68%	1994-2007	2.80%	1983-2009
Motorcyclists	2.20%	1997-2009	2.56%	1983-2009
Pedal cyclists	4.28%	see note	3.69%	see note
Pedestrians	5.31%	1995-2009	5.75%	1991-2009
Others	1.56%	1994-2007	5.53%	1991-2009

Note: An improved method has been used to estimate values for pedal cyclists, as described in section 2.5

To summarise these analyses of the changes in 2008 and 2009, the fatality trends for motorcyclists, pedal cyclists and pedestrians do not appear to have changed so the forecasts have not changed appreciably from those prepared previously. The fatality trends for car occupants and others, however, did change so these forecasts have changed. The starting point for each forecast is the relatively low 2009 rate, with the post-2009 rate of reduction being the average rate from the 1994-2007 period. This uses the general forecasting procedure once again, without taking account of the possibility that these changes in 2009 resulted from the recession and that there may be further effects of recession after 2009. If the pattern observed after the previous recession is repeated in the next few years, these two fatality forecasts are likely to be about 7% too high. If the current recession is protracted then this difference may prove to be more than 7%.

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 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 2.7 shows that the serious casualty rate for others has fallen steadily for over twenty years, so it is reasonable to assume that this rate will fall equally steadily over the forecasting period. There can be less confidence in forecasts of the fatality rate for others, however, as discussed above.

The possibility that any of these trends might change in future should be borne in mind when considering the forecasts 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 discussed the possibility that economic recessions may have influenced two of the fatality trends, and the uncertainty that this introduces. Neverthe-

less, 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 inevitable 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 2035 (DfT, 2010b), but judgement is required in the case of motorcycling.

The central forecast from the 'Road Transport Forecasts 2009' is that traffic in England will grow by 7% between 2003 and 2015, by 25% between 2003 and 2025 and by 43% between 2003 and 2035. Traffic volumes are required for 2020 and 2030 to forecast casualties in these years. Interpolation of the DfT data gives traffic growth of 13% between 2009 and 2020 and of 30% between 2009 and 2030. These data are illustrated in Figure 2.8, where the solid line shows the actual data to 2009, 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.
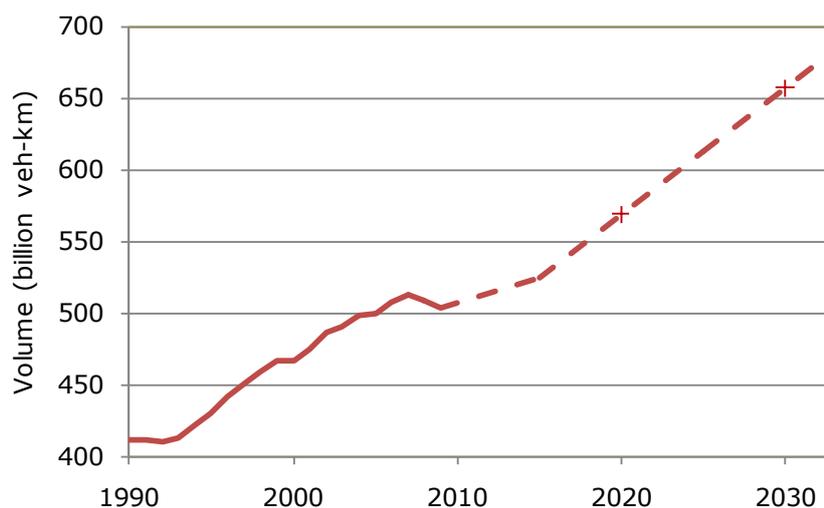

Figure 2.8 Actual and forecast traffic volumes, Great Britain

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 7 years. Two scenarios will be examined for motorcycle traffic after 2009: 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, relative to the volume in 2003: growth of 11% by 2015, 16% by 2025 and 24% by 2035.

Previous post-2010 casualty forecasts (Broughton, 2010) have assumed that the volumes of walking and cycling would change in parallel in the future, but increasing evidence that the trends for the two modes have diverged in recent years make this assumption untenable. The National Travel Survey (DfT, 2010c) is the main source of information about the volume of personal travel in Great Britain. Figure 2.9 shows that

the volume of walking has scarcely changed since 1996, but the volume of cycling has tended to rise rapidly since about 2002 following an earlier decline.
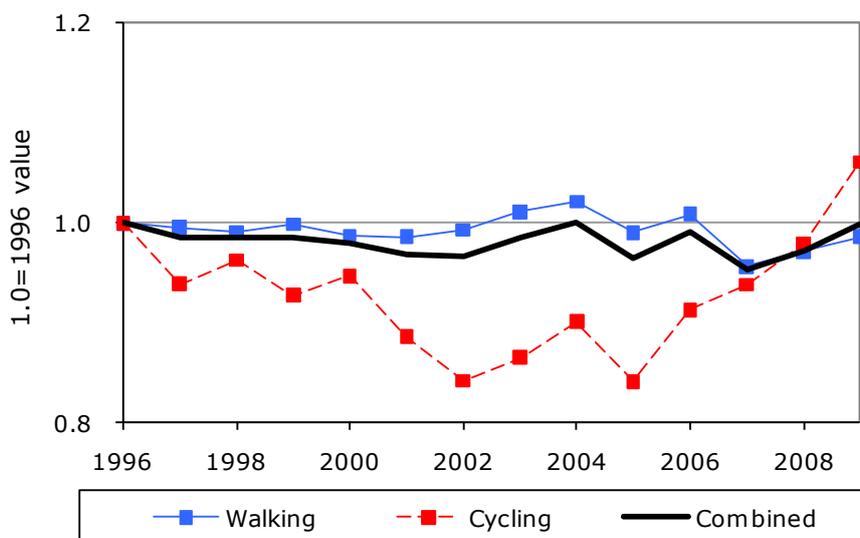

Figure 2.9 Trends in the volume of walking and cycling, Great Britain

The serious casualty rate in Figure 2.6 has risen since 2004, but the rate calculation includes the volume of motor traffic but not the volume of cycling. This suggests that the change in the cyclist casualty trend is related to the change in the cycling trend.

It is unfortunate that the DfT forecasts are provided only for the combination of walking and cycling, as the casualty forecasts require separate figures for walking and cycling. Consequently, the DfT forecasts must now be disaggregated into forecasts for walking and cycling that are consistent with the recent trends shown by the NTS data. If the volume of cycling is assumed to continue to increase at the recent rate then it would grow by 34% between 2009 and 2020, and by 64% between 2009 and 2030. The corresponding increases for walking that match the combined DfT forecasts are 9% by 2020 and 11% by 2030. The casualty forecasts presented in section 3 use these values.

There are many alternative disaggregate forecasts that are consistent with the combined DfT forecasts, although they seem less credible as they involve greater deviations from recent trends as shown by NTS data. Appendix B examines the sensitivity of the overall casualty forecasts to the choice of disaggregation by evaluating four of these in addition to the 'central' disaggregation specified above. They range from equal growth of walking and cycling (the scenario that was studied by Broughton (2010)) to strong growth of cycling combined with little growth of walking. The results show that the forecast of the overall fatality reduction varies very little across the range of alternatives, but the overall reduction of serious casualties is slightly more sensitive. The separate cyclist and pedestrian casualty forecasts, however, certainly are sensitive to the choice of scenario.

2.5   Forecasting pedal cyclist casualties

Equation (4) is used to forecast the number of pedestrian and pedal cyclist casualties. If the volume of walking or cycling is broadly constant over the period used to calculate the adjusted casualty rates, then the value of α calculated from the trend in these rates can be used for the forecast. This had appeared to be the case for walking and cycling, and remains the case for walking, so there is no need to amend the forecasts for pedestrian casualties. It is now clear, however, that the volume of cycling has risen in recent years, so the forecasts for pedal cyclist casualties need to take account of this.

This can be done by dividing the number of cyclist casualties per year by the NTS cycling index shown in Figure 2.9. This estimates the number of casualties that would have been

expected if the volume of cycling had remained at its 1996 level (the calculation actually uses a smoothed index because of the variability of the NTS index). Figure 2.10 shows the rates from Figure 2.6 (labelled Killed and Serious), which are then adjusted to allow for the trend in the volume of cycling (the 'adjusted' rates). The adjusted series are clearly more linear than the original rates, so the exposure adjustment has been partially successful in identifying stable trends. On the other hand, they are not as linear as the rates found for the other road user groups. One possible explanation could be that the volume of cycling has increased more rapidly than indicated by the NTS data, or alternatively that the increase has occurred in relatively risky environments or among relatively risky groups of cyclist.
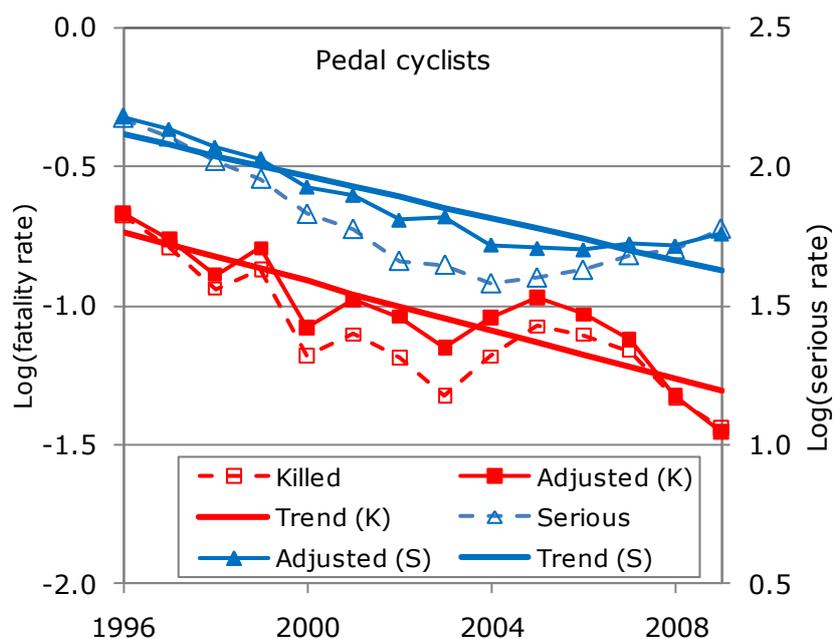
Figure 2.10 Adjusted version of Figure 2.6 that allows for trend in volume of cycling

A regression line (labelled Trend) has been fitted to each adjusted series. The gradients of these lines provide the values of α listed in Table 2.2 that will be used in (4) to forecast the number of cyclist casualties. These values are slightly less than the values calculated from the regression lines in Figure 2.6, which will increase the casualty forecasts slightly.

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 programme continues to develop, the DESS measures develop as specified in section 2.2 but there will be no *new* road safety measures. To reiterate the definition in the Introduction, a new measure in this context is either innovatory or a *substantial* expansion of an existing measure, and the general introduction of advanced primary safety equipment to the vehicle fleet has been cited as an example. 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. If new measures were to be introduced, however, then these forecasts could well prove to be conservative.

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 casualty forecasts are presented as numbers (serious casualty numbers are rounded) and as reductions from the 2005-09 averages that are shown in Table 3.1. A reduction of 0% for a group of casualties in the following tables implies that the future number is predicted to be unchanged from the 2005-09 average, while a value of 25% implies that the number is predicted to fall by one quarter. Various of the forecasts are illustrated in sections 3.1.1 and 3.1.2 in the context of time series of casualty data from 1990.

Table 3.1 2005-09 average numbers of casualties

	Car occupants	Motor-cyclists	Pedal cyclists	Pedestrians	Others	All road users
Killed	1407	544	130	613	122	2816
Serious	11577	5776	2398	6145	1328	27224

The first four forecasts are based on what are described in Appendix A.2 as the "most plausible scenarios" for the development of car secondary safety, namely to the 2012-13 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	Motor-cyclists	Pedal cyclists	Pedestrians	Others	All road users
Killed	941	353	94	301	79	1767
	33%	35%	28%	51%	35%	37%
Serious	6110	3840	2520	3180	650	16300
	47%	34%	-5%	48%	51%	40%

Table 3.3 Casualty reduction forecast for 2020, motorcycling grows by 25%

	Car occupants	Motor-cyclists	Pedal cyclists	Pedestrians	Others	All road users
Killed	941	441	94	301	79	1855
	33%	19%	28%	51%	35%	34%
Serious	6110	4800	2520	3180	650	17200
	47%	17%	-5%	48%	51%	37%

Table 3.4 Casualty reduction forecast for 2030, no growth in motorcycling

	Car occupants	Motor-cyclists	Pedal cyclists	Pedestrians	Others	All road users
Killed	1056	270	83	183	74	1666
	25%	50%	36%	70%	39%	41%
Serious	4430	2830	2370	1840	406	11900
	62%	51%	1%	70%	69%	56%

Table 3.5 Casualty reduction forecast for 2030, motorcycling grows by 25%

	Car occupants	Motor-cyclists	Pedal cyclists	Pedestrians	Others	All road users
Killed	1056	337	83	183	74	1733
	25%	38%	36%	70%	39%	38%
Serious	4430	3540	2370	1840	406	12600
	62%	39%	1%	70%	69%	54%

These forecasts suggest that, even if no new road safety measures are taken, the number of people killed in road accidents in 2020 is likely to be more than one third lower than the 2005-09 average, and the reduction of the number seriously injured is likely to be slightly greater. The corresponding reductions for 2030 are about two fifths and more than one half.

It should be emphasised that these forecasts are based largely on past trends, and it is not certain that these will continue into the future. Projections from 2020 to 2030 are likely to be particularly uncertain. These forecasts suggest a relatively small reduction in fatalities between 2020 and 2030 compared to that which has occured in recent decades, but if new measures are introduced, for example new primary vehicle safety measures such as Electronic Stability Control, then this is likely to prove to be conservative.

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 2008-09 level for both the 2020 and the 2030 forecasts. With this assumption, the secondary safety of the great majority of cars would be appreciably less than with the earlier assumption, especially in terms of preventing fatal casualties, so the estimated casualty reductions are considerably smaller. 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 3% and for serious casualties by 1%. Naturally, the changes are larger for the 2030 forecasts, 12% for Killed and 2% 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	1029	1855	1029	1943
	27%	34%	27%	31%
Serious	6410	16600	6410	17600
	45%	39%	45%	36%

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	1395	2005	1395	2072
	1%	29%	1%	26%
Serious	5020	12500	5020	13200
	57%	54%	57%	52%

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 2008-09 level; the plausible assumptions are that there will be progress to the 2012-13 level for the 2020 forecasts and to the 2014-15 level for the 2030 forecasts.
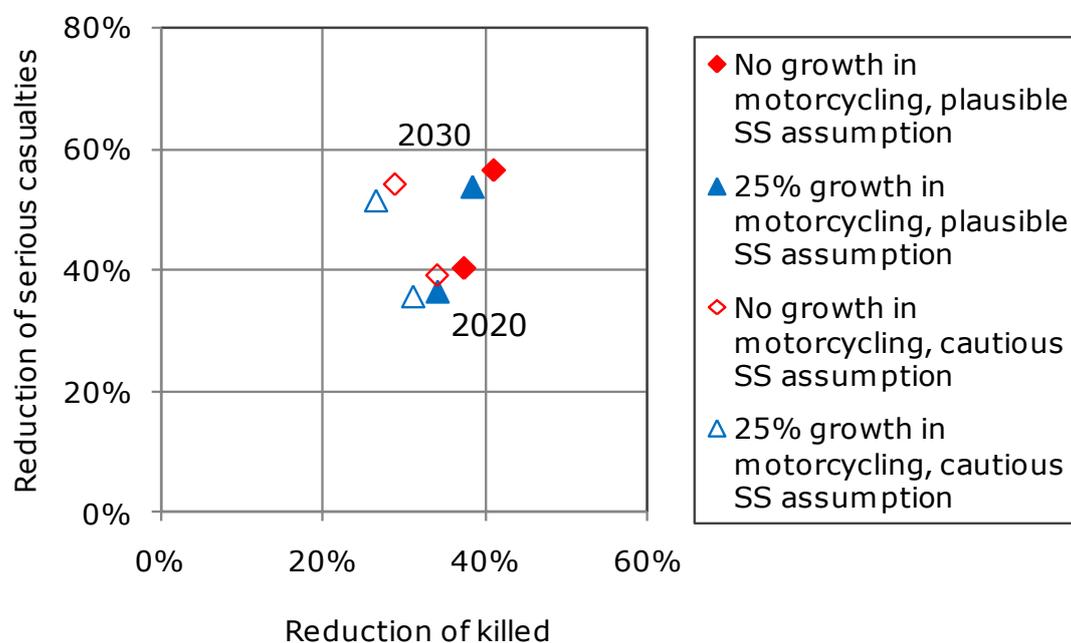
Figure 3.1 Summary of forecasts

Section 2.4 raised the possibility that traffic growth may be less than forecast. To test the sensitivity of the casualty forecasts to the traffic growth assumption, the following tables incorporate traffic growth that is one half of the growth predicted by the DfT report, namely 6½% between 2009 and 2020 and 15% between 2009 and 2030. The overall forecasts from the Tables 3.2-3.5 appear in the columns headed 13% and 30% traffic growth. The effect of halving the assumed traffic growth is shown to be comparable 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	
	6½% traffic growth	13% traffic growth	6½% traffic growth	13% traffic growth
Killed	1702	1767	1790	1855
	40%	37%	36%	34%
Serious	15700	16300	16600	17200
	42%	40%	39%	37%

Table 3.9 Casualty reduction forecast for 2030, all road users

	No growth in motorcycling		25% growth in motorcycling	
	15% traffic growth	30% traffic growth	15% traffic growth	30% traffic growth
Killed	1543	1666	1610	1733
	45%	41%	43%	38%
Serious	11000	11900	11700	12600
	60%	56%	57%	54%

Appendix B.2 presents the results of a further sensitivity test. Budgetary reductions following the economic recession of 2008 and 2009 may mean that the level of road safety engineering will be lower in future than it has been over the past decade. The appendix shows that in the extreme case that the effectiveness of new engineering measures is halved then the casualty reductions forecast for 2020 are reduced by about one twentieth, while some of the reductions forecast for 2030 are proportionately rather larger.
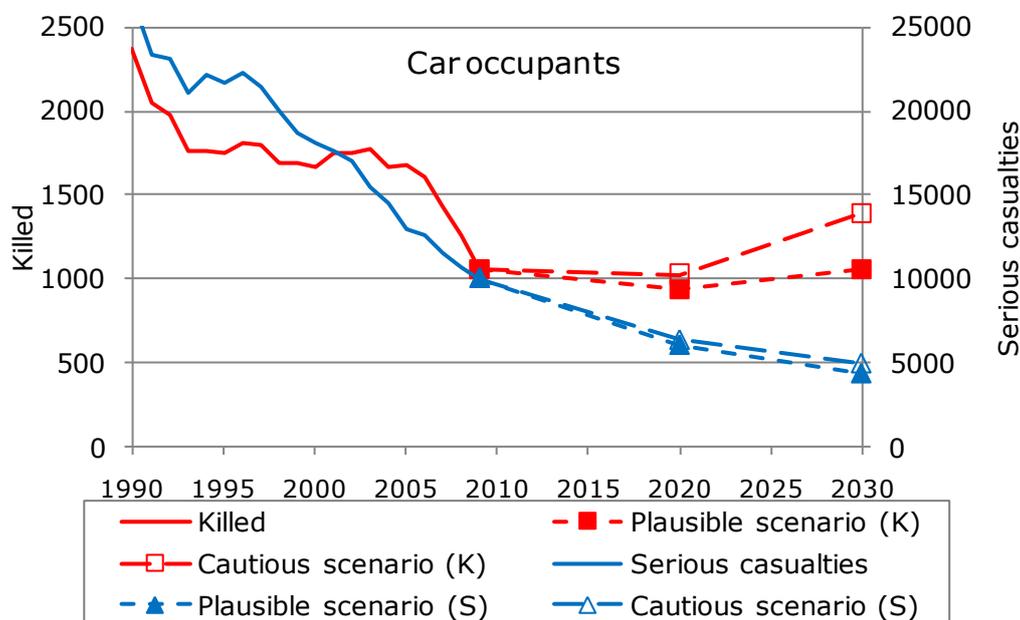
3.1.1   *Car occupant casualty forecasts*

Figure 3.2 Car occupant casualty forecasts

Figure 3.2 relates the car occupant casualty forecasts presented in the previous section to the actual data from 1990 to 2009, comparing the two secondary safety scenarios. It brings out the contrasting trends for fatal and serious casualties, building upon the different patterns of the adjusted rates that are shown in Figure 2.2. The adjusted serious casualty rate has fallen steadily, so the assumption that secondary safety

improvements will shortly cease simply slows the expected reduction of the number of serious casualties. By contrast, the adjusted fatal casualty rate rose for over a decade from about 1993, but the improvement of secondary safety over that period prevented the number of fatalities from rising appreciably. The assumptions that these improve-ments will shortly cease and that the adjusted rate will soon begin to rise again lead to the possibility that the number of fatalities will begin to rise in future.

This is not certain, however, and the car occupant fatality rate could follow a different trend, particularly in the period to 2030. Therefore the sensitivity of the car occupant fatality forecasts to future developments in car safety will be explored using three scenarios which will be compared with the scenario for future improvement of secondary safety that was labelled 'plausible' in Figure 3.2:

1. an optimistic scenario for secondary safety improvements - that improvements will continue until the 2020-21 registration year (NBU roads only),

2. an intermediate scenario: that the adjusted fatal casualty rate will rise only half as fast as shown in Figure 2.3 – perhaps as a result of technical developments such as universal fitment of Electronic Stability Control to cars,

3. an optimistic scenario for the adjusted fatal casualty rate: that the rate will remain at its 2009 value.

Table 3.10 presents the predicted fatality reduction for car occupants and all road users (car occupants are the only road users affected by these scenarios). It illustrates the sensitivity of the overall forecast to the assumption about the adjusted fatality rate. The reasons for the steady rate rise between the end of the previous recession and the onset of the current recession are unclear, but it would be unwise to assume that it will not be repeated once the current recession ends. If the benefits of future car safety develop-ments can be quantified, it would be better to treat them as new measures in the forecasting model (section 2.1) rather than to manipulate the value of α.

Table 3.10 Fatality reduction forecasts for four car safety scenarios

Scenario	2020				2030			
	Car occupants		All road users		Car occupants		All road users	
plausible	941	33%	1767	37%	1056	25%	1666	41%
1	882	37%	1708	39%	957	32%	1566	44%
2	814	42%	1641	42%	802	43%	1411	50%
3	703	50%	1530	46%	606	57%	1216	57%

3.1.2   *Casualty forecasts for other road user groups*

The casualty forecasts for the other groups will now be illustrated, following the example of Figure 3.2. First, the forecasts for motorcyclists are shown in Figure 3.3, with two scenarios. In the "no growth" scenario, the volume of motorcyclist traffic is the same in 2020 and 2030 as in 2009. In the "25% growth" scenario, the volume of motorcyclist traffic grows by 25% between 2009 and 2020, and stays at this level in 2030.
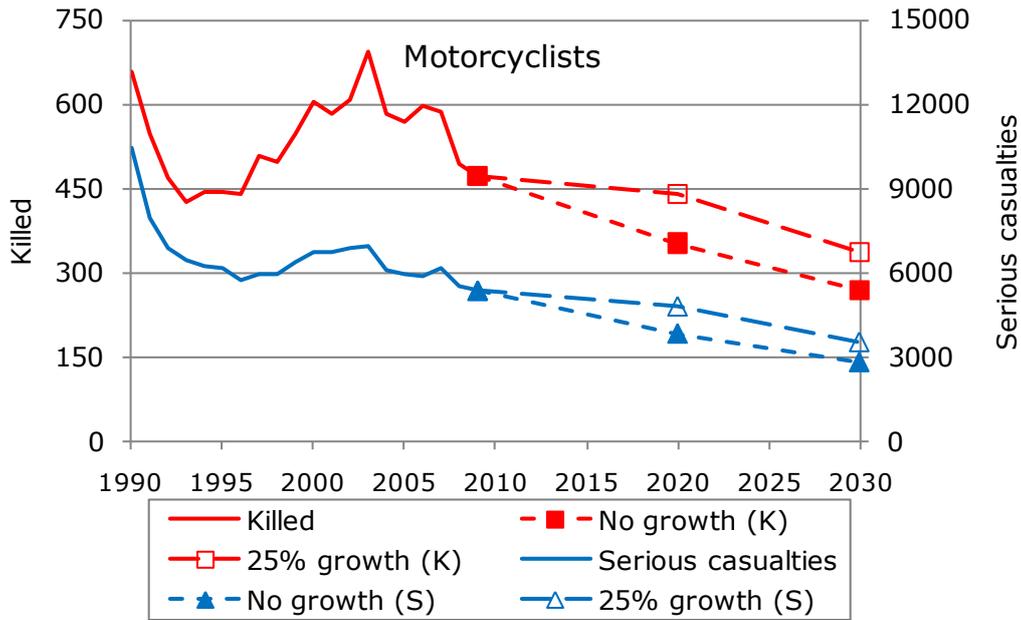
Figure 3.3 Motorcyclist casualty forecasts

The only scenarios for walking and cycling that have been examined are alternative ways of disaggregating the combined DfT exposure forecast (Appendix B.1). The following figures use two scenarios:

- the "strong growth of cycling/weak growth of walking" scenario used for the forecasts in section 3.1: the volume of cycling grows by 34% by 2020 relative to 2009, and by 64% by 2030; the volume of walking grows by 9.1% by 2020 relative to 2009, and by 11% by 2030

- the "equal growth of cycling and walking" scenario: the volumes of walking and of cycling grow by 13½% by 2020 relative to 2009, and by 20% by 2030.
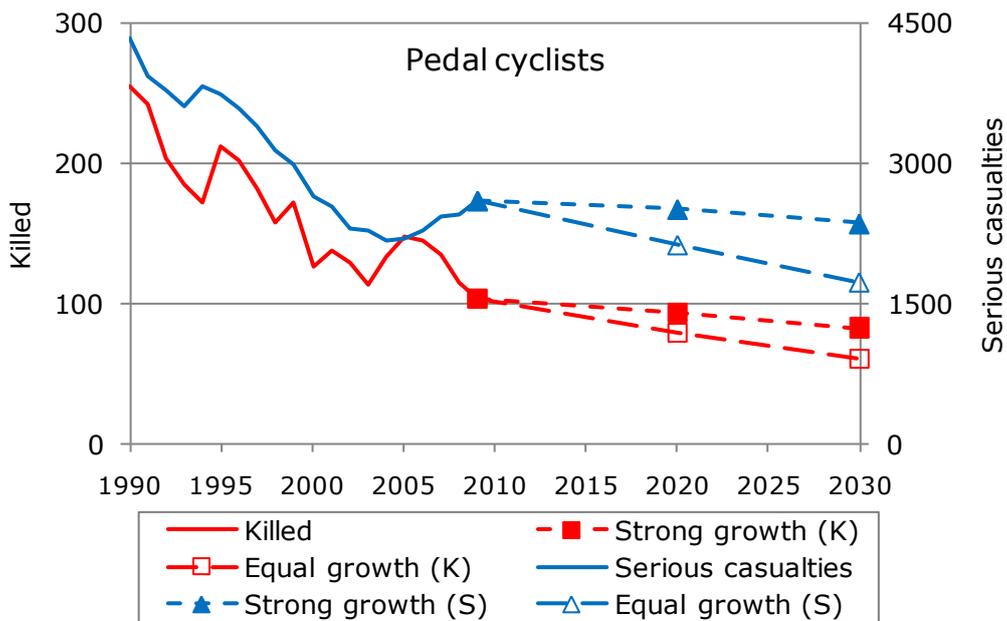

Figure 3.4 Pedal cyclist casualty forecasts

Clearly, the difference between the two scenarios will be greater for pedal cyclists than for pedestrians. Figure 3.4 shows that if the volume of cycling grows strongly then the

number of pedal cyclist casualties is likely to fall only slowly. By contrast, Figure 3.5 shows that the number of pedestrian casualties is likely to fall steadily with either scenario.
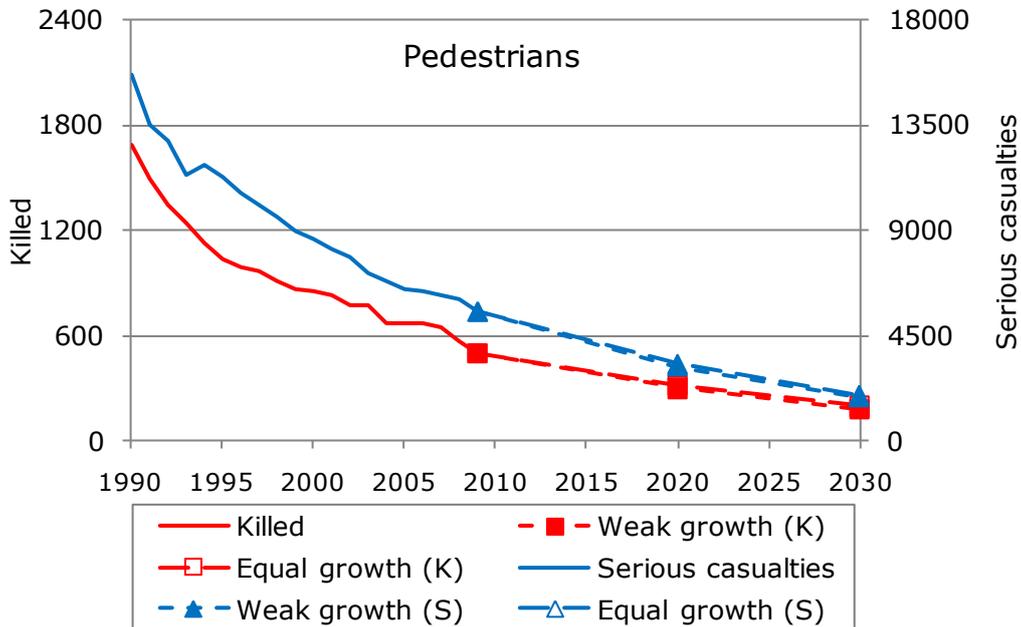

Figure 3.5 Pedestrian casualty forecasts

Finally, Figure 3.6 presents forecasts for other casualties. The number of fatalities is likely to fall very slowly, following the trend in the period before the recession. The number of serious casualties is predicted to fall steadily, as in recent years.
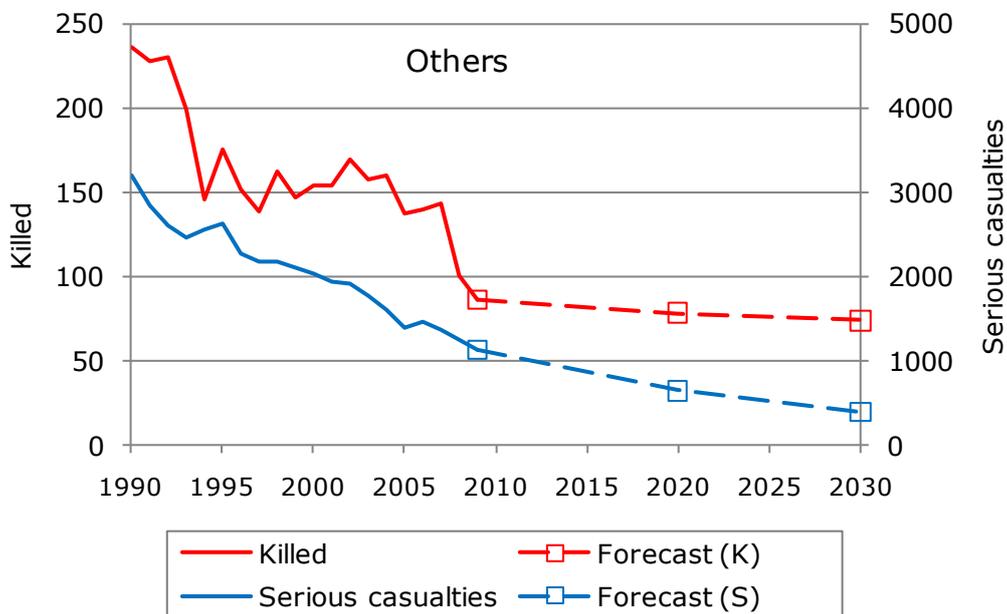

Figure 3.6 Other casualty forecasts

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 the DfT's "Safety Targets and Accident Reduction Group" helped to prepare the casualty reduction 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 step has not been required on this occasion. Consequently, if new measures are introduced then these forecasts, particularly to 2030, are likely to be conservative.

3.3 Forecasts of pedestrian and pedal cyclist casualty rates

Section 2.4 introduced the data from the National Travel Survey (NTS) estimating the distance walked and cycled nationally. The National Road Traffic Survey (NRTS) is an alternative source for the distance cycled, and Broughton and Knowles (2009) compare the trends. They tended to diverge between 1996 and about 2002, but have since tended to rise in parallel.

Table 3.11 presents the 2005-09 baseline data, with average KSI for cyclists and pedestrians and the distance travelled estimated from NTS data. The final column estimates the cyclist casualty rate using NRTS data for comparison with the NTS-based figure.

Table 3.11 Baseline casualty data

2005-09 averages	Pedal cyclists (NTS)	Pedestrians	Both	Pedal cyclists (NRTS)
KSI	2528	6758	9286	
Distance travelled (million km)	4045	18494	22540	4581
KSI rate (per million km)	0.62	0.37	0.41	0.55

KSI forecasts for pedestrians and pedal cyclists in 2020 have been prepared using the methods, data and assumptions that were used above, in particular that the volumes of walking and cycling will grow by 9% and 34% respectively. Separate results are presented using the NTS and NRTS figures for the distance cycled: although the rates are lower with the NRTS figures, the percentage reductions are unchanged. These figures suggest that the cyclist KSI rate will reduce by one quarter by 2020, and the pedestrian KSI rate by one half.

To demonstrate the advantage of forecasting rates rather than numbers, the table also includes forecasts for an alternative scenario: walking and cycling increase equally, with the increase for the combined modes being as great as in the first scenario. Although the forecast KSI reductions are different, the KSI rate reductions are unchanged.

Table 3.12 Forecasts for 2020 with alternative assumptions about growth of walking and cycling

| | Walking grows by 9%, cycling grows by 34% | | | Walking and cycling both grow by 13½% | | |
	Pedal cyclists	Pedestrians	Comb-ined	Pedal cyclists	Pedestrians	Comb-ined
KSI forecast	2612	3561	6173	2212	3704	5917
reduction	-3%	47%	34%	12%	45%	36%
KSI rate (per million km)(NTS)	0.48	0.18	0.24	0.48	0.18	0.23
reduction	23%	52%	41%	23%	52%	44%
KSI rate (per million km)(NRTS)	0.43		0.23	0.43		0.23
reduction	23%		42%	23%		44%

This will also be true when exposure of the combined modes varies, provided the increases do not exceed 60%. TRL 382 discussed the possibility that greater growth might lead to a 'safety in numbers' effect, which was incorporated in the forecasting model. It may be noted that the trend analysis in section 2.5 showed no sign of such an effect at the national level.

The results presented above have included the combined rate for cyclists and pedestrians, as well as the individual rates. There are pros and cons to forecasting the combined rate rather than the individual rates. The main advantage is that the variability of the annual estimates of the distance cycled would cause fewer problems in estimating the casualty rate to measure progress towards the forecast. The main drawback is that, as there are many more pedestrian casualties than cyclist casualties, progress towards a combined forecast would be driven mainly by progress in reducing pedestrian casualties. Thus the separate interests of cyclists and pedestrians would be confused, with cyclists tending to lose out to pedestrians.

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 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, and are displayed in Figure 4.1. With the exception of the fatality rate increase in 2006, the relation between casualties and traffic has been as regular as that observed for all road users.
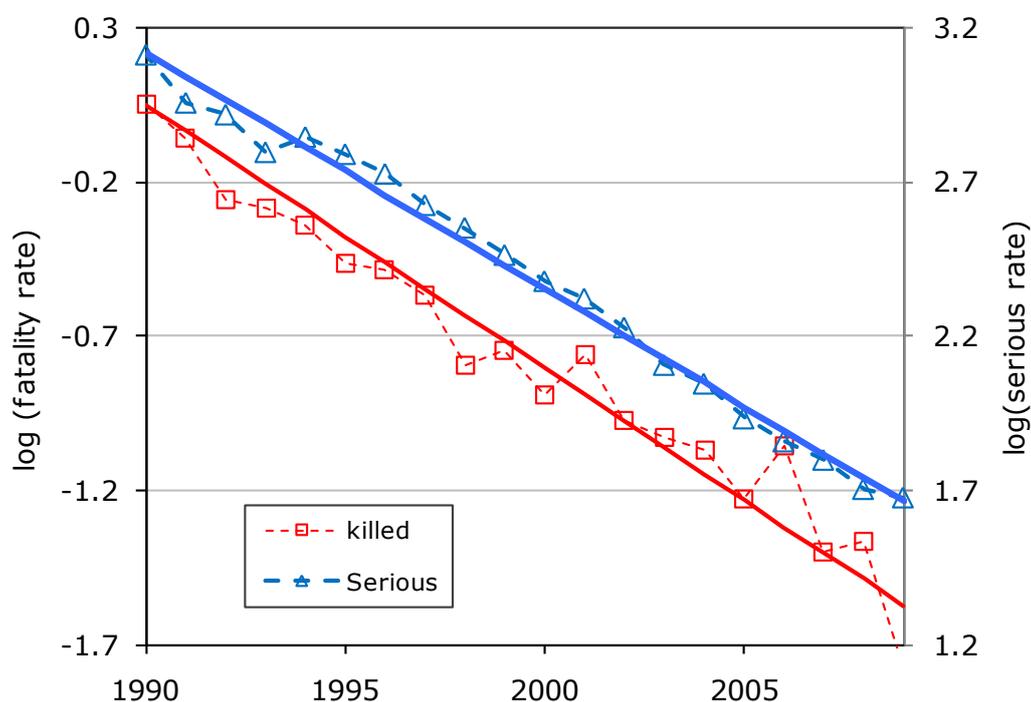

Figure 4.1 Logarithm of child casualty rates

The solid lines are fitted to the casualty rates from 1983-2009. The serious casualty rate in 2009 was close to the trend, while the fatality rate was below.

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 2005-09 average.

Table 4.1 Child casualty reduction forecasts

	Forecasts		Reduction from 2005-09 average	
	Killed	**Serious**	**Killed**	**Serious**
2005-09 average	127	2940		
2020	48	1354	62%	54%
2030	24	742	81%	75%

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 2005-09 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 2009, i.e. between the 1994-98 average and 2009. The number of children killed fell by 69% over this period, and the number of serious casualties by 61%. 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 upon 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 can provide the numerical context for developing the new road safety strategy.

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.

The fact that the number of people killed in road accidents fell markedly in 2008 and 2009 has raised real questions about the forecasting process. It has been seen that the five serious casualty trends upon which the forecasts are based continued largely unaltered in 2008 and 2009. Consequently, the serious casualty forecasts of section 3 have scarcely changed from earlier forecasts.

The same consistency in 2008 and 2009 was also found in the fatality trends for motorcyclists, pedal cyclists and pedestrians, so the rate forecasts for these groups are also very similar to the earlier forecasts. In the case of car occupants and others, however, the falls in fatalities in 2008 and 2009 were clearly not consistent with the trends to 2007. The new forecasts are lower than the previous forecasts as they incorporate the lower 2008 and 2009 data, but the approach to forecasting has not been changed. The parallels with the fatality trends of these two groups during the economic recession of 1990, however, suggest that the recession may have contributed to the falls seen in 2008 and 2009. The result of assuming that these two trends will, over the next few years, follow the pattern seen after the previous recession is to reduce these two forecasts slightly.

The forecast rates are then combined with DfT predictions about the distances that will be travelled by road in 2020 and 2030 to produce casualty forecasts. These forecasts assume that core road safety programme continues to develop in coming years, and that the secondary safety of the car fleet will continue to improve. The sensitivity of these forecasts to alternative predictions of traffic growth has been assessed.

Data from the National Travel Survey suggest that the volume of cycling has grown since about 2002, having previously been falling. This accounts in part for the rising trend for cyclist casualties in recent years, and the casualty forecasts have been developed to take account of continuing growth in the volume of cycling over the coming decade. Unfortunately, the DfT travel predictions relate to the combination of cycling and walking rather than to the separate modes, so the casualty forecasts have made use of a disaggregation of the combined DfT prediction. Fortunately, it has been shown that the sensitivity of the overall casualty forecast to the choice of disaggregation is low.

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 can play a valuable role in formulating a new road safety strategy and in monitoring implementation of the strategy.

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 upon 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. It appears that progress with reducing casualties on NBU roads continues undiminished, but that a limit may have been reached on BU roads.

Acknowledgements

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Appendix A   The casualty benefits of improved secondary safety

Section 2 introduced the important role of secondary safety analyses in the analysis of past casualty trends for car occupants and in forecasting. This appendix presents details of the methods used and the results achieved.

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 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 to car design which 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 were 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 5.1 presents results from the analysis of accident data from 1989 to 2009. Fatal and serious casualties in accidents on Built-Up (BU) and Non Built-Up (NBU) roads were analysed separately. The upper graphics show the proportions of driver casualties that were killed, while the lower graphics show the proportions that were seriously injured. Car 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 A.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. The analysis reported by Broughton (2010) has been updated to include the data from accidents in 2009, and the new results provide improved indications about the secondary safety of the latest cars, i.e. those first registered in 2008 and 2009. Only 46 drivers of these cars were killed in 2009 and 534 seriously injured, however, so these indications are necessarily imprecise. 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. It is now beginning to appear that the improvement of secondary safety on BU roads has not progressed beyond the level of 2004-05 cars. The results for NBU roads suggest, however, that improvement has continued undiminished on these roads (results from Broughton (2010) had shown signs of some diminution).
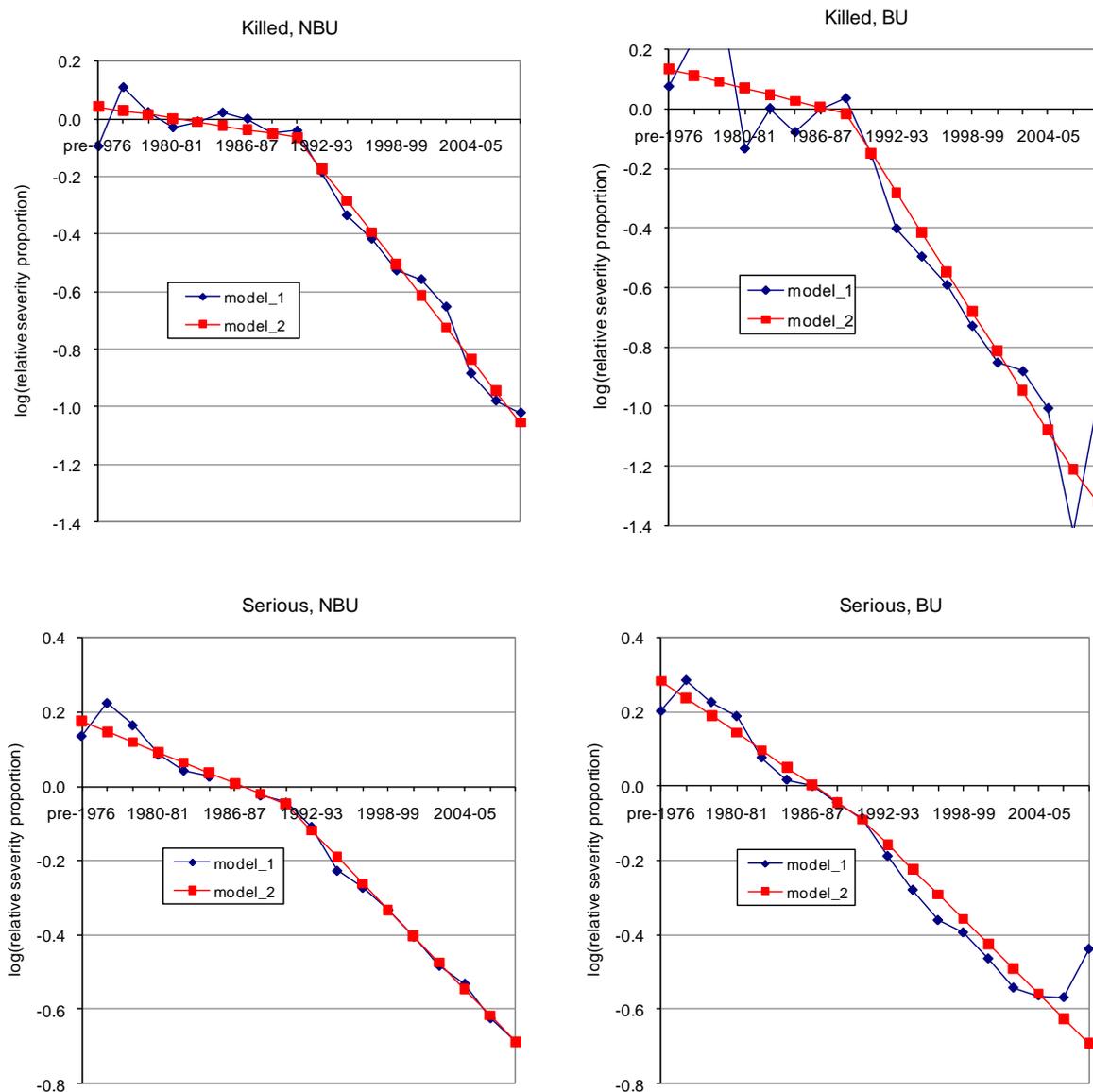
Figure 5.1 Coefficients representing effect of registration year

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 2009 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, although the results for the most recent cars provide signs that progress may have

ceased on BU roads (approximately one quarter of car driver fatalities occur on BU roads). It is unfortunate but inevitable that the newest cars are least well represented in the accident data, so the coefficients that represent their secondary safety are the least precise.

A.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 upon 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 5.1. 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≤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 4 years newer.

The process is illustrated in Figure 5.2. 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.
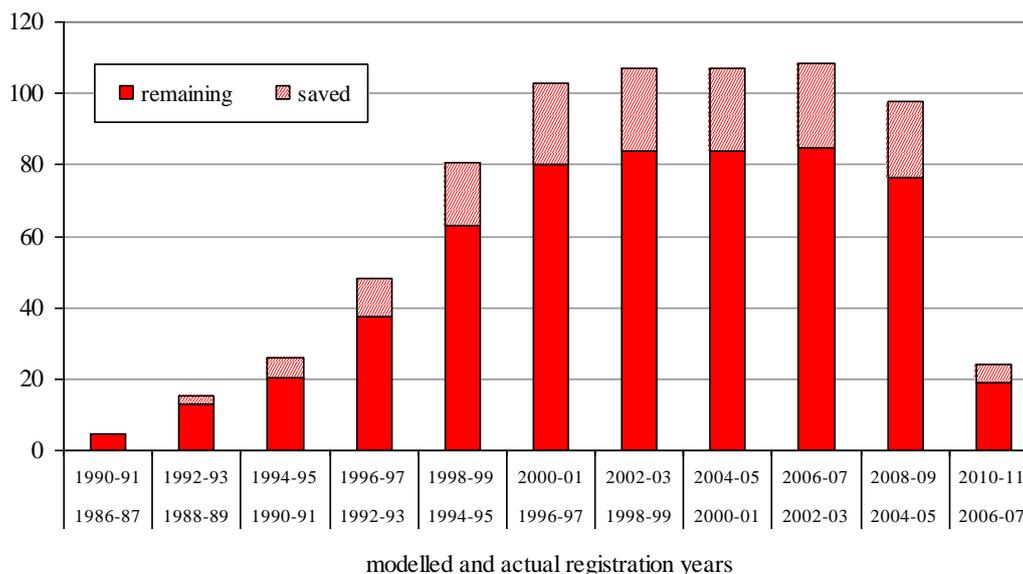
Figure 5.2 Modelled effect on driver fatalities in 2006 if all cars had been 4 years newer

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 forecast 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 b) 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. Figure 5.1 suggests that there may be no casualty reductions on BU roads beyond the level represented by 2004-05 cars (taking account of the limited statistical precision of the results for the most modern cars). The results for NBU roads suggest, however, that the rate of casualty reduction has not diminished on these roads.

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 upon the degree of confidence about the development of new cars' secondary safety between 2008 and 2010. The corresponding factor for serious casualties lies between 10.7% and 12.1%.

A.2 Predictions for 2020 and 2030

While accident data from the year 2006 were used for the example presented in the previous section, accident data from 2009 are used for the forecasts in section 3. The

following results are based on the analysis of accident data from 1989 to 2009 that was reported in the previous section.

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 5.1 demonstrated that the linear assumption made over 10 years ago has been justified, but it now appears possible that there may be no progress on BU roads beyond the level of 2004-05 cars. Even on NBU roads 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 on NBU roads in cars from the 2008-09 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(2009, 2020) to alternative assumptions about the future development of secondary safety has been tested. Each scenario assumes that

o   on BU roads there is no progress beyond the level of 2004-05 cars (this is a cautious assumption as the evidence is based on a relatively small group of accidents),

o   on NBU roads 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 2008-09 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 21 years is inevitably more speculative than forecasting over 11 years to 2020. The results for SS(2009, 2020) and SS(2009, 2030) are compared in Figure 5.3. The values for 2008-09 represent replacement of older cars by modern designs, so these benefits are pre-determined; the values for the later registration years estimate the incremental benefits expected alternative assumptions about the scope for further advances in secondary safety.
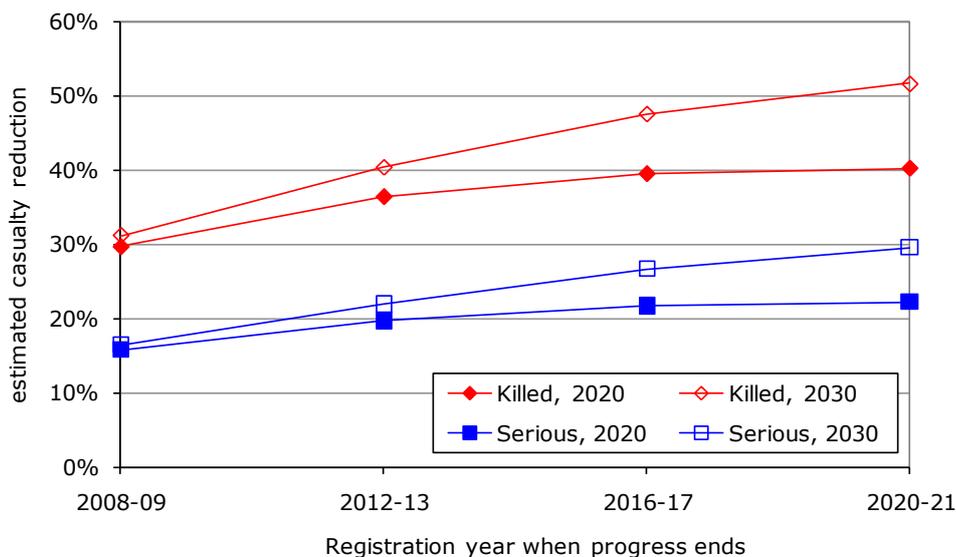
Figure 5.3 SS(2009, 2020) and SS(2009, 2030) calculated with alternative assumptions

For 2020, a scenario that appears plausible is that progress will continue at the same rate until the 2012-13 registration year. The exact trajectory is relatively unimportant; presumably progress will begin to slow before 2012. This scenario will be used for the casualty forecasting, and the precise reductions that will be used in the 2020 forecasts are 36% for killed and 20% for serious casualties, based on the 2009 accident data. Secondary safety would probably develop a little further between 2020 and 2030, to the level represented by the 2014-15 registration year, and the reductions that will be used for the 2030 forecasts are 47% for killed and 26% for serious casualties.

The most cautious forecasting scenario is that secondary safety will not improve beyond the current level, i.e. the level achieved in the 2008-09 registration year. In order to test the sensitivity of the overall forecasts to the assumption about future progress with secondary safety, section 3 also presents forecasts that are based upon this scenario. More precisely, these assume that the replacement of older cars by new cars with the 2008-09 level of secondary safety will reduce the number of car occupant fatalities by 30% and the number of serious casualties by 16% in both 2020 and 2030.

Appendix B   Sensitivity of casualty forecasts

B.1 Walking and cycling

It was explained in section 2.4 that the DfT traffic forecasts are provided only for the combination of walking and cycling. There is increasing evidence that the trends for the two modes have diverged in recent years, which makes it desirable for the casualty forecasts to reflect this divergence. The forecasts in section 3 use a central disaggregation of the DfT combined forecasts, but alternatives exist. This appendix investigates the sensitivity of the casualty forecasts for 2020 to the choice of disaggregation, based on the forecasts summarised in Table 3.2 (forecast for 2020, most plausible scenario for the development of car secondary safety, no growth in motorcycling).

Five scenarios will be evaluated, ranging from walking and cycling growing equally to strong growth in cycling combined with very little growth in walking. If the DfT forecast for the combination of walking and cycling prove to be correct, the actual outcome should lie within this range. The precise scenarios are as follows:

	Walking	Cycling	Combination	
1	13.5%	13.5%	13.5%	the scenario used previously (Broughton, 2010)
2	11.0%	25.0%	13.5%	
3	9.1%	34.0%	13.5%	the scenario evaluated in section 3
4	5.7%	50.0%	13.5%	
5	2.4%	65.0%	13.5%	

The forecasts are recalculated for each scenario, varying these parameters but keeping all others constant. The casualty reductions are listed in Table 5.1; the reductions for car occupants, motorcyclists and others are unchanged from Table 3.2 so are not included.

Table 5.1 Casualty reductions for five scenarios

Scenario	Killed			Serious casualties		
	Pedal cyclists	Pedestrians	All road users	Pedal cyclists	Pedestrians	All road users
1	39%	49%	34.2%	11%	46%	40.0%
2	32%	50%	34.1%	2%	47%	39.5%
3	28%	51%	34.1%	-5%	48%	39.0%
4	19%	52%	34.0%	-18%	50%	38.3%
5	11%	54%	34.0%	-29%	51%	37.6%

As the exposure of one mode rises, the associated increase in casualties is largely offset by the casualty reduction for the other mode resulting from the reduced exposure of that mode. The results show that the overall fatality reduction scarcely varies by scenario, but the overall reduction of serious casualties is more sensitive.

B.2 Road safety engineering

Road safety engineering is the third of the DESS measures. The casualty forecasts have assumed that the level of effect achieved over the past decade will be maintained in future, but budgetary reductions following the economic recession of 2008 and 2009 may mean that this assumption proves to be over-optimistic. The sensitivity of the forecasts to the assumption will be assessed.

Section 2.2 summarises the information about the overall effectiveness road safety engineering measures that was presented in TRL 382. The consequences of halving the effectiveness will be tested by reducing the relevant parameters by 50% with the four scenarios that lead to the forecasts summarised in Table 3.2-Table 3.5. The overall

casualty reduction forecasts for these four 'base scenarios' are shown in Table 5.2, together with the change in casualty reduction that is estimated when the effectiveness parameters are halved. The reductions forecast for 2020 are reduced by about one twentieth, while two of the four reductions forecast for 2030 are proportionately rather larger.

Table 5.2 Sensitivity of casualty forecasts to reduced road safety engineering

Original Table		Table 3.2	Table 3.3	Table 3.4	Table 3.5
Year		**2020**	**2020**	**2030**	**2030**
Growth in motorcycling		**None**	**25%**	**None**	**25%**
Casualty reduction	Killed	37%	34%	41%	38%
in base scenario	Serious	40%	37%	56%	54%
Change in casualty	Killed	-1.9%	-2.0%	-3.4%	-3.5%
reduction	Serious	-1.8%	-1.9%	-2.6%	-2.7%

Updated post–2010 casualty forecasts

TRL

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 prepares the next road safety strategy. 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 the current road safety programme will continue to develop in coming years, but that no major new measures will be introduced. The forecasts take account of the implications of the major reduction in road accident fatalities that occurred in 2009.

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.

Other titles from this subject area

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