Post Opening Project Evaluation

Meta-analysis : Safety

December 2008

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Glossary

Term	Definition
COBA	**COst Benefit Analysis** – a computer program which compares the costs of providing road schemes with the benefits derived by road users (in terms of time, vehicle operating costs and accidents), and expresses the results in terms of a monetary valuation. The COBA model uses the fixed trip matrix unless it is being used in Accident-only mode.
DfT	**Department for Transport**
Do Minimum	In scheme modelling, this is the scenario which comprises the existing road network plus improvement schemes that have already been committed.
Do Something	In scheme modelling, this is the scenario detailing the planned scheme.
KSI	**Killed or Seriously Injured**
PIA	**Personal Injury Accident.** A road traffic accident in which at least one person required medical treatment.
PIA/mvkm	PIA/mvkm is the number of **PIA**s per **million vehicle kilometres** where 'vehicle kilometres' are the number of vehicles using a section of the road multiplied by the length of the road.
POPE	**Post Opening Project Evaluation**, before & after monitoring of all major highway schemes in England.
STATS19	A database of injury accident statistics recorded by police officers attending accidents.
TPI	**Targeted Programme of Improvements**.
webTAG	DfT's website for guidance on the conduct of transport studies

1. Introduction

Overview

1.1 The Highways Agency is responsible for improving the strategic highway network by delivering schemes within the Major Schemes Programme. These schemes are subject to a detailed appraisal that includes the impact of the scheme on safety.

1.2 The appraisal of the safety impact is based upon detailed modelling techniques which produce predictions of the numbers of accidents saved and the financial benefit thereof. The modelling is based upon modelled traffic volumes on key links and national average accident rates per million vehicle kilometres by road type.

Purpose of this Report

1.3 This report is the meta-analysis of the safety evaluations of major schemes undertaken as part of Post Opening Project Evaluation (POPE) of Highways Agency Major Schemes. This analysis therefore includes major schemes which have opened since 2002 and is one of the 'daughter documents' which support the main meta-analysis report.

1.4 The main objectives of the Safety Meta-analysis Report are threefold:-

- To identify and examine the accuracy of the predictions for the change in the number of accidents, based on the POPE studies undertaken for these schemes at the stages of one and five years after opening;
- To interpret the differences between the predicted and outturn savings using evidence-based methods; and
- To provide feedback to the appraisal process by identifying any lessons that can be learnt.

1.5 This report specifically looks to address these issues and derive a series of lessons learnt and recommendations for the Highways Agency and Department for Transport (DfT) to consider as part of any revisions to the safety appraisal process.

1.6 The monetised benefits of accident savings over the appraisal period are considered separately in the Economy meta-analysis report.

Safety Modelling

1.7 After discussion with the Highways Agency TAME (Traffic Appraisal, Modelling and Economics) section, the key areas of interest for the meta-analysis of safety impacts have been identified. These are:

- How good are the predictions of the safety modelling, compared to the outturn savings?
- For schemes which have been evaluated at the One Year After and Five Years After stages, does the comparison of accident results show that predictions will get more accurate as sample time period increases? and,
- What evidence is there for any change in accident rates due to online widening?

1.8 In order to answer these questions, the individual POPE scheme evaluation reports have been reviewed in detail, however further analysis of the sample of schemes for which accident information is available has also been undertaken so that a comprehensive response to these questions can be provided.

Data Sources

Predicted Impact on Safety

1.9 The modelling of the safety impact of a scheme is done at the time of the scheme appraisal through the use of the COst Benefit Analysis (COBA) software. The COBA (COst Benefit Analysis) program compares the costs of providing road schemes with the benefits derived by road users (in terms of time, vehicle operating costs and accidents), the results of which contribute to the appraisal process. The COBA model examines the network of roads directly including the scheme under appraisal and the surrounding road network where impacts are expected.

1.10 In terms of safety, the output from the COBA model specifically provides predictions of:

- The numbers of personal injury accidents saved:
  - In the opening year;
  - In the design year; and
  - In total over the whole appraisal period;
- Predicted numbers of casualties saved over the appraisal period by severity of injury (fatal/severe/slight); and
- The predicted monetised benefit of the safety impact over the appraisal period. This is based on the monetised value of the casualty savings taking severity into consideration, and the monetised value of the accident savings including an allowance for damage-only accidents. Standard values for these savings are taken from the Department for Transport estimates of the values for prevention of road casualties and road accidents for use in the appraisal of road schemes (Design Manual for Roads and Bridges, Volume 13 – the COBA manual).

1.11 The safety evaluation in POPE considers the accident saving impact over the whole of the network as that modelled in COBA.

1.12 It is worth noting that many of the schemes covered within this meta-analysis have appraisals with COBA models dating from the late 1980s to 1990s and thus were appraised differently from current guidance. In many cases COBA was used based on a fixed trip matrix, whereas with hindsight and certainly using current guidance, variable trip modelling would have been more suitable.

Outturn Accident Impact

1.13 The POPE evaluation of the outturn safety impact of a scheme is based upon calculating the difference between the annual numbers of personal injury accidents in the period before the scheme was built and after opening. The area covered is the network modelled in COBA, not just the road directly affected by the scheme.

1.14 This Before and After data for accidents has been collected for as many key links as necessary, and have been compared with the same links within the COBA model to allow a direct comparison between the two sets of figures.

1.15 The source of the observed accident data is the STATS19 data on Personal Injury Accidents collected by the police and processed by local authorities. This is obtained for at least 3 years prior to the start of construction, and for the period following the opening of the scheme which should be at least 12 months. As far as possible, the area included is the same as that used in the original modelling.

1.16 Accident information is subject to validation by the DfT, and validated data has been used wherever possible within these evaluations. In Atkins' experience, not all accident data holders are fully aware of the process; hence there may be some occasions where unvalidated data has been used. Since this issue came to light, the approach is now to ask specifically whether the observed accident data has been validated.

1.17 It is recognised that three years is the normal minimum period for considering accident impacts; however this data is examined in the POPE One Year After stage in order to examine whether there are any emerging trends at this early stage, and whether the Major Scheme programme as a whole is delivering safety benefits, albeit using preliminary data. It is accepted that a minimum of three years of data should really be used before conclusions can be drawn with confidence on any one particular scheme, and hence the following analysis has not examined individual scheme differences, rather derived conclusions for the sample as a whole, which helps to iron out random variations.

1.18 There are a number of schemes where the safety evaluation at the Five Years After stage is available, and these have also been assessed so that accident totals are derived five years before and five years after scheme opening.

1.19 The outturn accident saving is calculated by taking the annual average number of accidents during the before period and subtracting the opening year accident total (or annual average saving for older schemes).

1.20 Note that this calculation of outturn savings does not take into account the impact of:

- The declining trend in accident rates over time, which although negligible over short timescales, can influence changing trends when considering a Five Years Before and Five Years After timescale;
- Background traffic growth; and
- Additional traffic attracted to the area from outside the modelled network. Clearly, this cannot be assessed within the model if it has not been considered, and there are many examples of schemes (as outlined in the Daughter Document on traffic issues) where much wider traffic volume changes have occurred from those modelled. While this additional traffic will increase accidents in the area studied for the outturn calculation, the redistribution of traffic from roads outside those covered by the model will contribute a small amount to accident savings on the relieved roads which is unmeasured in evaluation.

1.21 The accident modelling within COBA does allow for the first two of these, but critically for the schemes evaluated as part of POPE to date, the fixed trip model used at the time of the appraisal does not cover the scenario of significant extra traffic being attracted to the corridor from a wider area than that covered by the scheme's model.

1.22 In summary, this means that the number of vehicles in the modelled area in the do minimum and do something scenarios have generally been the same within the appraisal of the schemes, but our evaluations have suggested that traffic volume changes have often been wider than those modelled. Hence, the traffic prediction limitations in terms of model network size influence the accident predictions and outturn evaluations.

The Sample of Schemes

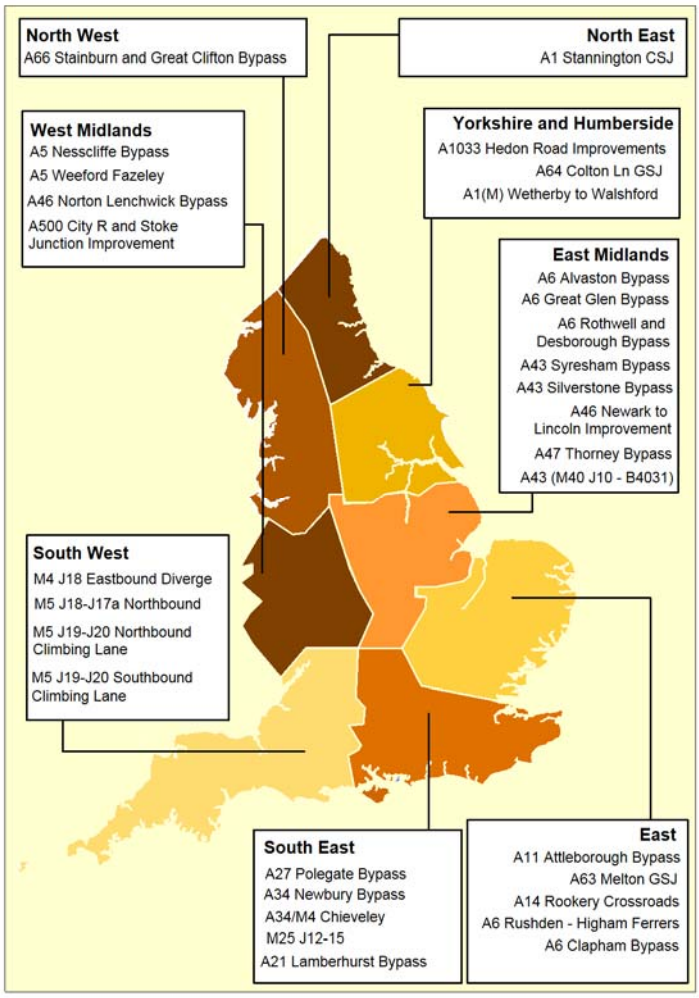
1.23 In order to evaluate the predicted and outturn accident savings, the schemes where accident information has been evaluated have been categorised into three broad groups as follows:

- Bypass and predominantly offline schemes;
- Online widening schemes; and
- Junction improvements.

1.24 For this evaluation of safety impacts, this report considers all mandatory POPE schemes evaluated since 2002 for which detailed safety modelling has been obtained, and draws information from 29 different POPE schemes.

1.25 The locations of the schemes included in the analysis are shown in Figure 1.1.

Figure 1.1 - Location of Schemes



1.26 It is mandatory within the POPE process to undertake One Year After (OYA) and Five Years After (FYA) evaluations, after the scheme has opened. However, as the POPE process only started by evaluating schemes that opened in mid 2002, there are very few schemes in the Five Years After stage where the evaluations and approval have been completed and, hence, the majority of the conclusions drawn have been related to the One Year After stage.

1.27 Table 1.1 summarises the sample of schemes that have been used within this daughter document, identified by evaluation period and by category.

Table 1.1 – Number of Schemes used in Safety Meta-Analysis

Scheme type	Number at One Year After Stage	Number at Five Years After Stage
Bypass / Offline	15	7
Online widening	6	2
Junction improvement	8	-
All	**29**	**9**

2. Findings at the One Year After Stage

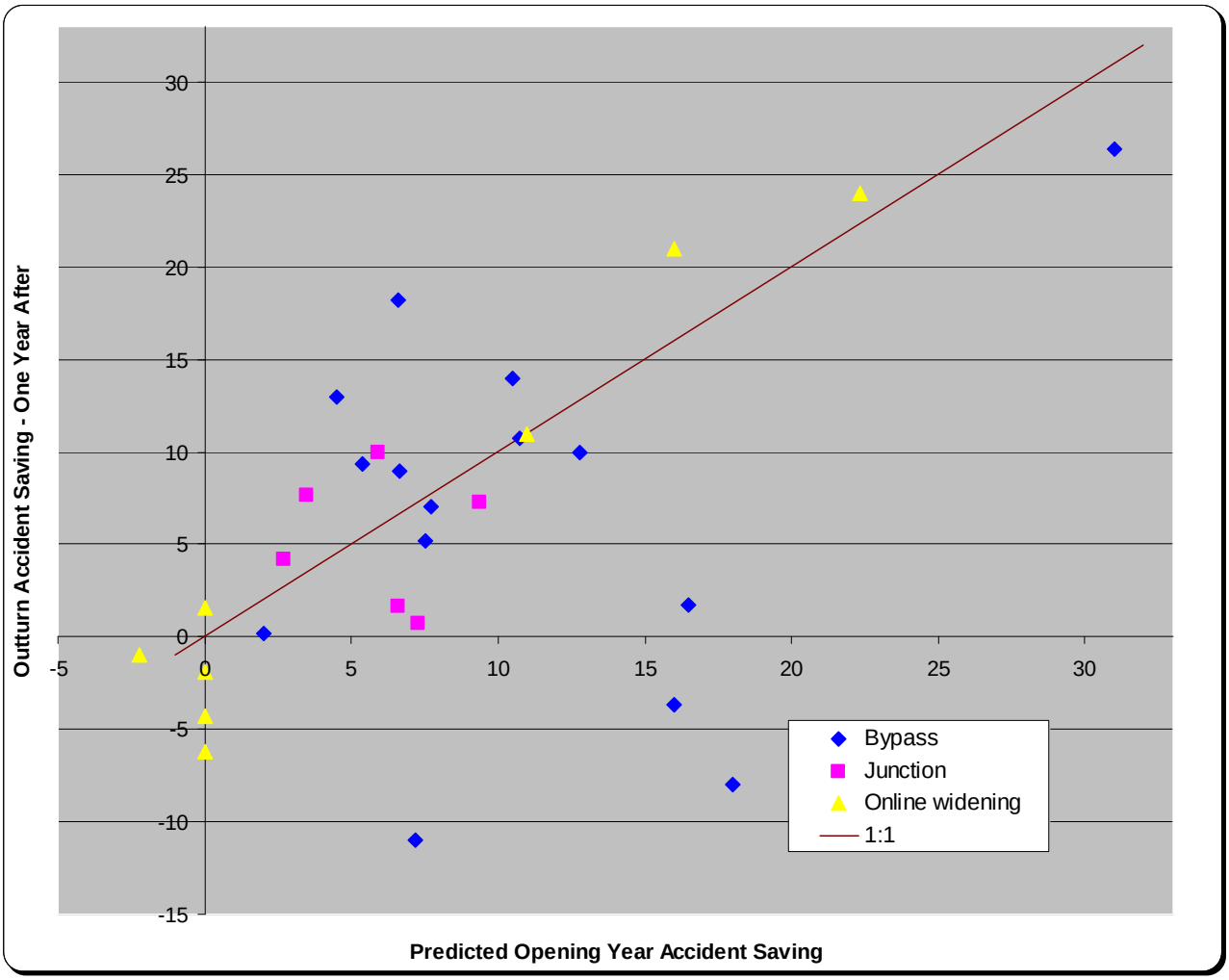
2.1 The POPE One Year After evaluations include an analysis of the outturn accident statistics in order to examine the evidence that the predicted Accident Savings are being forecast relatively accurately.

2.2 As stated earlier, three years is normally considered to be the minimum period for the analysis of accident statistics, however it is included in the POPE One Year After evaluation in order to examine whether any early trends can be identified.

Summary of Relationship between Predicted and Outturn savings

2.3 The relationship between the outturn opening year accident saving and the predicted opening year accident saving is summarised in Table 2.1, and the data for the individual schemes are illustrated in Figure 2.1 against a one-to-one trend line.

Figure 2.1 – Predicted and Outturn Accident Annual Average Saving (One Year After)



2.4 The scatter plot and one to one line show that although there is some correlation between the predicted and outturn numbers of accidents saved in the opening year, there is wide variation through the data set.

2.5 Overall, roughly half of all schemes showed outturn accident savings above the figure predicted and half below predicted, showing that there was no systematic bias in the predictions.

Table 2.1 – Summary of Accident Savings at One Year After Stage

Results based on 29 schemes	Predicted Opening Year Saving	Outturn Opening Year Saving
Total accidents saved	246	178
Mean saving per scheme	8.5	6.1
Mean difference per scheme between the predicted and outturn accident saving	-2.3 (-9%)	
95% Confidence Interval of the Mean difference per scheme between the predicted and outturn accident saving[1]	-25.9 – 10.9	
Standard Deviation of the Outturn against Predicted savings from a 1:1 relationship[2]	8.5	

2.6 There are 29 schemes for which there are predictions of the opening year saving and at least one year of post opening accident data. The key points regarding the summary shown in the table are:

- Total accidents saved in the opening year for 29 schemes is 178 which is 28% below the total of the forecast savings of 246;
- The mean annual number of accidents saved per scheme is observed to be 6.1 compared to the average prediction of 8.5 per scheme, hence on average, 2.3 fewer accidents saved per scheme are observed than predicted. However when a confidence interval is used, it becomes clear that the variability in the accident data means that this difference could easily have occurred by chance rather than through an underlying real difference; and
- The standard deviation of the outturn savings against the predicted values from a perfect 1:1 relationship between the two is 8.5. This figure also indicates a poor fit of the outturn data against the predicted as shown by the scatter of the points against the 1:1 line in Figure 2.1.

2.7 At this stage, the important question is why have accident savings for many schemes been less than forecast? There are a number of reasons why this discrepancy could have occurred and these are discussed below and in much greater detail in the Daughter Document on Traffic Impacts:

- Additional traffic drawn into the corridor over and above that modelled within the predictions; and
- Further development or changes to road network. Many of the early schemes evaluated under POPE were originally modelled in the late 1980s/early 90s and were based on fairly simplistic models. Clearly, a gap of 15 to 20 years could include many developments which were not foreseen. For example, the POPE evaluation of the worst performing scheme here[3] suggests that the increased accidents are likely to be a result of the complexity of additional junctions added on the route, which were not modelled, as well as strategic reassignment issues that were not modelled within the forecasts.

[1] To avoid making an assumption that the underlying distribution of the differences is normal, an approximation of the distribution has been used based on using linear interpolation of a binned frequency distribution with bin size 6. This has been used to calculate the 95% Confidence Interval.

[2] Given by the formula : $\sqrt{\frac{\sum_{n}(x-y)^2}{n}}$ where x and y are the predicted and outturn opening year savings and $n=29$

[3] A43 M40 –B4031 Dualling. Junctions were added to the A43 to provide access from the M40 J10 to the motorway service station.

Comparison of Accident Savings by Scheme Type at One Year After Stage

General points

2.8 Clearly, the importance of safety in the scheme objectives, and the magnitude of the accident savings possible vary considerably. For the purpose of this evaluation, schemes have been grouped into bypass (i.e. the scheme is primarily offline), junction (primarily online) and online widening (all or primarily online), as shown earlier in Table 1.1.

2.9 Figure 2.1 shows the scatter of the relationships between predicted and outturn accident savings in the opening year by scheme type against a 1:1 relationship trend line. The key statistics summarising the accident savings data by scheme type above are given in Table 2.2.

Table 2.2 – Accident Savings at One Year After Stage by Scheme Type

Type	No.	Number of Schemes at or Above Predicted	Standard Deviation of Ratio of Predicted-Outturn from 1:1	Total of Predicted Opening Year Savings	Total of Outturn Opening Year Savings	% Diff between Total Predicted and Outturn Savings
Bypass	15	6	11.2	162	102	-37%
Junction	6	3	4.3	35	31	-11%
Online widening	8	5	3.4	47	44	-6%
All types	**29**	**14**	**8.5**	**246**	**178**	**-28%**

Bypass schemes

2.10 The majority of evaluated schemes can be categorised as bypasses. All but one of these schemes involved the bypassing of a single carriageway A-road and, for the majority, the new road is of dual carriageway standard. Due to the very nature of bypass schemes it is common for safety to be an important objective when they are appraised, and thus it is expected that the highest numbers of accidents saved both in the predicted and outturn data, should be for bypasses.

2.11 Key points regarding the evaluation of the safety impacts of bypass schemes are:

- The majority of bypass schemes showed savings below those expected in the opening year;
- Bypass schemes account for the majority of the total opening year predicted and outturn accident savings;
- The total outturn saving, however, is only two-thirds of the total predicted saving; and
- As shown in the graph, the accident savings for bypass schemes show a wide scatter of predicted and outturn results. The statistic of the standard deviation of the results from a perfect prediction as shown by the 1:1 relationship line in the graph, also shows that based on the available data there is a poor correlation between the predicted and outturn accident savings in the opening year.

Junction improvement schemes

2.12 This accident analysis includes six schemes which are categorised as predominantly junction improvements. All are on A-roads, although one is part of a junction with a motorway.

2.13 As shown in the economy report, junction improvement schemes are generally of a smaller scale than other major schemes. Thus, although safety may be an important objective of the scheme, the predicted accident savings are likely to be lower than the average savings for bypass schemes.

2.14 Key points regarding the evaluation of the safety impacts of junction schemes are:

- Overall, the total outturn savings from these schemes is close to the total predicted, with half performing better than predicted and half worse; and
- The magnitude of the savings per scheme for a single year are generally quite low, averaging around eight per scheme, hence, the expected accident changes for individual schemes are insufficient to expect a statistically significant result. Therefore, the only important figure for meta-analysis of the safety of junction schemes at the One Year After stage is the total saving for all six schemes. This overall figure is approximately as predicted.

Online widening schemes

2.15 Online widening schemes include upgrades of single carriageway A-roads to dual carriageway (3 schemes), urban four lane A-road to dual carriageway (1 scheme) and motorway widening (5 schemes)[4].

2.16 The DfT publishes standard accident rates expected for different types of road. These are expressed as PIA per million vehicle kilometres. The modelling for the widening of single to dual carriageways predicts accident benefits using these rates.

2.17 Under current accident appraisal guidance, the default accident rate for motorways and dual carriageways with three or more lanes are the same as for the equivalent two lane road type. This means that if the scheme is modelled using default rates, simply adding a lane does not result in the model giving a prediction of net accident saving. This has been the case for the four motorway schemes evaluated here for which a COBA was obtained. For such schemes to achieve measured safety benefits, the appraisal approach should have adopted observed accident rates for the Do Minimum and COBA default rates for the Do Something, and this could provide accident benefits for the widened section, but also accident savings from the wider network, i.e. roads experiencing traffic reductions should also be assessed. This approach has NOT been adopted in the sample of schemes that looked at so far within POPE, and the POPE evaluations have shown that accident benefits have not been considered or have been predicted to be minimal.

2.18 It should be noted that the scheme with a prediction of a negative saving, i.e. an increase in the number of personal injury accidents (A11 Attleborough widening from single carriageway to dual carriageway), is forecast to be beneficial in safety terms overall due to a reduction in accident severity caused by the expected removal of head-on and right-turn accidents, hence the monetised safety benefit over the full appraisal period is positive.

2.19 There is particular interest in the evaluation of online widening schemes and thus a more detailed analysis of the POPE findings at the One and Five Years After stages of these schemes is given in Table 2.3, which shows:

- In line with accident modelling guidance on accident rates, upgrading from single to dual carriageway shows clear statistical evidence of an improvement in safety;
- It is not possible to draw any conclusions about the safety impact of motorway climbing lanes based on a single year of post opening data, as all available examples shown indicate insignificant changes in accident numbers. This is also consistent with current guidance; and

[4] Including M25 J12-15 which was excluded from the main OYA analysis shown in Table 2.2 analysis due to the large differences in results depending on area chosen,. The scope of the safety model is not known because the COBA model was not obtained. The AST states that safety effect is minimal.

- There is evidence from the evaluation of the M25 J12 – J15 scheme that widening to five and six lanes can have safety benefits in the first year in the area widened, but also demonstrates that the widened section should not be considered in isolation.

Table 2.3 – Evidence of Safety Impact of Online Widening at the One Year After Stage

Scheme name	Description	Observed Accident rate (PIA/mvkm)[5]		Number of accidents saved		Statistically significant saving?
		Before	After	Predicted	Outturn	
A11 Attleborough Bypass Improvements	Online dualling of 5km of single carriageway with existing GSJ	0.08	0.09	-2	-1	No
A11 Roudham Heath – Attleborough Improvements	Mostly online dualling of 10km rural single carriageway	0.12	0.02	22	24	Yes – clear evidence[6]
A46 Newark to Lincoln Improvement	Mostly online dualling of 13 km rural single carriageway	0.21	0.08	11	11	Yes – clear evidence
A1033 Hedon Rd Improvement	Upgrading of 6.7km of 4 lane urban road to dual carriageway	0.71	0.38	16	21	n/a
M25 J12 – J15[7]	Motorway widening (from 4 to 5 lanes J12 – J14, 6 lanes J14 – J15, through jcts: 3 to 4 lanes)	0.14 (J12 – J15) 0.13 (J10 – J16)	0.11 (J12 – J15) 0.13 (J10 – J16)	'minimal'	36 (J12 – J15) -18 (J10 – J16)	Yes for J12 – J15 but worsening accident rates up and downstream mean that overall J10 – J16 there is no change
M4 J18 eastbound diverge	Motorway climbing lane and widened diverge (3 to 4 lanes)	0.13	0.09	none	1.6	No
M5 J18a– J17 Northbound	Motorway climbing lane (3 to 4 lanes)	0.15	0.30	none	-6.2	No
M5 J19 – J20 Northbound Climbing Lane	Motorway climbing lane (3 to 4 lanes)	0.09	0.16	none	-4.3	No
M5 J19 – J20 Southbound Climbing Lane	Motorway climbing lane (3 to 4 lanes)	0.09	0.12	none	-1.9	No

[5] PIA/mvkm is the number of personal injury accidents per million vehicle kilometres. These figures here are for the route directly affected, not the whole network. Unlike the absolute accident saving figures, these rates takes into account traffic growth.
[6] Five Year After study also shows statistically significant savings.
[7] M25 J12 – J15 scheme is not included the main OYA analysis due to the modelled area being unknown and large differences in outturn results depending on area chosen.

Key Findings

The question was to assess how well the safety impact of schemes was being predicted during the appraisal process by determining the accuracy of their model predictions for the opening year over the whole model network and not just the road itself, i.e. how the outturn accident saving for a scheme compared to that predicted.
The key findings show that:

Overall prediction accuracy

- The 29 schemes show a wide variation of success in the actual safety improvement in the opening year compared to the forecast. Hence, the conclusion is that the One Year After data shows that the predictions from the safety modelling of the opening year saving show poor correlation with the outturn data. This may be due to weakness in the modelling of schemes or that the observed changes seen in the first year are not indicative of the long term trend in accident rates;
- Roughly half of the schemes included were performing better than expected and half worse;
- Overall, a total saving of 178 accidents is attributed to the impact of these schemes in their opening year, averaging 6.1 per scheme, compared to a predicted saving of 246 accidents, averaging at 8.5 per scheme; and
- Savings are on average 9% or 2.3 accidents below opening year predictions.

Bypass schemes

- Bypass schemes show wide variability between the magnitude of accident savings predicted and the actual outturn figure. In general there seems to be little correlation between predicted and outturn figures for the opening year, hence the possible reasons outlined in the first bullet point above equally apply;
- Due to their very nature, bypass schemes tend to have higher predictions of accident benefits than other types of schemes, but 60% of the outturn accident savings are below the prediction; and
- Overall outturn accident savings are about a third lower than predicted.

Junction improvements

- Taken as a whole, junction schemes are performing as expected;
- However, on an individual scheme basis, there seems to be almost no correlation between predicted and outturn figures for the opening year; and
- The predicted and outturn accident savings are generally lower than the average savings for bypass schemes.

Online widening

- There is some evidence that online widening forecasting accuracy is good;
- There is clear statistical evidence of the success of online widening for rural single carriageways upgraded to dual carriageway;
- There is insufficient data at this stage to draw any conclusions regarding the safety impact of motorway widening, including motorway climbing lanes; and
- M25 J12 – J15 shows that widening to five and six lanes showed significant benefits in the opening year directly on the widened section. However it may have had a negative effect on safety on the adjacent sections of motorway, resulting in no net safety impact.

3. Findings at the Five Years After Stage

Overview

3.1 The meta-analysis of the POPE safety evaluations at the Five Years After stage has two aims:

- To compare annual savings in the first five years with the forecast; and
- To analyse whether the annual rate of savings after five years is closer to the prediction than the outturn in the opening year.

3.2 At this stage, there are two Five Years After studies which were completed for pre-TPI schemes and therefore have no One Year After study. There are currently seven schemes at the Five Years After stage of POPE that have previously been evaluated at the One Year stage. None of the Five Years After reports for these latter schemes have been finalised, hence the results presented here should be considered as provisional.

3.3 It should be noted that the results of the COBA modelling of the accident saving does not give year-by-year predictions of the accident savings for the years following the opening year. However it does give a prediction for the design year, which represents the situation 15 years after opening, i.e. the opening year +14. Major schemes are expected to have long term impacts and it is normally the case that the forecasts of the numbers of accidents saved in the opening year and design year are only slightly different, and hence for the purpose of this meta-analysis, it is assumed that the forecast annual saving for the first five years is identical to that for the opening year saving.

Outturn Savings at Five Years stage compared to predicted

Summary of overall savings

3.4 Due to the small number of schemes at the Five Years After stage, the analysis has not been split by scheme type as with the One Year After analysis. From the schemes that were available, the comparison between the opening year accident saving for the scheme as forecast by the model and the average annual accident saving is shown in Figure 3.1 and summarised in Table 3.1.

3.5 The graph in Figure 3.1 indicates that the comparison for one of the schemes (A43 Dualling[8]) is an outlier. There are good explanations for this finding; hence it has been excluded from the data presented in the summary.

[8] A43 M40 – B4031 Dualling. This scheme was the dualling of 6.5km of A43 and improvements to the M40/A43 junction including access from the M40 J10 to the motorway service station. POPE evaluation of suggests that the increased accidents are likely to be a result of the complexity of additional junctions added on the route, which were not modelled, as well as strategic reassignment issues that were not modelled within the forecasts.

Figure 3.1 – Predicted and Outturn Annual Average Accident Saving (Five Years After)

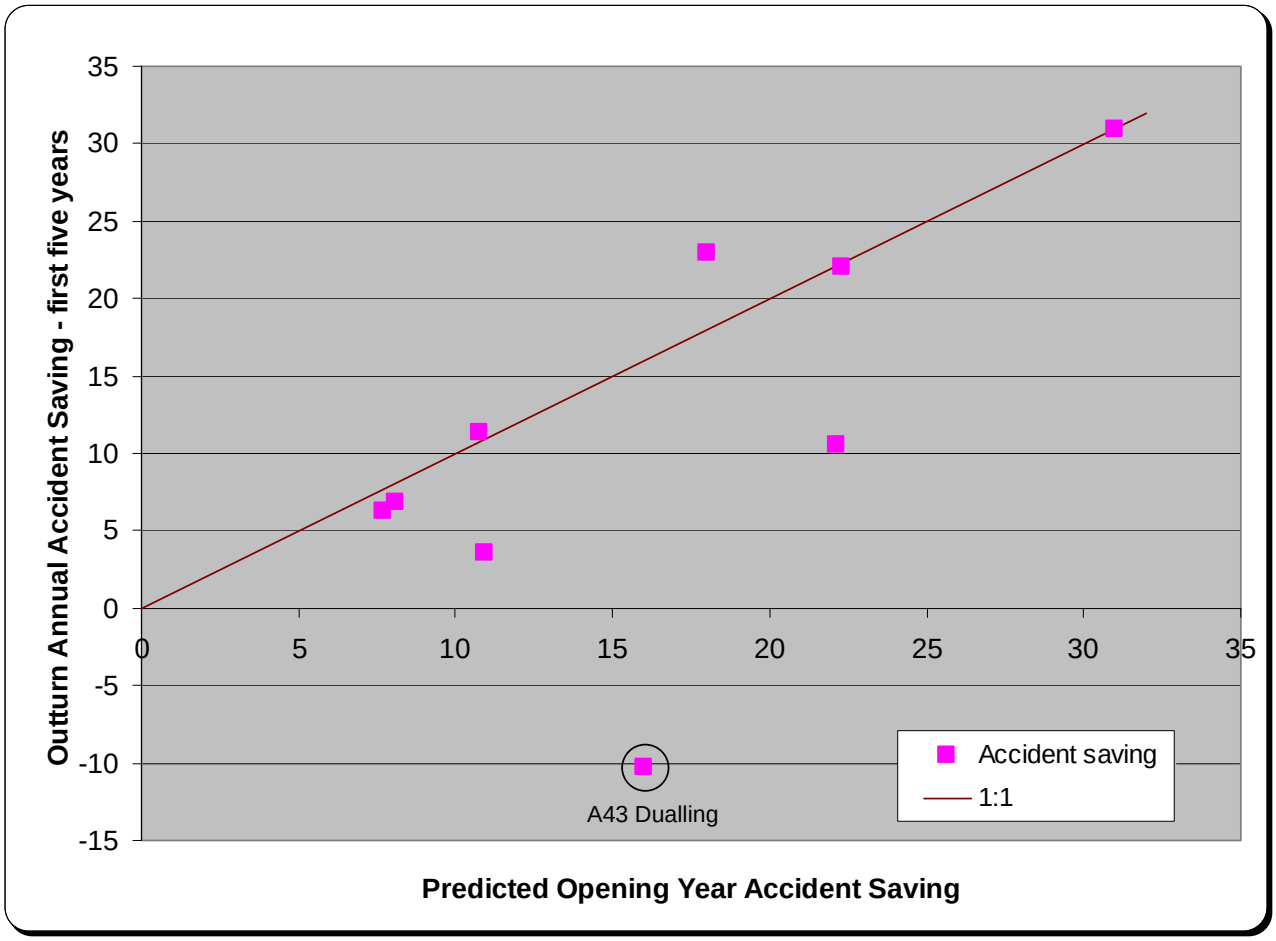


Table 3.1 – Summary of Annual Accident Savings at Five Years After Stage

Results based on 8 schemes (excludes outlier)	Predicted Opening Year Saving	Outturn Average Annual Saving in first Five Years
Total annual accidents saved	130.9	114.7
Mean per scheme	16.4	14.3
Mean percentage difference per scheme between the predicted and outturn accident saving	-15%	
Standard Deviation of the Outturn against Predicted savings from a 1:1 relationship	5.2	

3.6 Excluding the outlier, the key points from the scatter graph and summary above are:

- Five schemes had annual accident savings close to the predicted number, one was better and two worse;
- Two underperforming schemes had outturn savings that were a lot lower than predicted resulting in the total annual accident saving of 115, 12% below the total predicted;
- Visually, there appears evidence of correlation between the forecast and outturn saving shown in Figure 2.1; and
- The key finding is that, based on this set of schemes, the results for the Five Years After evaluations are closer to the predictions than at the One Year After stage. This is found by

comparing the standard deviation from the 1:1 line for the Five Years After figures with that for the one year after figure shown in Table 2.1.

Improvement of accuracy of accident savings forecast over time.

3.7 It could be expected that given the random variations of the occurrence of accidents, the annual average saving from the Five Years After data would be more accurate than the data available at the One Year After stage. Indeed, guidance recommends that 3 – 5 years of accident data are required for robust assessment.

3.8 To analyse the validity of this hypothesis, for all schemes which have been evaluated under POPE at both the One and Five Years After stages, the predicted accident savings have been compared to the outturn results for one year and the annual average at five years. The results are illustrated in Figure 3.2 and summarised in Table 3.2. Note that as in the previous sub-section the A43 outlier has been omitted from the summary statistics.

Figure 3.2 – Predicted Accident Savings Compared to Outturn at One Year and Five Year After Savings

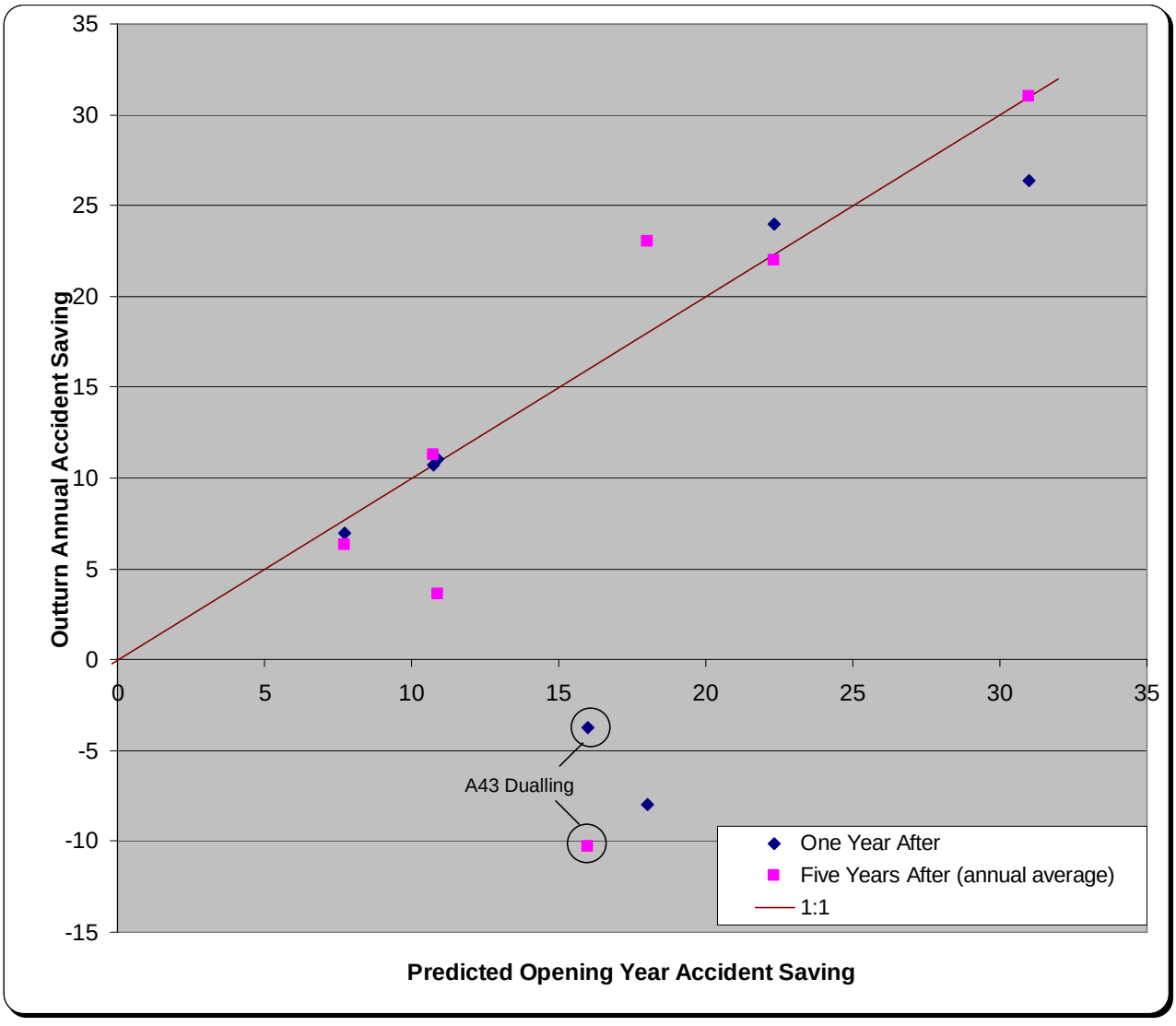


Table 3.2 – Summary of Annual Accident Savings: One Year After Compared to Five Years After Stage

Results Based on 6 Schemes (excluding outlier)	Predicted Opening Year Saving	Outturn Opening Year Saving	Outturn Average Annual Saving in First Five Years
Total accidents saved	100.7	71.1	97.2
Mean	16.8	11.9	16.2
Standard Deviation of the Outturn against Predicted savings from a 1:1 relationship		10.8	3.7

3.9 For the six schemes which have been evaluated at the One Year and Five Years After stages, the key points from the scatter graph and summary above are:

- There is an improvement in the observed number of accidents saved per year in the Five Years After compared to the opening year,
- After five years, the outturn annual saving is close to that predicted; and
- The standard deviation of the outturn against predicted savings from a perfect 1:1 match indicates that for these six schemes, the accident saving prediction becomes more accurate over time.

Key Findings

The main question addressed by the meta-analysis of the Five Years After data was whether prediction accuracy improves over time:

- Based on a fairly small sample of schemes which have been evaluated both at the One and Five Years stages, the accuracy of the forecast of accident savings over the early years does seem to improve over time, in that the Five Years After comparison with predicted is closer than the One Year After; and
- After five years, the total savings are close to those predicted.

4. Conclusions and Recommendations

Overview

4.1 This section provides a summary of the conclusions and emerging recommendations from this safety impact report. The main areas of assessment were:

- Lessons learnt on data availability;
- How good are predictions of accident savings?
- What conclusions can be drawn regarding online widening accident changes; and
- Is a One Year After evaluation of accidents unreliable?

4.2 The answers on these areas of assessment are for the Highways Agency to consider as part of revisions to the appraisal process.

Data Availability

4.3 The schemes subject to evaluation opened from 2002 onwards, however the appraisal or justification of these schemes was undertaken in the 1990s, well before POPE started. Therefore the evaluation team were dependent on the original appraisal material and reports being available, and this was not always the case.

Key Findings on Data Availability

- The POPE process has helped to archive important appraisal reports and computer programs. In the case of accident evaluation, it is important to have access to the scheme COBA, and this is now undertaken as a matter of course;
- Accident data is generally well-recorded, with excellent detail recorded in the STATS19 data; and
- There is uncertainty within organisations over the use of unvalidated and validated accident data.

How good are the predictions in accident savings?

4.4 This question required a full assessment of whether a scheme has performed as predicted in terms of accident savings. In order to evaluate this, the following measures have been adopted to address this for all schemes:

- The assessment of accident savings has concentrated on the total sample, rather than looking at individual results;
- The mean number of accident savings per scheme are also reported; and
- The Standard Deviation of the outturn compared to the predicted accident savings against a 1:1 line gives information on overall correlation.

4.5 A total of 29 schemes were considered in the analysis, and these were categorised into bypass, online widening and junction improvement schemes.

Key Findings on Prediction Accuracy

- The 29 schemes included in the analysis at the One Year After stage show outturn accident savings vary significantly against the predicted levels in the opening year compared to the forecast. The total outturn accident saving is 28% lower than the predicted levels in the opening years;
- Overall, roughly half of all schemes showed outturn accident savings above the figure predicted and half below predicted showing that there was no systematic bias in the predictions;
- When disaggregating the results by scheme types of bypass, online widening and junction improvements, the correlation between outturn and predicted accident savings is still weak for bypass and junction schemes. The total number of accidents saved are similar to the predicted levels for both online widening and junction improvement schemes whereas bypass schemes have an overall saving of a third less than predicted;
- Online widening does show good correlation between outturn and predicted levels of accident saving, although this is partially due to the low predictions for motorway schemes;
- The overall conclusion however, is that the evaluation of accident savings one year after scheme opening indicates that the predictions show poor correlation with the outturn data;
- The reasons for the differences may be due to many factors including;
  - Accidents are inherently random and hence need a large sample in order to draw firm conclusions;
  - The outturn accident saving is based on the comparison of the average number of accidents in the three years before compared to the opening year. Scheme models are based on accident data from earlier years, in some cases dating back to the 1980s, and hence the accident comparison will not be from the same years;
  - There may have been other safety measures e.g. speed reduction schemes or weight restrictions etc. installed in the period between that used as the accident statistics in the appraisal of a scheme and the before period used in the POPE evaluation. This would appear likely where safety was recognised as a serious problem and/or there was a lengthy time gap between appraisal and scheme construction;
  - Accident predictions for many schemes evaluated here were based on COBA fixed trip models, this means that the number of vehicles in the modelled network in the do minimum and do something scenarios is the same. The outturn accident savings are based on the annual number of accidents before and after. The traffic analysis has shown that for some of these schemes there is more traffic in the network used in the traffic and accident modelling following scheme opening than before; more than can be accounted for by background traffic growth, and invariably the reassignment into the corridor has been wider than the appraisal model that has been used;
  - Modelling for the opening year impact does not take into account the ramp-up period during which users adapt to the new road layout and which may be prone to accident rates not typical of the long-term trend. Further POPE evaluation of schemes at the Five Years After stage will lead to a bigger sample to verify this finding, and help to quantify; and
  - For one scheme with a negative accident impact, the evaluation area was by necessity very wide, so during the time frame analysed, there could have been other changes occurring across the town which resulted in an increase in accidents[9] .

[9] A27 Polegate Bypass combined with the local authority scheme A22 New Route has modelled impacts across Eastbourne

Do predictions get more accurate over time?

4.6 This question was addressed by analysing the results from the set of schemes for which outturn and predicted accident savings were available for both the One Year After and Five Year After stage.

4.7 Only six schemes fulfilled these criteria. From these the key findings on improvements in accuracy have been:

- A sample of only six schemes was available whereby outturn and predicted accident savings were available for both the One Year After and Five Year After stage;
- Analysis of the small number of schemes which have been evaluated at both the One Year and Five Years After stages, does suggest that predictions of accident savings do get more accurate over time; and
- From the sample, the outturn average annual saving increases compared to the one year data and more closely reflects the predicted values, and in addition the statistical variation as measured by the standard deviation from the 1:1 correlation between predicted and outturn saving is significantly better than for the One Year After scenario.

What evidence is there for any change in accident rates due to online widening?

4.8 From a sample of nine schemes which are entirely or predominantly online widening, there have been the following findings:

- Widening of rural single carriageway A-roads show significant outturn benefits in the first year for two schemes and hence appears to be reasonable to use improved accident rates as per guidance, although the sample is still small, hence this conclusion will be subject to continual review as more relevant schemes are evaluated;
- It is too soon to be able to identify the safety impact of motorway climbing lanes. The schemes analysed here were forecast to have no accident savings and initial findings have been consistent with that forecast; and
- M25 J12 – J15 shows that widening to five and six lanes showed, in this case, significant benefits in the opening year directly on the widened section. However, with additional traffic in the corridor, there has been a negative effect on safety on the adjacent sections of motorway, resulting in no net safety impact.

Recommendations

Accident Data and Reporting

- Archiving of key documents and COBA files should be maintained, with all scheme consultants fully aware of the requirement to do this. The scheme COBA model is critical to the evaluation of accident savings, as this ensures the same links are compared as where outturn accidents are available, and COBA will continue to be used for the calculation of predicted accident benefits, even though TUBA is now used for calculation of other economic benefits;
- Clarity is required on the use of validated data for the post opening period, and advice more widely publicised.

Safety Issues

- Care should be exercised in comparing accident savings and rates on individual schemes one year after opening, as there is currently poor correlation between outturn and predicted levels, however the outturn and predicted accident changes do reflect the same pattern and therefore there is continued merit in looking at accidents at the One Year After stage;
- Meta-analysis of the results from all scheme evaluations shows that, the opening year savings tend to be below that predicted. One of the key reasons for this in many cases is that the model network when the scheme is appraised was insufficiently wide to take all reassignment into the corridor into account. The POPE evaluation is based on the same network as the original appraisal, and hence the recommendation for improving this is similar to improving the accuracy of the traffic forecasts, i.e. all likely roads where traffic volume changes are likely to happen should also be considered for accident changes;
- The total outturn accident savings at the One Year After stage are 28% below predicted, over the set of 29 schemes, while for eight schemes at the Five Year After stage, the total outturn savings were only 12% below forecast. This evidence of improved accuracy over the longer period shows that it is important to refine further these conclusions as more Five Years After evaluations are completed;
- Current guidance recognises the need to consider how the forecasting of accident savings can appropriately deal with extra traffic being attracted to the corridor. Findings from POPE meta-analysis have emphasised the importance of using a sufficiently wide and detailed area in the model for routes where strategic (and local) re-assignment is likely to be an issue. However this may not be appropriate or cost effective in all cases[10], but the limitations of a reduced network should be recognised in determining likely accident benefits;
- Casualty reduction is an important objective for the Highways Agency, as set out in the Government's 2010 KSI casualty reduction target. Although POPE does evaluate casualty impacts of schemes, there is no forecast of opening year casualty saving hence this meta-analysis has not considered this. As it would be useful for the POPE meta-analysis to provide input into how the major schemes are contributing to this target, consideration should be made for COBA to produce an output of opening year casualty saving forecasts rather than just for the whole appraisal period. At present, opening year accident savings are obtained, but as severity splits vary by road type, it is not an easy calculation to derive first

[10] As detailed in the traffic report, the A43 corridor has much higher traffic flows than predicted and this is believed to be re-routeing motorway traffic. Clearly the extra traffic is likely to reduce the accident savings in this corridor but as this traffic only makes up a tiny proportion of the traffic on the M1 or M40, it is not possible to identify whether there is a corresponding change in accident numbers on the motorways.

year casualties unless the COBA is re-run with the appraisal period set to one year, i.e. the Last Scheme Year is set to the First Scheme Year;

- Motorway climbing lanes schemes have been appraised using default accident rates rather than observed data as in the current guidance. This results in no safety benefits being forecast despite safety being an objective. ;
- Although evidence from this meta-analysis does not indicate at present that there should be a change to the default accident rates for online widening schemes within current guidance, there is a need for continued study of the accident rates on widened trunk roads and motorways to confirm this when a larger sample is available.

Appendix A

List of Schemes used for Safety Meta-analysis

Table A.1 – Schemes used in Safety Analysis

Scheme	Results used
A1 Stannington Grade Separated Junction	1 yr
A1(M) Wetherby to Walshford	1 yr
A1033 Hedon Road Improvements	1 yr
A11 Attleborough Bypass Improvements	1 yr
A14 Rookery Crossroads	1 yr
A21 Lamberhurst Bypass	1 yr
A27 Polegate Bypass	1 yr & prelim 5yr
A34 Newbury Bypass	5yr only
A34/M4 J13 Chieveley	1 yr
A41 Aston Clinton Bypass	1 yr
A43 M40 –B4031 Dualling	1 yr & prelim 5yr
A43 Silverstone Bypass and Syresham Bypass	1 yr & prelim 5yr
A46 Newark – Lincoln Improvement	1 yr & prelim 5yr
A46 Norton Lenchwick Bypass	5 yr only
A47 Thorney Bypass	1 yr
A5 Nesscliffe Bypass	1 yr
A5 Weeford – Fazeley Improvements	1 yr
A500 City Road and Stoke Junction Improvement	1 yr
A6 Alvaston Bypass	1 yr
A6 Clapham Bypass	1 yr & prelim 5yr
A6 Great Glen Bypass	1 yr & prelim 5yr
A6 Rothwell and Desborough Bypass	1 yr
A6 Rushden and Higham Ferrers Bypass	1 yr
A63 Melton Grade Separated Junction	1 yr
A64 Colton Lane Grade Separated Junction	1 yr
A66 Stainburn and Great Clifton Bypass	1 yr
M4 Jn 18 Eastbound Diverge	1 yr
M5 J18a – J17 Northbound Climbing Lane	1 yr
M5 J19 – J20 Northbound Climbing Lane	1 yr
M5 J19 – J20 Southbound Climbing Lane	1 yr