Ministry of Transport
TE MANATŪ WAKA

Evaluation of Road Safety Outcomes to 2005

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CORPORATE FINANCE & ECONOMIC EXPERTISE

Contents

EVALUATION OF ROAD SAFETY OUTCOMES TO 2005

1. Introduction and Summary

1.1 This report updates and develops the analysis undertaken for the Ministry of Transport (MOT) (acting on behalf of the National Road Safety Committee) in the November 2004 "Initial Evaluation of Road Safety to 2010 Strategy" report by Taylor Duignan Barry Limited and Parker Duignan Limited.

1.2 This updated report analyses the outcomes achieved by the implementation of the Safety Administration Programme (SAP) aspects of the Road Safety to 2010 strategy as at the mid-point of that strategy i.e. 2005. In accordance with the specifications for the November 2004 report, the focus is on enforcement and compliance measures and the analysis of the interventions is based on the Police and Land Transport New Zealand road safety output classes as detailed in the annual SAP statement.

1.3 Land Transport New Zealand (Land Transport NZ) was formed in late 2004, by the merger of the Land Transport Safety Authority (LTSA) and Transfund. Land Transport NZ now undertakes the road safety operational activities previously undertaken by LTSA. Road safety policy and research functions were transferred to the Ministry of Transport at the same time.

1.4 In this report the contraction "LTSA/Land Transport NZ" is used to refer to either or both of LTSA and Land Transport NZ in regard to operational activities previous undertaken by LTSA up until late 2004 and these activities previously undertaken thereafter by Land Transport NZ.

1.5 Similarly, the contraction "LTSA/MOT" is used to refer to either or both of LTSA and the Ministry of Transport in regard to policy and/or research previously undertaken by LTSA.

1.6 In order to assess the effectiveness of the enforcement and compliance measures, the contributions of two other factors to road safety also need to be considered, namely, the safety benefits of road engineering projects and vehicle crashworthiness improvement. Therefore estimates of the contributions of these factors are discussed in the relevant sections of this report.

Methodology

1.7 Section 2 of this report discusses possible methodologies for analysis of the contribution of expenditure under the SAP to road safety outcomes. The methodology adopted is based on comparing SAP expenditure with compliance and enforcement outcomes (e.g. mean vehicle speeds) and road fatalities and injuries. Generally, the analysis is based on a comparison of the average outcome for 1997 to 1999 with the outcome for calendar 2005 (or in some cases 2004/05). This summary reports data based on this comparison.

Outcomes

1.8 The increase in SAP expenditure over the comparison period was around 36% in dollar terms, but only around 12.4% when adjusted for cost inflation applying to the specific resources financed by the SAP which increased significantly faster than general inflation. The expenditure increase was used to finance a substantial increase in enforcement activity, with offence notices ("tickets") issued by Police officers increasing by 72% (while speed camera tickets decreased).

1.9 Compliance outcomes i.e. speed, drunk driving incidence and use of restraints (seat belts), improved substantially. Surveys record that the proportion of vehicles exceeding 110kph (i.e. the enforced limit) on the open road fell from around 20% to 5% and seat belt use increased from 87% to 95% for adult front seat passengers and from 58% to 86% for adult rear seat passengers. The following table indicates that the compliance outcomes for 2005 were better that the targets set for 2004 in the Road Safety to 2010 Strategy.

Table 1: Intermediate Outcomes

Intermediate Outcomes	**Avge 97-99**	**2001**	***Target 2004***	**2005**	**Chg 97/99-05**
Speed, rural winter mean km/hr	101.8	100.2	***99***	**97.1**	-4.7
Speed, % exceeding 110 km/hr	20%	13%	n/a	**5%**	-15 (% pts)
Speed, rural winter 85th pctile km/hr	113	109	***107***	**104**	-9.0
Speed, urban mean km/hr	55.6	54.9	***55.2***	**52.4**	-3.2
Speed, % exceeding 60 km/hr	22%	18%	n/a	**7%**	-15 (% pts)
Speed, urban 85th pctile	62	61	***61***	**58**	-4.0
Alcohol surveyed % over limit	2.0%	1.2%	n/a	**<1%**	
Seat belts (adult): front	87%	92%	***92%***	**95%**	8 (% pts)
Seat belts (adult): rear	58%	70%	***75%***	**86%**	28 (% pts)
Children restrained: 0-14, all	88%	89%	***90%***	**94%**	6 (% pts)

1.10 In order to assess the road safety outcomes achieved two adjustments are required, firstly to take into account the growth of population, traffic volumes and registered vehicles and secondly to take into account the contribution of road engineering and vehicle improvements.

1.11 Section 4 of the report presents outcomes regarding fatalities, injuries and social cost of crashes adjusted for each of the growth factors listed. Adjusted for the most relevant factor - billion vehicle kilometres travelled (BVKT) - fatalities fell by around 30%, while hospitalisations (of more than one day) and total hospital bed-days fell by around 20%. (Hospitalisation data is analysed rather than reported injury data because as discussed in section 4 below, injury data appears to have been affected by changes in reporting practice.) The following table compares the outcomes with the targets in the Road Safety to 2010 Strategy.

Table 2: Overall Outcomes (per BVKT)

Overall Outcomes (per BVKT)	1998	2001	***Target 2004***	**2005**	**Chg 98-05**	***Target 2010***
Rural deaths	18.4	17.4	n/a	13.1	**-29%**	
Urban deaths	8.68	6.85	n/a	5.88	**-32%**	
Total deaths	14.2	12.6	***9.9***	**10.1**	**-29%**	***6.1***
Drivers killed with excess alcohol	1.81	1.52	n/a	1.44	**-20%**	
Fatal crashes "too fast for conditions"	3.85	3.41	n/a	2.79	**-28%**	
Fatalities avoided if belt worn	0.91	0.97	n/a	0.67	**-26%**	
Hospitalised, more than 1 day	100.9	88.1	***66***	**78.4**	**-22%**	**44**
Hospitalised, more than 3 days	67.1	58.9	***42***	**53.5**	**-20%**	**28**
Total hospital bed-days	1388	1151	n/a	1061	**-24%**	
Total Hospitalisations	170	186	***140***	**178**	**+4%**	***90***

1.12 Social cost per BVKT, was reduced by around 22%. While fatalities per BVKT fell 30%, the reduction in reported serious injuries per BVKT and particularly in reported minor injuries per BVKT was lower and this is reflected in the social cost analysis. (Issues regarding the adjustment of reported injury data to take into account changes in reporting practice are discussed in section 4 of the report.) The following table compares the outcome regarding social cost with the targets in the Road Safety to 2010 Strategy.

Table 3: Social Cost Outcomes

Social Cost (2006 prices)	**Avg 97-99**	**2001**	**2003**	***Target 2004***	**2005**	**Chg 97/99-05**	***Target 2010***
Total $M	3847	3235	3380	***3290***	**3324**	**-13.6%**	
$M/BVKT	105.7	89.6	87.1	***80***	**82.7**	**-21.8%**	52.6
$M/10,000 pop	1.02	0.84	0.84	***0.84***	**0.81**	**-20.1%**	0.78
$M/10,000 veh	1.57	1.23	1.21	***1.22***	**1.10**	**-30.2%**	1.13

Attribution

1.13 Section 5 of the report examines the attribution of the improvement in outcomes between road engineering, vehicle crashworthiness improvements and compliance and enforcement activities. There is no straightforward way to precisely assess what effect the different interventions have had in generating the overall outcome. One approach, however, is to consider the implications of independent estimates that have been made of the individual factors and then assess the implications of this report's analysis.

1.14 The contribution of road engineering to reductions in fatalities, injuries and social cost from Transfund projects over the period were estimated in a 2003

study by Peter Vulcan and others, commissioned by LTSA[1]. The contribution of vehicle crashworthiness improvements to reductions in crash fatalities and social cost were estimated in a 2005 Monash University Accident Research Centre study based on newly available data relating to the actual New Zealand crashed vehicle fleet characteristics[2]. For earlier increases in and compliance activities Guria (1999)[3] estimated an incremental benefit to cost ratio of between 8 and 13 to 1, while Cameron et al (2002)[4] found the Supplementary Road Safety Package a benefit to cost ratio of about 20 to 1. The lower estimate, 8 to 1, is used in the analysis set out below.

1.15 The following attribution table provides a summary of the effect of the alternative estimates. The table takes as its starting point the assumption that all of the observed improvement in deaths, injuries and social cost is attributable to the combined effects of the three factors listed in para 1.13 above. For each row in the table, the first two columns are the assumptions applied and the third column shows the remaining factor. In each row, the effect of the remaining factor is calculated by starting with the observed improvement and removing the effects of the two assumptions to derive the change that remains to be explained and which is attributed to the third (remaining) factor.

Table 4: Attribution Analysis

			Implied Attribution (% Chg per BVKT)			
Assumption 1	Assumption 2	Remaining Factor	Magnitude of Remaining Factor's Effect			
			Rural Deaths	Urban Deaths	Hosp > 1 Day	Total Social Cost
Vulcan Road	Monash Vehicle	Incr SAP Exp	-7.2%	-11.9%	-0.8%	1.2%
Incr SAP Exp	Vulcan Road	Vehicle Improv	-15.7%	-19.9%	-10.7%	-8.8%
Incr SAP Exp	Monash Vehicle	Road Improv	-11.3%	-15.8%	-4.3%	-1.8%

The results set out in the above table above provide a range of estimates for the attribution to the three factors under consideration of the gains in road safety achieved over the five year period to 2005. The estimates are summarised in the following table.

1 P. Vulcan, P., Hayes, I., Haworth, N., McLean, J. (2003), "*Assessment of Strategies, Policies and Programmes Affecting Road Safety*" Report to Land Safety Authority New Zealand.

2 Keall, M., Newstead, S. and Scully, J. (2005). "*Projecting Effects of Improvements in Passive Safety of the New Zealand Light Vehicle Fleet to 2010"* Monash University Accident Research Centre.

3 Guria, J. (1999). *"An Economic Evaluation of Incremental Resources to Road Safety Programmes in New Zealand"*. Accident Analysis and Prevention, 31, pp. 91-99.

4 Cameron, M., Guria, J. and Leung, J. (2002). *"An Evaluation of the Supplementary Road Safety Package"* Land Transport Safety Authority, Wellington, New Zealand.

Table 5: Summary of Estimates of the Contributions of Factors

Factor/Source of Estimate	Vulcan (2003)	Monash (2005)	Guria (1999)	Residual Analysis (This Report)
Road Improvements				
Rural Deaths	-10.1%			-11.3%
Urban Deaths	-10.1%			-15.8%
Hosp > 1 day	-8.4%			-4.3%
Total Social Cost	-8.4%			-1.8%
Vehicle Improvements				
Rural Deaths		-14.5%		-15.7%
Urban Deaths		-14.5%		-19.9%
Hosp > 1 day		-14.5%		-10.7%
Total Social Cost		-14.9%		-8.8%
Incr SAP Expenditure				
Rural Deaths			-5.9%	-7.2%
Urban Deaths			-5.9%	-11.9%
Hosp > 1 day			-5.0%	-0.8%
Total Social Cost			-5.5%	1.2%

(Note: The assumptions have been imposed in the table that urban and rural deaths change by same % and that hospitalisations >1 day and injuries change by the same %.)

1.16 The above table suggests that each of the three factors considered has played a significant role. Importantly, given this report focuses on the contribution of increased SAP expenditure, the analysis appears to confirm that the increased SAP expenditure under the Road Safety to 2010 Strategy has had a significant effect in reducing fatalities.

1.17 One point of note is that the above table indicates that (based on the Monash estimates) vehicle improvements provide the largest contribution to improved road safety outcomes over the period considered.

1.18 There are two key issues for further work arising from the analysis in this report. The first is the need to clarify, if possible, whether the increase in the total number of reported injuries (after adjusting for traffic volumes) is a real increase or is the result of changes in practices regarding hospital admissions, ACC claims and Police reporting. The second is the desirability, to the extent resources and information permits, of an ex-post analysis of the safety benefits of road engineering projects and also the actual achieved crashworthiness improvements in the vehicle fleet. Improved confidence in the estimates of the contributions of these factors to road safety outcomes would greatly facilitate assessment of the achievements of the Road Safety to 2010 Strategy.

2. Methodology

2.1 Evaluation of an intervention such as expenditure on road safety depends upon a comparison with a counterfactual i.e. a view of what would have happened in the absence of the intervention. As it happens LTSA/Land Transport NZ and Police road safety funding, remained virtually unchanged over the period 1997/98 to 1999/00 (hereafter 1997-99), and then increased substantially from 2000/01. This increase resulted from the implementation of the Road Safety to 2010 strategy.

2.2 The substantial increase from 2000/01, after a period of relatively constant funding, offers the opportunity of identifying how the increase in funding has translated into changes in outcomes. Essentially the average road safety outcome for the period 1997-99 can serve as a counterfactual with which to compare the 2005 outcome (provided relevant changes such as in population, the vehicle fleet and vehicle kilometres travelled are taken into account). The use of a three year average as the basis for comparison is helpful in reducing the effect of random fluctuations which are present in the data and could obscure the underlying trends. While use of a three year average is workable for the base there is a trade-off as regards what will be compared with that base. The trade-off is between the benefit of reducing the effect of random fluctuations through use of an average versus the value of focussing on recent outcomes given there has been an increase in funding and improvement in outcomes through to the recent period. This trade-off has been decided in favour of focussing on the latest outcomes data rather than focussing on an average of several years. (This is in line with the specifications for the November 2004 report).

2.3 Accordingly, the prime focus of this report is to compare recent, usually 2005, outcomes to the average for the period 1997-99 after allowing for growth in population, kilometres travelled and vehicle fleet. This provides the basis for an evaluation of the results achieved by the increased funding – to the extent that the observed outcomes can validly be attributed to the increased funding. The report is vulnerable to the effects of fluctuations in annual results because it depends on road safety outcome data for a single year – usually calendar 2005. As it happens, however, the initial data for the following year 2006 suggest that, when the full data for that year is available, the outcome will be compatible with that for 2005 and there is no indication that 2005 was affected by problematic fluctuations (although such an analysis does not rule out the possibility that it will eventually become apparent that the analysis was affected by such a fluctuation).

2.4 A number of methodologies are used to examine whether the outcomes are validly attributable to the increased expenditure. In general the key issue is to attempt to assess the benefits being achieved by each of the different types of intervention that are being funded e.g. interventions aimed at improving compliance with speed limits (“speed control”) or with compliance regarding use of constraints. This is not straightforward because all of the interventions potentially contribute to the same desired outcome namely the reduction of road fatalities, injuries and property damage. Thus the challenge is to separate

out the effects of the different interventions. The standard approach to this issue of multiple causes and effects in policy evaluations is to attempt to trace out how the major interventions are believed to contribute to the outcome objectives of reducing road fatalities, injuries and property damage i.e. the "intervention logic" associated with the interventions. The intervention logic is a description of the causal links that focuses on defining measurable "intermediate outcomes" that the intervention is intended to achieve, these being means to the end of achieving the overall outcome sought, in this case reduction in the road toll. While tracing out an intervention logic can often provide insights into the effectiveness of an intervention, a quantitative assessment of the benefits usually requires the availability of additional information.

2.5 This report considers the intervention logic which is proposed (explicitly or implicitly) by LTSA/MOT, the Police and researchers as connecting the increased expenditure on interventions such as speed control to the ultimate outcomes of reductions in crashes, and resulting fatalities and injuries. In general, the examination of the intervention logic is based on considering developments in specific intermediate outcomes that are part of the chain of logic connecting the expenditure (i.e. on specific LTSA/Land Transport NZ or Police outputs) to the ultimate outcomes. Thus an intermediate outcome for speed control interventions is the distribution of speeds, and in particular the mean speed, observed in annual surveys undertaken using speed cameras.

2.6 In undertaking this report we considered three different methodologies for deriving quantitative estimates of the benefits of the different road safety interventions under consideration.

- Firstly, for some major interventions, crash reports provide information on changes in the contribution of specific casual factors (e.g. alcohol) to crashes. Changes in the prevalence of these causal factors can in some cases be interpreted to provide an estimate of the effect of the increase in expenditure on the intervention targeted at that causal factor.

- Secondly, for some intervention logics, researchers have estimated a quantitative relationship between the corresponding intermediate outcome, e.g. the mean speed of traffic, and the overall road toll. Not surprisingly, much more research on such relationships has been undertaken overseas than in New Zealand and, consequently, the issue of judging the applicability of the research to New Zealand is involved.

- Thirdly, regression analysis could be used, whereby an equation is estimated which is the best "fit" to explain the outcome results (expressed quantitatively) as a "weighted" combination of the quantities of the different outputs (or in some applications the intermediate outcomes). The reliability of the estimated weights (coefficients) depends on the number of separate observations i.e. in this case the number of periods for which data on the outcomes are available. In the current case the objective is to provide an evaluation related to the increase in expenditure since 1999/00. Given this time period there are too few annual observations to undertake a regression analysis. A larger number of observations are available for

quarterly data but the one study that has been undertaken using regression analysis noted that limitations regarding quarterly data suggest "we should use quarterly models mainly for comparing the overall effects and not for individual effects, since the error is likely to be greater at that level"[5]. Thus although the results of the study referred to are interesting, regression analysis is of limited relevance to the evaluation until more observations are available (i.e. more years have elapsed since 1999/00).

2.7 Given the limitations applying to the second and third methodologies, as discussed above, the main methodology of this report is the first approach. We examine developments in the intermediate outputs and developments reported by Police attending crashes in regard to various related casual factors such as speed ("too fast for conditions"). The available data allow a degree of attribution of developments regarding crashes to the various causal factors and thereby to the interventions targeted at those factors. The attribution is incomplete and some uncertainty remains regarding the strength of the causality, but the analysis appears to provide useful insights that can inform future decision-making regarding expenditure on different interventions.

2.8 Various measures of the direct outputs produced are available for the enforcement interventions (e.g. hours logged, tickets issued and breath tests administered) and for advertising expenditure (e.g. viewers and listeners reached and awareness and opinion survey results). Although the measures involved, such as tickets issued and breath tests administered, do not capture all of the effects involved and, in particular, the deterrent effect of visible patrols, this does not undermine the analysis in this case. The reason is that the main contribution of analyses of these measures for the period concerned is to confirm that there was a very marked increase in enforcement activity. The data appears generally consistent with the Police attribution of hours to outputs, although it is not possible to verify that attribution and clearly some activities, such as patrolling, cannot in practice be compartmentalised into separate outputs such as speed limit enforcement.

2.9 Having confirmed through the measures such as tickets issued that a substantial increase in enforcement activity did indeed occur which is in general terms consistent with the reported attributable hours data, the analysis moves on to the issue of identifying the effects of the increased activity in different enforcement areas. With the exception of the "Visible road safety enforcement" output, measures are available indicating some effects of the enforcement on motorist behaviour in such areas as wearing of restraints, speed and breath alcohol levels. These behavioural effects can viewed as intermediate outcomes of the enforcement interventions.

2.10 Some research is available on the links between enforcement and the intermediate outcomes, for example between tickets issued for speeding offences and average speed travelled. For the period of the evaluation, however, it is not really necessary to rely on such research since the increase

[5] Cameron, M., Guria, J. and Leung, J. (2002). *"An Evaluation of the Supplementary Road Safety Package"* Land Transport Safety Authority, Wellington, New Zealand, p64.

in enforcement and the effects on behaviour are sufficiently dramatic that the causal links to enforcement generally seem clear without needing to depend on regression analysis or other techniques that might otherwise be required.

2.11 While the links between the outputs (i.e. enforcement) and the intermediate outcomes (e.g. mean speeds) seem clear for the major enforcement activities (with the exception of "Visible road safety enforcement") the links between the intermediate outcomes and the overall outcome sought (reduction in fatalities and injuries) are much more difficult to analyse.

2.12 The desired overall outcomes are a reduction in road fatalities and injuries resulting from crashes in which the factors addressed by the interventions feature as a cause (or as a mitigating factor in the case of restraints). In principle, the fatalities and injuries can be combined into one measure of social cost by attributing dollar values to fatalities and (different types) of injuries. There are, however, issues regarding the comparability of the reported injury data between years in the recent period which result in issues in interpreting the social cost estimates. The estimates and the issues are discussed in section 4 below.

2.13 Analysis of road safety developments needs to recognise that, absent any change in interventions or characteristics of the vehicle fleet, fatalities and injuries might be expected to reflect the growth in population, traffic volumes (vehicle kilometres travelled) or possibly (for congested roads) registered vehicles. By 2005 the population, total vehicle kilometres travelled and registered vehicles were around 8.2%, 10.4% and 23.8% respectively higher than the 1997-99 average[6]. The measures most relevant to adjust for growth appear to be the rates of fatalities and hospital bed-days per 100,000 of population ("per 100K pop") and per billion vehicle kilometres travelled ("per BVKT"). The analysis is complicated by the marked variability in traffic volume growth between years and the sharp contrast between recent rapid growth in rural traffic and decline in urban traffic. Unfortunately, the split between urban and rural traffic volumes is available only since 2000. An estimate for 1998 has been derived by assuming rural traffic volumes grew at the same rate as total traffic volumes between 1998 and 2000. The data are set out in the following table.

Table 6: Vehicle Kilometres Travelled

Year	VKT (billion)		
	Total	**Rural**	**Urban**
1998	36.4	*19.0**	*17.4**
2000	37.2	19.4	17.8
2001	36.1	19.6	16.5
2003	38.8	21.9	16.9
2004	n/a	n/a	n/a
2005	40.2	23.2	17.0

Source: MOT except * which is authors' estimate

[6] For vehicle kilometres travelled the calculation compares 2005 with 1998 (no survey in 1997 or 1999).

2.14 Based on the above estimates it turns out that between 1997-1999[7] and 2005 rural fatalities per rural BVKT and urban fatalities per urban BVKT have reduced to a similar extent, namely 29% and 32% respectively (see para 4.5 below). Unfortunately, hospitalisation data classified by rural versus urban is not available so this analysis cannot be undertaken for such data. This is important because hospitalisation data must be utilised to overcome discontinuities in reporting of injuries as discussed in para 4.2 below. Given this aspect, other approaches to adjusting for growth have also been reported. Both the urban and the rural outcome data have been expressed as rates per 100K pop and per 10,000 vehicles to provide insight into the changes in fatalities, hospitalisations and hospital bed-day rates.

3. The Components of the Road Safety to 2010 Strategy

3.1 The Road Safety to 2010 strategy involves a variety of ongoing, expanded and new initiatives. Contributions to reductions in fatalities, injuries and social cost of road crashes are expected to come from three sources:

- Increased enforcement and compliance (e.g. education) activity;
- The safety benefits of road engineering projects;
- The improvement in the vehicle fleet's crashworthiness.

Each of these sources of improvement is discussed below.

The Increase in LTSA/Land Transport NZ and Police Road Safety Funding

3.2 Funding of the Land Transport Safety Authority and Police (road safety) outputs has increased over the five years to 2004/05 as set out in the table below which details Police actual and LTSA/Land Transport NZ voted expenditure under the SAP.

Table 7: Safety Administration Programme Voted Expenditure

	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05
Police	**$154.1M**	**$164.1M**	**$181.2M**	**$186.4M**	**$197.2M**	**$207.3M**
LTSA	**$22.5M**	**$25.6M**	**$28.4M**	**$42.0M**	**$42.2M**	**$33.4M**
Total	**$176.6M**	**$189.7M**	**$209.5M**	**$228.4M**	**$239.4M**	**$240.7M**

Ex GST

In addition to the above SAP funding other funding of road safety related expenditure includes:

- Transfund financed expenditure justified by safety objectives;
- Local authority expenditure comprising road engineering, and other activity;
- ACC financed expenditure on road safety promotion.

[7] See footnote 2.

The contribution to road safety of Transfund financed road construction and re-engineering (including assisted Local Authority works) is discussed after analysing how the increase in SAP funding since 2000/01 has been utilised.

3.3 Within the overall increase in the SAP funding the allocation to different outputs has changed substantially over the recent period. As a basis for this evaluation the following table provides full details of this allocation including to new outputs such as the Highway Patrol. The data is expressed in dollar terms with the inflation aspect being discussed later.

Table 8: Details of Safety Administration Programme Voted Expenditure

OutputClass/Output	1999/00	2004/05	$M Chg	% Chg	04/05 % Total
Police					
Strategic capability and road policing					
Road policing management and strategic capability	$0.0M	$5.6M	$5.6M	n/a	2.7%
District road policing mgnt & intel	$0.0M	$0.9M	$0.9M	n/a	0.4%
Highway patrol groups	$0.0M	$24.6M	$24.6M	n/a	11.8%
Speed control	$23.0M	$22.0M	-$1.0M	-4%	10.6%
Traffic camera operations	$12.1M	$13.0M	$0.9M	8%	6.3%
Drinking or drugged driver control	$32.9M	$42.8M	$9.9M	30%	20.6%
Restraint device control	$5.0M	$7.6M	$2.6M	52%	3.7%
Visible road safety enforcement	$34.7M	$27.5M	-$7.2M	-21%	13.3%
Commercial vehicle investigation and road user charges enforcement	$9.0M	$12.4M	$3.3M	37%	6.0%
Subtotal	**$116.7M**	**$156.3M**	**$39.6M**	**34%**	**75.4%**
Road policing incident and emergency management					
Crash maintenance and investigation	$19.6M	$25.1M	$5.4M	28%	12.1%
Traffic management	$6.3M	$5.9M	-$0.5M	-7%	2.8%
Subtotal	**$26.0M**	**$30.9M**	**$5.0M**	**19%**	**14.9%**
Road policing resolutions					
Sanctions and prosecutions	$3.9M	$12.3M	$8.4M	218%	5.9%
Court orders	$0.6M	$0.5M	-$0.1M	-22%	0.2%
Subtotal	**$4.5M**	**$12.8M**	**$8.3M**	**187%**	**6.2%**

OutputClass/Output	04/05 % Total	2004/05	$M Chg	% Chg	1999/00
Community engagement					
Police community services	$4.1M	$2.0M	-$2.1M	-51%	1.0%
School road safety education	$2.9M	$5.3M	$2.4M	82%	2.6%
Subtotal	**$7.0M**	**$7.3M**	**$0.3M**	4%	3.5%
Police Total	**$154.1M**	**$207.3M**	**$53.2M**	**34%**	**100.0%**
LTSA/Land Transport NZ					
Policy Advice	$3.5M	$2.9M	-$0.6M	-18%	8.6%
Safety Information & Promotion	$15.4M	$20.4M	$5.0M	32%	61.1%
Grants Management	$2.8M	$7.8M	$5.0M	181%	23.4%
Safety Audit	$0.9M	$1.7M	$0.8M	94%	5.0%
Licensing	$0.0M	$0.2M	$0.2M	n/a	0.7%
Vehicle Impoundment	$0.0M	$0.4M	$0.4M	n/a	1.3%
LTSA/Land Transport NZ Total	**$22.5M**	**$33.4M**	**$10.9M**	**48%**	**100.0%**
Grand Total	**$176.6M**	**$240.7M**	**$64.0M**	**36%**	

* Funding in 1997/98 and 1998/99 was very similar to that of 1999/00

The Highway Patrol Group is a new type of output since it is based on the type of road patrolled rather than being based on a specific type of road offence as with most other outputs. It is understood a high proportion of the resources devoted to the Highway Patrol are concerned with speed issues although clearly other interventions such as drunk driver control are also involved.

3.4 The above dollar increases include the effect of inflation. Prices as measured by the CPI, the GDP deflator and the producers price (inputs) index (PPI) for 2004/05 (i.e. average of the four quarterly index levels in that year) were 13.1%, 14.3% and 14.6% respectively above the average for 1999/00. Thus adjusted for general (GDP deflator) inflation, Safety Administration Programme funding for 2004/05 was around 19.2% higher in real terms than for 1999/00 (i.e. around $38.7M in 2004/05 prices).

3.5 MOT has calculated that the Police remuneration increased by around 4.2% per annum (p.a.) or around 12.9% over the period 1990/00 to 2004/05. Based on this cost inflation for remuneration and PPI inflation for other inputs, Police

road safety funding for 2004/05 was around 12% higher in terms of real purchasing power (for police inputs) than for 1999/00 (i.e. around $22.0M in 2004/05 prices). The hours reported by Police increased by around 16.6%.

3.6 LTSA/Land Transport NZ have advised that the inflation in TV advertising prices over the relevant period was higher than the 32% increase in safety information and promotion expenditure implying that in real terms less advertising time could be purchased in 2004/05 than in 1999/00.

3.7 In summary, expenditure on the Safety Administration Programme when adjusted for the level of general inflation was around 19.2% or $38.7M higher in 2004/05 than in 1999/00, but when adjusted for cost inflation applying to the specific resources used in road safety, expenditure was no more than 12.4% or $26.5M higher. The difference results from the higher than average inflation in Police remuneration and advertising costs. The above analysis refers to total Police road safety expenditure – the analysis of the components of that expenditure is detailed in section 5.

The Increase in Enforcement & Compliance Achieved

3.8 The above analysis summarises the increase in expenditure on road safety enforcement and education. The next step is to assess the results in enforcement and compliance achieved.

3.9 For the first output class, road policing, hours recorded and tickets issued provide relatively precise quantitative measures of the delivery of the outputs. For "Drinking or Drugged Driver Control", breath tests administered provides a specific measure of the delivery of the enforcement output. The following table details the increase in tickets issued and breath tests.

Table 9: Tickets and Breath Tests

Offence Category	1999/00	2002/03	2004/05	% Chg 00-05
Speeding (Under 100 kph)	67,756	190,433	299,427	148%
Speeding (Over 100 kph)	52,998	159,036		
Speeding – Other (Trailer etc)	2,804	14,710	10,073	259%
Drink Drive Offences	28,646	24,744	27,408	-4%
Seat Belt/helmet	32,373	76,182	73,508	127%
Dangerous/unsafe etc	85,885	95,757	101,942	19%
Licence/hours/condition/COF	281,208	408,936	434,546	55%
Other Transport Offences	8,757	23,197	16,838	92%
Sub Total "Officer Tickets"	**560,427**	**992,995**	**963,742**	**72%**
Speeding - Speed Camera	440,195	488,714	394,585	-10%

Offence Category	1999/00	2002/03	2004/05	% Chg 00-05
Total All Tickets	**1,000,622**	**1,481,709**	**1,358,327**	**36%**
Breath Tests (for Alcohol)	***1,783,000***	***2,413,430***	***1,946,134***	***9%***

The above table indicates that the around 34% nominal and no more than 12% real increase in funding of road policing has been matched by a substantially larger increase in tickets issued, particularly tickets issued by officers which have increased by 72% in total. The increase has been spread across most offence types with particularly large percentage increases in speeding tickets and seat belt/helmet tickets. These two areas received large increases in funding (taking into account the introduction of the Highway Patrol). In the case of Drink Driving Offences the number of tickets issued has reduced but the increase in breath tests administered suggests that the reduction is due to less offending rather than less enforcement. Enforcement activity in the form of breath tests administered peaked at 35% above 1999/00 levels but has now fallen back to 9% above 1999/00 levels.

3.10 Beyond the measure of output delivery, there are a set of measures of intermediate outcomes which can be linked by an "intervention logic" to the outputs on the one hand and to the overall outcomes on the other. The desired overall outcomes are a reduction in fatalities and injuries resulting from crashes in which the factors addressed by the interventions feature as a cause (or as a mitigating factor in the case of restraints). As recorded in the next table the increase in tickets issued has been associated with a marked improvement in compliance. Mean speeds and the percentage exceeding speed limits fell. The increase in breath tests was associated with less drunken driving offences detected in surveys.

3.11 The intermediate outcomes of above enforcement outputs are summarised in the following table which shows substantial improvements in compliance.

Table 10: Intermediate Outcomes

Intermediate Outcomes	Avge 97-99	2001	2003	2005	97/99-05 Chg
Speed (kph)					
Speed, rural winter mean	101.8	100.2	98	97.1	-4.7
Speed, % exceeding 110 km/h	20%	13%	6%	5%	-15%
Speed, rural winter 85th pctile	113	109	105	104	-9.0
Speed, rural summer mean	102.6	101.9	99.9	n/a	
Speed, urban mean	55.6	54.9	53.7	52.4	-3.2
Speed, % exceeding 60 km/h	22%	18%	12%	7%	-15%
Speed, urban 85th pctile	62	61	60	58	-4.0

Intermediate Outcomes	Avge 97-99	2001	2003	2005	97/99-05 Chg
Drunk driving					
Surveyed % over limit	2.0%	1.2%	<1%	<1%	
Restraints					
Seat belts (adult): front	87%	92%	92%	95%	8%
Seat belts (adult): rear	58%	70%	81%	86%	28%
Children restrained: 0-14, all	88%	89%	96%	94%	6%

* Based on interpolation of 2004 results since no survey was undertaken in 2003

These major improvements in compliance have been achieved in a relatively short period. Examination of the longer time series for these compliance areas indicates that while some improvement in compliance was occurring prior to the expanded funding and policing from 2000/01, the improvement accelerated markedly from that time. The data provides compelling evidence that intensified enforcement combined with the LTSA/Land Transport NZ's advertising and education programmes generated the improved compliance. While it is relatively easy to measure compliance in the above areas, it is more difficult in the case of the Visible Road Safety output where funding has been reduced.

3.12 In addition to the above compliance and enforcement components of the Road Safety to 2010 strategy, contributions to reductions in fatalities, injuries and social cost of road crashes are expected from road engineering and vehicle fleet crashworthiness. These are discussed next.

Transfund Financed (Including Assisted Local Authority) Expenditure

3.13 Transfund assessed a construction or re-engineering project's contribution to safety as one component when assessing whether the project's benefit cost ratio is sufficient to justify funding. The safety benefits accrue each year from the date of construction either indefinitely into the future (e.g. widening a cutting) or until replacement is required (e.g. a wire barrier). Transfund discounted future benefits by a standard discount rate which has been the subject of several studies. (Because it is applied to "pre-tax" benefits the discount rate appears high in comparison with commercial rates applied to post-tax cashflows.) An allowance is made for increased future traffic volumes but not for any **real** increase in the social cost of a fatality or injuries over the life of the project. Arguably, the social cost will increase in line with growth in real per capita incomes. However, omission of this growth factor needs to be seen in the context of the willingness to pay approach to social cost which ensures a full value is placed on fatalities and injuries.

3.14 For the purpose of assessing the contribution of the Road Safety to 2010 Strategy to the reduction in fatalities between 1997-99 and 2005, the contribution of Transfund projects to safety over this period needs to be considered. It is interesting to consider Transfund's estimates of this contribution and the estimates for 2002/03 are relevant since this is the middle

of the period under analysis.

3.15 Transfund's 2002/03 annual report estimates that National Land Transport Programme projects (including local authority projects) which were to be allocated funding and planned to start in 2002/03, with a total cost of $596M, had expected benefits of $2695M. The benefits comprised congestion relief of $1523M, safety benefits of $516M and route quality and efficiency benefits of $656M[8]. The $516M is the present value of the flow of annual savings in social cost over a number of years - the annual equivalent is discussed below. Transfund's 2002/03 report advised that "meaningful benefit data are available only for construction projects at this stage".

3.16 The expected reductions in fatalities, injuries and social cost from Transfund projects were estimated in a 2003 study in which Peter Vulcan and others were commissioned by LTSA to assess strategies, policies and programmes affecting road safety (the Vulcan 2003 Report). This study estimates that planned road construction and re-engineering would reduce fatalities, injuries and total associated social cost by 4.2%, 3.5% and 3.3% respectively over the three years to 2005/06[9].

3.17 Given the Vulcan 2003 Report's base year social cost of $3.6B (June 2002 dollars) the estimates would represent an annual social cost reduction of $118M. The implication is that on average for those three years, road construction and re-engineering expenditure provides savings in social cost of around $40M per annum. This can be reconciled with the Transfund estimate of a $516M present benefit from the 2002/03 expenditure if on average the projects concerned yield benefits for more than 10 to 12 years. In general, use of the original project analysis appears to be the only way to assess the benefits of Transfund and local authority expenditure apart from the few cases where follow up monitoring is being used such as in relation to "black spot" treatment (see discussion later).

3.18 The Vulcan 2003 Report estimates imply annual rates of reduction over the three years to 2005/06 in fatalities and injuries of around 1.4% and 1.2% per annum respectively from Transfund financed projects. LTSA provided an alternative estimate in 2004 that road construction and re-engineering over the nine years 2001 to 2010 would reduce fatalities and injuries by 10.2% or around 0.75% per annum. The LTSA estimate implies that in comparing 2005 with 1997-99, road construction and re-engineering could account for a reduction of around 5.4% in fatalities whereas the Vulcan 2003 Report's estimate would correspond to a reduction of around 10.1% for fatalities and around 8.4% for injuries.

3.19 While neither estimate relates exactly to the period of interest (1997-99 to 2005), the Vulcan 2003 report estimates covered the period to 2005/06 whereas the LTSA estimates covered the period to 2010. Based on this

[8] Transfund Annual Report 2002/03 p 21.

[9] P. Vulcan, P., Hayes, I., Haworth, N., McLean, J. (2003), "*Assessment of Strategies, Policies and Programmes Affecting Road Safety*" Report to Land Safety Authority New Zealand, p 101.

comparison, the Vulcan 2003 Report estimate is more relevant for the analysis of the period under consideration and, accordingly, the Vulcan 2003 Report estimate has been used in the analysis in later sections of this report.[10]

Vehicle Fleet Crashworthiness Improvements

3.20 Prior to the commencement of the Road Safety to 2010 Strategy, LTSA estimated that improvements in vehicle design would reduce fatal and serious injury to light vehicle occupants by 18% over the nine years 2001 to 2010. This rate for light vehicle occupants is equivalent to a per annum reduction for all vehicles of around 1.3% per annum. (In absence of better information this is assumed to apply in the same manner to fatalities serious injuries and total social cost.) For 2005 compared to the average of 1997-99 this is a 9.5% reduction.

3.21 Monash University Accident Research Centre in 2005 used the same methodology as the LTSA estimates, but applied newly available data relating to the actual New Zealand crashed vehicle fleet characteristics, in place of the earlier reliance on assumed crashed fleet characteristics. This study derived a much higher estimate of the effect of improvements in vehicle design, namely a reduction in fatal and serious injury to light vehicle occupants by around 30% over the 10 years 2000 to 2010. This rate for light vehicle occupants is equivalent to a per annum reduction for all vehicles of around 1.86% per annum. (In absence of better information this is assumed to apply in the same manner to both fatalities and serious injuries.) For 2005 compared to the average of 1997-99 this is an around 13.8% reduction.

3.22 Given that the Monash analysis is based on newly available data on the actual characteristics of the New Zealand crashed vehicle fleet, the Monash estimate has been used in the analysis in later sections of this report.

4. The Overall Outcome

4.1 The next step in the analysis is to examine the gains achieved relative to the comparison period in terms of reductions in fatalities, injuries and property damage. In terms of social cost, the major aspects are the loss of lives in fatalities and the loss of the enjoyment of life and of productivity due to injuries. These costs far outweigh the direct cost of hospitalisation and other medical costs and property damage.

Uncertainties Regarding Injury Reporting

4.2 An important factor in the analysis is that injuries, particularly minor injuries, appear to have increased significantly in the period 2000 to 2005. The data relating to some key measures of outcomes are as follows:

[10] Both the Vulcan (2003) report and the LTSA estimates used the detailed Transfund programme. However, the Vulcan report starts with the 2002/03 National Land Transport Programme (NLTP) and examines the 2004/05 and 2005/06 NLTP forecasts. The LTSA estimate starts with the 2003/04 NLTP and examines the NLTP forecasts to 2010.

Table 11: Deaths, Reported Injuries, Hospitalisations and ACC Claims

Year	Road deaths	Reported serious injuries	Reported minor injuries	Hospitalisations for more than one day	ACC motor vehicle new[11] claims
Avg 97-99	516	2480	10124	3671	
2000	462	2243	8719		
2001	455	2435	9933	3180	33700
2002	404	2600	11318	3022	35800
2003	461	2578	11794	2994	39800
2004	436	2469	11351	3025	42200
2005	405	2519	11906	3153	45500

A key issue is the extent to which (if at all) the increase in minor injuries reported in the above table should be interpreted as a real increase as opposed to being attributable to either increased ACC claims or reporting. The related issue is why motor vehicle claims to ACC have increased so substantially. The assessment of the outcome to date of the Road Safety to 2010 Strategy is directly affected by the view taken regarding the apparent increase in minor injuries, since the increase in minor injuries, particularly between 2001 and 2002, is so large it may offset the reduction in fatalities depending upon the social costs ascribed to fatalities versus injuries, as discussed below.

The Focus on Hospitalisations over One Day

4.3 This report focuses on the fatalities and "hospitalisations over one day" data. Arguably, this data is much more reliable than reported injuries or ACC claims since both of the later may be (more) affected by changes in behaviour regarding reporting and submission of claims. Hospitalisations for over one day may have also been affected by admission changes since hospitals generally have been seeking to reduce average lengths of stay, but this would tend to affect the hospital bed-day data rather than the admissions over one day data. The original injury targets for 2010 were expressed in terms of hospitalisations to avoid issues regarding crash reporting rates.

4.4 A very unfortunate consequence of the apparent distortion in reported injury data and consequent need to rely on hospitalisation data is that it becomes more difficult to make full use of data on aspects of reported injury causing crashes such as details of the contribution of alcohol and speed to crashes. As a consequence of the unreliability of data regarding crashes causing injury, the analysis becomes more dependent on data relating to fatal crashes (which do not involve the reporting distortion) but this gives rise to a different concern. The number of fatal crashes is small in absolute terms and thus random fluctuations can significantly affect the analysis and limit the extent to which conclusions can be drawn.

[11] The claims are described as new if they relate to injuries that have not been reported previously.

Outcomes Based on Fatalities and Hospitalisations Over One Day

4.5 The tables below set out the data adjusted for the growth in population, in vehicle kilometres travelled, and in the number of registered vehicles.

Table 12: Overall Outcomes

Overall Outcomes (per 100,000 pop)	**Avge 97-99**	**2001**	**2003**	**2005**	**97/99-05 Chg**
Rural fatal crashes	8.31	7.40	7.18	6.03	-27.5%
Urban fatal crashes	3.45	2.86	2.92	2.29	-33.5%
Rural deaths	9.96	8.88	8.43	7.44	-25.3%
Urban deaths	3.66	2.93	3.07	2.44	-33.4%
Drivers killed with excess alcohol	1.74	1.43	1.82	1.42	-18.8%
Fatal crashes with alcohol involved	3.04	2.70	3.09	2.46	-18.9%
Fatal crashes "too fast for conditions"	4.20	3.66	4.17	3.17	-24.4%
Fatalities avoided if belt worn	1.44	0.91	1.12	0.66	-54.1%
Hospitalised, more than 1 day	96.9	82.6	74.7	76.9	-20.6%
Hospitalised, more than 3 days	64.5	55.2	49.9	52.5	-18.6%
Total hospital bed-days	1334	1079	994	1040	-22.0%

Overall Outcomes (per BVKT) (1998 Urban/Rural breakdown est. by TDB)	**98**	**2001**	**2003**	**2005**	**98-05 Chg**
Rural fatal crashes	15.32	14.54	13.15	10.65	-30%
Urban fatal crashes	8.28	6.67	6.92	5.53	-33%
Rural deaths	18.4	17.4	15.4	13.1	-29%
Urban deaths	8.68	6.85	7.28	5.88	-32%
Drivers killed with excess alcohol	1.81	1.52	1.88	1.44	-20%
Fatal crashes with alcohol involved	3.24	2.88	3.20	2.51	-22%
Fatal crashes "too fast for conditions"	3.85	3.41	3.61	2.79	-28%
Fatalities avoided if belt worn	0.91	0.97	1.16	0.67	-26%
Hospitalised, more than 1 day	100.9	88.1	77.2	78.4	-22%
Hospitalised, more than 3 days	67.1	58.9	51.6	53.5	-20%
Total hospital bed-days	1388	1151	1027	1061	-24%

Overall Outcomes (per 10,000 vehicles)	Avg 97-99	2001	2003	2005	97/99-05 Chg
Rural fatal crashes	1.29	1.08	1.03	0.82	-37%
Urban fatal crashes	0.53	0.42	0.42	0.31	-42%
Rural deaths	1.5	1.3	1.2	1.0	-35%
Urban deaths	0.57	0.43	0.44	0.33	-42%
Drivers killed with excess alcohol	0.27	0.21	0.26	0.19	-29%
Fatalities avoided if belt worn	0.23	0.15	0.19	0.11	-50%
Hospitalised, more than 1 day	15.0	12.1	10.7	10.4	-29%
Hospitalised, more than 3 days	10.0	8.1	7.1	7.1	-28%
Total hospital bed-days	206	158	142	141	-31%

4.6 The above outcome data indicates for the period analysed a reduction in fatalities per 100K pop of over 27% and a reduction in hospital bed-days per 100K pop of around 22%. The reduction for both rural and urban fatalities on a per BVKT basis is around 30%. The reductions on a per 10,000 vehicles basis were over 37% for fatalities and over 28% for hospitalisations and hospital bed-days.

4.7 The above tables indicate that the reduction in fatality and hospitalisation rates was associated with a reduction in cases where the attending Police officer recorded “too fast for the conditions” as a contributing factor and a major improvement in the use of restraints. There was a reduction in cases of drivers with excess alcohol, but the reduction was less than the overall reduction in fatalities. Thus the improvement in regard to alcohol over the period considered was not as great as improvement in other aspects of driver and passenger behaviour and in vehicle and road engineering. (A year or two previous to the time period of the evaluation, there were big improvements in alcohol and, as a result, alcohol still contributes less to total road fatalities than it did in 1994 - down from 38% to 30% as a contributing factor.)

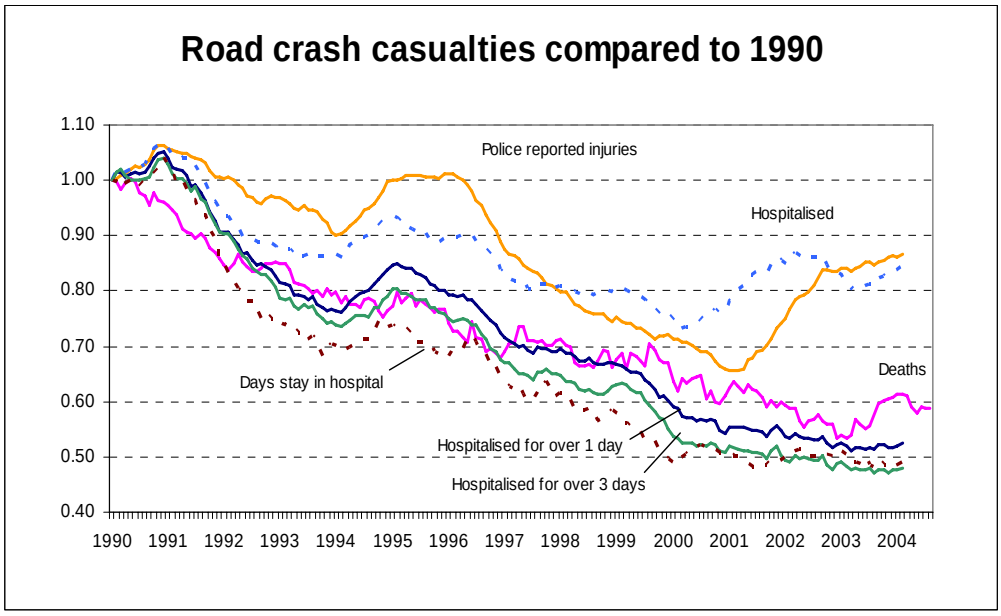
Outcomes Based on Estimates of Social Cost

4.8 The social cost of road fatalities and injuries is made up of several components. It includes cost of pain and suffering from loss of life and/or life quality, loss of productivity, medical, legal and court and property damage costs. The cost of pain and suffering due to a loss of life is calculated by attributing dollar values to statistical fatalities. The values are derived from a

"willingness to pay" study[12]. Corresponding dollar values have also been established for non-fatal injuries based on the fatality value. The unit value of each component of the social cost estimate is updated annually based on movements in average hourly earnings and other relevant price indices.

4.9 One major issue regarding the calculation of the total social cost of road crashes is that, as noted in para 4.2, the total number of reported injuries, which is required for the calculation, appear to have been affected by a change in admissions and reporting practices around 2000-01. The following graph illustrates the jump in total reported hospitalisations and reported injuries which is not matched by an increase in total days stay in hospital, hospitalisations for over 1 day or fatalities.

Chart 1: Road Crash Casualty Data



4.10 Since 2004, LTSA/MOT has developed a methodology designed to provide the best estimate of the actual total number of injuries taking into account the apparent jump in reporting of injuries, hospital admissions and ACC claims. To estimate the average crash cost, LTSA/MOT's practice (from the 2004 update onwards) is to use conversion factors which take into account the hospitalisation data. The factors are based on a 3-year rolling data centred at the subject year (e.g. for 2002 crash data, the conversion factors are based on the data for 2001-03). This is to smooth out the year-to-year variations in the level of reporting and to provide a larger sample size to improve the robustness of the analysis.

4.11 The following table sets out the conversion factors applied in obtaining the total social cost and indicates that the conversion factors fully offset the jump in reporting of minor injuries between 2000 and 2001, but do not take into

[12] See Guria, J (1991). *Estimates of Social Costs of Accidents and Injuries.* Wellington: Land Transport Division, Ministry of Transport and Guria, J (1993a), *Social Costs of Traffic Accidents.* Wellington: Land Transport Division, Ministry of Transport, August 1993.

account any further increase in reporting in 2002.

Table 13: Adjustment of Data for Reporting Gaps and Changes

	Fatalities	Reported Serious Injuries	Reported Minor Injuries	Serious Injury Conversion Factor	Minor Injury Conversion Factor	Total Social Cost All Injury Crashes (Jun 06 $m)
Avg 97-99	516	2480	10124	1.98	3.82	3,824
2000	462	2243	8719	2.04	3.98	3,481
2001	455	2435	9933	1.69	3.2	3,265
2002	404	2600	11318	1.69	3.2	3,274
2003	461	2578	11794	1.57	3.3	3,382
2004	436	2469	11351	1.66	3.51	3,338
2005	405	2519	11906	1.66	3.51	3,303

4.12 The total ACC claims data show an increasing trend in the number of new motor vehicle claims over the five years to 2005 which supports the increase in reported injuries data. According to the matching analysis conducted by ACC in 2004 using data for 2001-03, around 90% of reported serious injuries and 70% of reported minor injuries have a matched record in the ACC database. Due to lack of better information, LTSA/MOT takes the increase in the total number of ACC claims as a real increase in the total number of injuries. Arguably, the increase in the number of ACC new claims could be due to more claims being submitted rather than a real increase. At present there is not enough data to identify which view is correct.

4.13 The implication of the LTSA/MOT's assumption that there has been a real increase in the incidence of minor injuries is that, despite the reduction in the number of fatalities and approximately static numbers of reported serious injuries and hospitalised over 1 day injuries, the total social cost (at constant prices) of fatalities and injuries has remained roughly the same in the last 5 years. On this analysis the increase in minor injuries offsets the reduction in fatalities.

4.14 This analysis would imply that the reduction that has been achieved in road deaths and serious injuries (when adjusted for kilometres travelled i.e. per BVKT) has been accompanied by increased crashes that result in less serious crashes. This could be interpreted as suggesting that the effect of improvements in road engineering, vehicle crashworthiness and increased enforcement and compliance has been to reduce the serious effects of crashes rather than reducing the incidence of crashes per se.

4.15 To assess the impact of social cost ignoring minor injury crashes, the LTSA/MOT Crash Analysis System has been used to disaggregate the social cost estimate in terms of fatalities and serious injury crashes for the 5 years to 2005. The totals differ slightly from the published social cost estimates because of the different data source used.

Table 14: Social Cost Estimation

Social Cost Estimates (Jun 06 prices)	Total Social Cost of All Injury Crashes	Total Social Cost of Fatal and Serious Injury Crashes	Social Cost of F+S Crashes as a percentage of Total Social Cost All Injury Crashes
2001	$3,235M	$2,739M	85%
2002	$3,346M	$2,765M	83%
2003	$3,380M	$2,743M	81%
2004	$3,380M	$2,724M	81%
2005	$3,324M	$2,638M	79%

4.16 Over the period 2001 to 2005 the growth in population, billion vehicle kilometres travelled (rural plus urban) and vehicles registered has been 6.5%, 11.4% and 15% respectively. The following table sets out the social cost per 10,000 pop, per BVKT and per 10,000 vehicles.

Table 15: Social Cost Outcomes

Social Cost	Avg 97-99	2001	2003	2005	Chg 05/97-99
Total $M	3847	3235	3380	3324	-13.6%
$M/10,000 pop	1.02	0.84	0.84	0.81	-20.1%
$M/10,000 veh	1.57	1.23	1.21	1.10	-30.2%
$M/BVKT	105.7	89.6	87.1	82.7	-21.8%

4.17 For the most relevant measures, $M/10,000 pop and $M/BVKT, the reduction in social cost achieved (taking the increase in reported minor injuries as a real increase) is 20% to 22%. The next section of this report considers the attribution of this improvement.

5. Attribution to Road Engineering, Improvements in Crashworthiness and Compliance & Enforcement (Police & LTSA/Land Transport NZ Expenditure)

5.1 This section discusses the issues relevant to how the overall outcome regarding the reductions in fatalities, injuries and social cost might be attributed between three factors that may have contributed – Enforcement and Compliance, Safety Benefits of Road Engineering Projects and Vehicle Fleet Crashworthiness Improvements.

5.2 There is no straightforward way to precisely assess what effect the different interventions have had in generating the overall outcome for fatalities and hospitalisations summarised in the above table. A multiple regression analysis could be used to attempt to identify the different effects but there are not enough independent observations to isolate the effects with any certainty.

One approach in the circumstances is to consider the implications of independent estimates that have been made of the individual factors. As discussed earlier above the most relevant estimates of the contribution of Road Improvements have been made by the Vulcan 2003 Study. The most relevant estimates of the effect of Vehicle Fleet Crashworthiness Improvements have been made the Monash University Accident Research Centre. These estimates are summarised in the following table.

Table 16: Prior Estimates of Factor Contributions

Assumption	Chg 05/97-99
Vulcan Road Improvements (re Deaths)	10.1%
Vulcan Road Improvements (re Injuries)	8.4%
Vulcan Road Improvements (re Social Cost)	8.4%
Monash Vehicle Improvements (Deaths & Hosp)	14.5%
Monash Vehicle Improvements (Social Cost)	14.9%

5.3 No estimate of the contribution of enforcement and compliance in the period since commencement of the Road Safety to 2010 Strategy has yet been made[13] - the current report is an input for such an assessment. The analyses of the effect of earlier increases in enforcement and compliance activities are, however, a possible basis for such an estimate. Guria (1999)[14] found the incremental benefit to cost ratio of the SAP was between 8 and 13 to 1. Cameron et al (2002)[15] found the Supplementary Road Safety Package (SRSP) had a benefit to cost ratio of about 20 to 1.

5.4 Given that the above estimates relate to past increases in enforcement and compliance expenditure rather than the increase under examination in this report, it seems reasonable in applying them to use the lower estimate of 8 to 1 benefit. The 8 to 1 ratio would imply that the $26.5M real increase in SAP expenditure between 1999 and 2005 should have reduced social cost between 1997-99 and 2005 by around $212M or 5.5%. (This percentage change expected from increased SAP expenditure reflects the high estimate of social cost as calculated by LTSA – the effect of expenditure on enforcement and compliance is small because increased SAP expenditure is small compared to total social cost). As an approximation, the analysis of the SRSP suggests that the 5.5% reduction in social cost would reflect a reduction of around 5.9% in fatalities and a reduction of around 5.0% in serious injuries.

5.5 The following attribution table provides a summary of the effect of the alternative estimates. The table takes as it starting point the assumption that all of the observed improvement in deaths, injuries and social cost is attributable

[13] The Vulcan 2003 Study provides some estimates relating to Compliance & Enforcement but these appear to simply repeat the original estimates made at the start of the Strategy.

[14] Guria, J (1999). *"An Economic Evaluation of Incremental Resources to Road Safety Programmes in New Zealand"*. Accident Analysis and Prevention, 31, pp. 91-99.

[15] Cameron, M, Guria, J and Leung, J (2002). *"An Evaluation of the Supplementary Road Safety Package"* Land Transport Safety Authority, Wellington, New Zealand.

to the combined effects of the three factors listed in para 5.1 above.

5.6 For each row in the table, the first two columns are the assumptions applied and the third column shows the remaining factor. In each row, the effect of the remaining factor is calculated by starting with the observed improvement and removing the effects of the two assumptions to derive the change that remains to be explained and which is attributed to the third (remaining) factor. The effect attributed to the third factor is expressed in terms of the change in rural deaths, urban deaths, hospitalisations over 1 day and social cost per BVKT.

5.7 In the last two rows of the table, it is assumed that the effect of increased SAP expenditure is to reduce social cost by 8 times the amount expended.

Table 17: Attribution Analysis

Assumption 1	Assumption 2	Remaining Factor	Magnitude of Remaining Factor's Effect			
			Rural Deaths	Urban Deaths	Hosp > 1 Day	Total Social Cost
Vulcan Road	Monash Vehicle	Incr SAP Exp	-7.2%	-11.9%	-0.8%	1.2%
Incr SAP Exp	Vulcan Road	Vehicle Improv	-15.7%	-19.9%	-10.7%	-8.8%
Incr SAP Exp	Monash Vehicle	Road Improv	-11.3%	-15.8%	-4.3%	-1.8%

The results set out in the tables above provide a range of estimates for the attribution to the three factors under consideration of the gains in road safety achieved over the five year period to 2005[16], as summarised below.

Table 18: Summary of Estimates of the Contributions of Factors

Factor/Source of Estimate	Vulcan (2003)	Monash (2005)	Guria (1999)	Residual Analysis (This Report)
Road Improvements				
Rural Deaths	-10.1%			-11.3%
Urban Deaths	-10.1%			-15.8%
Hosp > 1 day	-8.4%			-4.3%
Total Social Cost	-8.4%			-1.8%
Vehicle Improvements				
Rural Deaths		-14.5%		-15.7%
Urban Deaths		-14.5%		-19.9%
Hosp > 1 day		-14.5%		-10.7%
Total Social Cost		-14.9%		-8.8%
Incr SAP Expenditure				
Rural Deaths			-5.9%	-7.2%
Urban Deaths			-5.9%	-11.9%
Hosp > 1 day			-5.0%	-0.8%
Total Social Cost			-5.5%	1.2%

(Note: The assumptions have been imposed in the table that urban and rural deaths change by same % and that hospitalisations >1 day and injuries change by the same %.)

16 See paras 3.14 to 3.23 above for discussion of how the Monash and Vulcan reports are used to derive estimates for the period 1997/99 to 2005 in this report. Thus the results depend on the Monash and Vulcan assumptions. (Both reports provide estimates for social cost and fatalities but not for hospitalisations which have been deduced.)

5.8 Although the above table indicates the estimates of the contribution of the three factors to improved road safety outcomes differ depending on the basis of the estimate, several important conclusions can nevertheless be asserted with confidence. Firstly, the table indicates that all three major factors – Enforcement and Compliance, Safety Benefits of Road Engineering Projects and Vehicle Fleet Crashworthiness Improvements - appear to have made significant contributions to reducing the level of road fatalities and serious injuries over the period 1997/99 to 2005. Secondly, the estimates set out in the table support the conclusion that improvements in vehicle crashworthiness provide the largest contribution to improvement in road safety outcomes. Thirdly, and, most importantly for the purposes of this report, the residual analysis appears to confirm that the increased SAP expenditure under the Road Safety to 2010 Strategy has had a significant effect in reducing fatalities.

5.9 Although the above conclusions appear robust, they do depend on the accuracy of the Vulcan, Monash and Guria estimates. Very little information is available regarding the margin for error of these estimates and this should be kept in mind when considering the above conclusions.

5.10 The assessment of the benefits of individual LTSA/Land Transport NZ and Police road safety outputs is discussed in the next section of this report.

6. Assessment of Benefits of Individual Outputs

6.1 The difficulties of distinguishing the effect of the three major factors at work - Enforcement and Compliance, Safety Benefits of Road Engineering Projects and Vehicle Fleet Crashworthiness Improvements – apply equally strongly to the issue of identifying the effects of the individual interventions that make up the SAP. However, it is useful to consider aspects of the way different interventions work because this does enable the effects to be isolated to a certain extent. This opens the way to assigning a range to the benefits which can be attributed to the different interventions or, more particularly, to the increases in funding implemented since 1999. In the specific circumstances of this evaluation it is useful to start by considering the effects of enforcement of restraint control, drunk driver control and speed control in that order and then to consider the other areas including visible road safety enforcement, commercial vehicle investigation and LTSA/Land Transport NZ expenditure.

Restraint Control

6.2 Before analysing the effect of other enforcement activities it is useful to clarify the extent to which the observed reduction in fatalities per 100K pop is attributable to greater use of restraints. For 2004/05 funding of restraint control was 77% higher than in 1999/00, with tickets issued being 127% higher. The intermediate outcome was an increase in the use of seat belts by front seat adults from 87% to 95% and substantial increase for rear seat adults from 58% to 86%.

6.3 LTSA/MOT has advised that the generally used estimate for seat belt risk reduction is that approximately 40% of casualties are saved by seatbelts. On

this estimate the 8 percentage point increase in the use of seat belts by front seat adults would be estimated to reduce casualty rates in this group by 3.2% compared to the 1997-99 base period. The 28 percentage point increase in the use of seat belts by rear seat adults would be estimated to reduce casualty rates in this group by around 11%. The contribution of rear seat adults to crashes is significantly smaller than that of front seat adults and so the expected overall reduction would be a little higher than the 3.2%.

6.4 For 2005 fatalities (per 100K pop) where the Police attending the crash assessed that seat belts were not worn were around 37% less than for 1997-99. This fall reduced the non-use percentage in car, van, truck and bus (CVTB) fatalities to a little over 24%. The high percentage of non-use indicates that those killed are not typical of vehicle occupants in general in regard to the percentage using restraints. A possible explanation is that the high non-use of belts reflects a high non-use among drivers killed with excess alcohol. If correct, this would indicate non-use among "non-alcohol affected" fatalities could be closer to the survey results.

6.5 Police assess use of belts would have avoided the following fatalities:

Effect if belts worn	**2005**	**Avg 1997-99**
Fatalities definitely avoidable	27	54
Fatalities possibly avoidable	31	24
Belts definitely not worn	78	114
Total CVTB fatalities	325	391

Thus fatalities that were definitely avoidable reduced by nearly 50%.

6.6 The conclusion from the above analysis is that a significant proportion of the reduction in fatalities between 1997-99 and 2005 is attributable to increased use of seat belts. No New Zealand data is available to identify the extent of savings in hospitalisation bed-days from increased use of seat belts, but the analysis regarding fatalities suggests substantial savings over the period 1997-99 to 2005.

Drunk and Drugged Driver Control

6.7 The next issue to consider is developments regarding alcohol as a factor in crashes. Funding of drunk driver control increased by 48% since 1997-99. The 9% increase in breath tests over the same period has been associated with significantly improved intermediate outcomes, namely a substantial reduction in the percentage of drivers over the breath limit in annual breath test surveys and a nearly 4% reduction in drunk driving offences detected by the 9% higher number of breath tests.

6.8 The fatalities outcome for 2005 includes a reduction in drivers killed with excess alcohol to 58 compared to 69 for 2004 and the 66 average for 1997-99 corresponding to rates per 100K pop of 1.42, 1.82 and 1.74 respectively. Fatalities assessed by attending Police as "alcohol involved" per 100K pop

were 2.85 for 2005 compared with 3.32 for 2004 and the 3.62 average for 1997-99. The overall fatalities with alcohol involved per 100K pop for 2005 and 2004 were 21% and 8% respectively less than the average for 1997-99.

6.9 Alcohol-related crashes and fatalities recorded a major jump between 2002 and 2003 but this was reversed by 2005. The more fundamental point is the intrinsic difficulty of reducing the road toll from excess alcohol. The issue is that the 1 to 1.5% percent of drivers who are over the breath limit (from surveys) are responsible for between 20% to 30% of fatal crashes and 12% to 15% of injury crashes. Drivers killed with excess alcohol are generally well over the limit rather than close to it and would be charged with an offence if breath tested. Surveys indicate that during the main drinking times around 1% of drivers are over the breath limit of 400 mgpl[17] with 2.2% registering as over 250 mgpl and 4.2% as over 150 mgpl[18].

6.10 The sharp difference in outcome between 2003 and 2005 is a warning regarding the difficulty of drawing conclusions regarding the benefit of the increased funding of drunk driver control. From an analytical perspective, however, the sharp fluctuation does provide some insight into the extent to which changes in the fatalities outcomes are attributable to the interaction between alcohol and other factors in particular speed as considered next.

Speed Control and Speed Cameras

6.11 Funding of speed control was $6.6M or 36% higher in 2004/05 than in 1997-99. In addition, expenditure on speed control was boosted by speed-related activities of the Highway Patrol (with overall funding of $26.7M) introduced in this period. Speeding tickets issued by Police officers nearly tripled and speed camera tickets also increased (despite a reduction in funding of the later of around $2.5M).

6.12 Speed survey results indicate a reduction in mean speeds of 4.7 kph (winter) for rural roads and of 3.2 kph for urban roads for 2005 (compared to the average for 1997-99). This has been achieved by a dramatic reduction in the percentage of drivers exceeding 110 kph (the current tolerance before a ticket is issued) from 20% to 5%. As the percentage travelling at or below 110kph increased, the average speed of this category remained virtually unchanged.

6.13 Total fatalities per 100K pop in 2005 were around 27% lower than the average for 1997-99. Fatalities per 100K pop for which attending Police assessed "too fast for conditions" was a contributing factor in 2005 were 21% percent lower than the average for 1997-99 and such crashes represented 32% of total crashes in 2005. The 2005 outcome represented a significant improvement from the situation in 2003 when fatalities from such crashes were only around 1.8% lower than the average for 1997-99.

6.14 Even where speed is not the cause of a potential crash, the speed at which a vehicle is travelling when a potential crash situation develops affects both the

[17] Micrograms of alcohol per litre of breath.
[18] Survey data for 2003.

prospects of avoiding the potential crash and the severity of the outcome if a crash does occur. Therefore, a range of studies have argued and tested the hypothesis that the mean speed of traffic is closely related to the frequency of crashes. According to a widely used rule of thumb a 1 kph change in mean speeds at around 100 kph is predicted to be associated with a 3% reduction in fatal crashes and some studies would argue that this understates the effect of speed[19]. The studies in which the relationship between mean speed and crash frequency has been derived have typically related to the effects of changes in speed limits. One challenge to such conclusions has been an argument that dispersion of speeds is a factor separate from mean speed in determining crash frequency. As it happens the reduction in mean speeds achieved since 1999 has also involved a compression of the speed distribution which in principle suggests that this particular reduction in mean speed should have, if anything, a stronger effect on crashes than the rule of thumb.

6.15 Based on the rule of thumb reported above, the 4.7 kph (winter) reduction in rural mean speeds would be predicted to result in a reduction in fatal crashes of 14%[20]. The effect of the 3.2 kph reduction in mean urban speeds would be smaller. The actual recorded reduction in rural and urban fatal crashes comparing 2005 with the average of 1997-99 was 27.5% and 33.5% respectively on a "per 100K pop" basis (and over 30% for rural fatal crashes on a per BVKT basis).

6.16 The rule of thumb is usually expressed as a relationship between the mean speed of all vehicles and all fatal (or all) crashes on the road or network for which mean speed is measured. In the present case the reduction in mean speed has been achieved by reducing the percentage travelling above 110kph with an unchanged mean speed for the increasing percentage travelling at or below 110kph. This does not invalidate the rule of thumb – indeed the compression of the distribution of speeds may enhance the effect. Rather than invalidate the rule of thumb, the implication is that the reduction in crashes is expected to come from a sharper reduction for the group where speed is reducing. The complication of the contribution of alcohol-related accidents makes it difficult to analyse the improvement fully however.

6.17 Police assessed for 2003 that in 29% and 25% of rural and urban fatal crashes and 50% and 41% of rural and urban injury crashes all vehicles involved were complying with the speed limit. As noted earlier, the mean speed of vehicles travelling within the current 110kph tolerance has remained virtually unchanged since 1997. This group has increased as the percentage travelling at higher speeds has been reduced from around 20% in 1997 to 5% in 2005. Speed limit enforcement has little or no effect on the speed of vehicles travelling within the tolerance speed or, therefore, on the number of crashes in this group, which, based on the 2005 survey, now includes 95% of vehicles in the rural roads. The potential gain from increased enforcement of the rural speed limit would appear to be constrained by the fact that only 5% are travelling above the tolerance limit. Reduction of the tolerance (or speed

[19] Nilsson developed a general relationship where by the number of fatal crashes varies as the 4th power of speed. For a 1 kph variation around 100kph this relationship suggests a 4% change in fatal crashes.
[20] Nilsson's formula would suggest a 10% to 14% reduction for rural crashes.

limits) would of course change this conclusion. If the tolerance is not changed and so potential further gains were thereby constrained, one issue would be whether the current compliance level could be maintained with less expenditure on enforcement. It is, of course, possible that compliance would deteriorate if expenditure was reduced, particularly given continued growth in traffic.

Visible Road Safety Enforcement

6.18 Funding of "Visible Road Safety Enforcement" which includes detection of a wide variety of offences has been reduced over the period to 2004/05 albeit that offence notices issued for dangerous and unsafe driving have increased somewhat. In contrast to areas such as drunken driving and speed control, it is difficult to assess intermediate outcomes in this area. The extent of crashes caused by failure to give way has attracted attention and a switch of resources to this area is underway. It is unclear whether the effects of this will be easily measured. Clearly, with 50% of rural injury crashes involving vehicles all complying with the speed limit (in 2003) and with 95% of surveyed vehicles travelling within the tolerance on rural roads by 2005, Visible Road Safety Enforcement might be important in reducing crashes in this large group. One way that Visible Road Safety Enforcement contributes to road safety outcomes is through the deterrence effect of enforcement. The issue regarding Visible Road Safety Enforcement is that measurement of the output being delivered and particularly of the results is more difficult to assess than for areas such as speed control where surveys demonstrate changes in actual driven speeds.

Commercial Vehicle Investigation and RUC Enforcement

6.19 Funding of commercial vehicle investigation and road user charge enforcement has increased by 35%. Truck crashes have been on a rising trend accounting for 17 or more percent of total fatalities. This reflects in part the increase in trucks usage of roads as well as the high lethality of such crashes. It is difficult to assess the effect of the increased funding particularly since enforcement of speed and other aspects is included in other outputs.

Incident and Emergency Management

6.20 Funding of "Incident and Emergency Management" is a substantial cost, being almost equal to funding of Visible Road Safety Enforcement". The largest item in this output is crash attendance and investigation costing $19.3M in 2004/05. The part of this expenditure that is discretionary is the reporting of crashes in detail and particularly the time spent on reporting of non-injury crashes. LTSA/MOT argues that this data is highly valuable in identifying black spots and assessing the effectiveness of interventions particularly as regards black spots. The cost of investigation is significant relative to funding of enforcement. A related issue is the variations in reporting practice that have distorted the time series of injury crashes. This change has been induced by a drive for more complete reporting. These issues may warrant a review of the framework for reporting.

Prosecutions and Sanctions

6.21 Funding for prosecutions and sanctions for 2005 at $10.8M was 249% higher than for 1999/00 reflecting the 77% increase in tickets issued by officers over the same period. This area of expenditure is "demand" driven. If the significant increases in compliance achieved in the speed and restraint areas are maintained and embedded, the level of expenditure on prosecutions may reduce somewhat but much of the expenditure relates to more serious cases of offending and as such the reductions may be limited.

LTSA/Land Transport NZ Expenditure

6.22 The largest items of LTSA/Land Transport NZ funding are Safety Information and Promotion, which was $20.4M for 2004/05, an increase of 32% from 1999/00, and Grants Management, which was $7.8M for 2003/04, and an increase of 181% from 1999/00. LTSA/Land Transport NZ analyse the public response to their advertising (and other information) campaigns in considerable depth and use this analysis in shaping overall strategy. Thus LTSA/Land Transport NZ employs market research to analyse public attitudes as a means to identify how interventions are working out in practice and how they and the supporting advertising campaigns could be more effective. Such surveys provide information on the effectiveness of advertising in improving acceptance as well as views regarding the likelihood of detection of infringements. The research also provides early warning that public acceptance of the causal relationship between crashes and causes such as alcohol is changing. LTSA/Land Transport NZ note that the surveys indicate that acceptance of the causal relationships and expectations of detection of infringements erode in the absence of advertising. These results do support the contention that advertising directly affects the success of educational activities and of enforcement. The increase in enforcement activities over recent years has been accompanied, appropriately, by a focus on advertising directed as raising awareness of compliance. In combination with the actual increased enforcement, the advertising appears to have been successful in substantially raising expectations that infringement will be detected. The focus on increasing awareness of enforcement in the recent period may have been at the expense of acceptance but LTSA/Land Transport NZ is moving to address this.

6.23 The evidence that public awareness of enforcement and acceptance of causal relationships erodes if not supported by advertising is clear. However, there is no easy way to assess how awareness and acceptance translates into intermediate outcomes such as reduced travel speeds and the overall outcome of crashes, fatalities and injuries. The market research data in principle provides information relevant to this assessment but would require extensive analysis to extract results.

7. Conclusion

7.1 This report analyses the developments in road safety outcomes comparing outcomes for 2005 for the period 1997/99. As noted the results may be

influenced by statistical fluctuations affecting the 2005 outcomes, although the data on outcomes for 2006 now becoming available have not indicated any conspicuous issues regarding the 2005 data.

7.2 The analysis of intermediate outcomes – mainly based on compliance surveys – suggests that the increased expenditure on compliance and enforcement as part of the Road Safety to 2010 Strategy has achieved significant improvements in compliance in areas such as speed and wearing of restraints.

7.3 In order to assess the effects on overall road safety outcomes a number of issues need to be considered. In this report the focus of the analysis is on data on outcomes which has been adjusted to recognise the increase in traffic volumes. Taking into account that adjustment, the level of fatalities and serious injuries has reduced considerably. The level of reported minor injuries, and ACC claims has, on the other hand, increased. Consequently, the social cost of road crashes (as calculated by LTSA/MOT) and adjusted for traffic volumes has been reduced but by significantly less than the reduction in fatalities (when adjusted for traffic volumes).

7.4 The attribution of the improvement among the three major factors of Enforcement and Compliance, Safety Benefits of Road Engineering Projects and Vehicle Fleet Crashworthiness Improvements is difficult. Analysis of this issue, based on consideration of independent estimates of each factor's role, suggests that each factor has played a significant role. Importantly, given this report focuses on the contribution of increased SAP expenditure, the analysis appears to confirm that the increased SAP expenditure under the Road Safety to 2010 Strategy has had a significant effect in reducing fatalities.

7.5 There are two key issues for further work arising from the analysis in this report. The first is the need to clarify, if possible, whether the increase in the total number of reported injuries (after adjusting for traffic volumes) is a real increase or is the result of changes in practices regarding hospital admissions, ACC claims and Police reporting. The second is the desirability, to the extent resources and information permits, of an ex-post analysis of the safety benefits of road engineering projects and also the actual achieved crashworthiness improvements in the vehicle fleet. Improved confidence in the estimates of the contributions of these factors to road safety outcomes would greatly facilitate assessment of the achievements of the Road Safety to 2010 Strategy.