

ROAD IMPROVEMENTS AS A ROAD SAFETY COUNTERMEASURE

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30 June 2003

1. A BRIEF STATEMENT OF THE ISSUE

It has been estimated that maintaining current road improvement programs in Australia will result in 453 lives saved per year by 2010.¹ This saving is equivalent to 25.6 per cent of the 1997 road fatality toll.

This paper aims to estimate the crash reductions and cost-benefits associated with specific types of road treatment used in black spot programs throughout Australasia, and to report on emerging approaches in road engineering.

2. AN ASSESSMENT OF THE ROAD SAFETY ISSUE

2.1. The development of black spot programs in Australasia

Locations with abnormally high numbers of crashes have been defined as *black spot sites*.² Black spot treatments entail the application of engineering measures aimed explicitly at reducing crash numbers and/or crash severity.³

- at a specific site or section of road
- along a route with high crash numbers
- area-wide, encompassing a collection of roads and streets that collectively have high crash numbers
- through mass action, whereby a known remedy is applied to a wide spread of locations with common crash problems.

Victoria introduced Australia's first so-called black spot program in 1979 on a modest basis (about \$0.4 million with four treatments implemented in the first year).⁴ The funding and scale of operations increased substantially over the next two decades, such that Victoria currently has a State black spot program comprising \$240 million for the period 2000/2001 to 2003/2004.

On 1 July 1990 the first national black spot program commenced as part of a 10-point package of road safety measures. Federal government support has continued, with the current four-year program having started in the 2002/2003 financial year.

State and Territory black spot programs are now commonplace throughout Australia and the terminology has also been widely applied to many road improvement programs at local government level.

New Zealand's crash reduction study programme was established in 1985. In 1989, the LTSA developed a monitoring system to collect data on the treated sites in order to analyse the effects of the programme. The monitoring system consists of both site data and information on works which are implemented at each site, which are then matched to crash data at each site for selected time periods.

2.2. On-going road improvement programs in Australasia

Capital works expenditure on roads in Australasia is given to general improvements and upgrades, particularly to improve vehicle mobility and to reduce congestion, to improve accessibility and to improve the efficiency of freight movement. While safety is usually not the prime priority, these improvements may produce safety benefits. For example the duplication of major routes to separate high-speed traffic travelling in opposing directions serves both mobility and safety functions. Safety improvements, although usually on a small scale, may also result from general maintenance programs.

2.3. The relative safety contributions of black spot vs. general road improvement programs in Australasia

It has been estimated that:

- for each \$100 million spent, black spot programs will save at least 20 lives
- for each \$100 million spent, general improvement programs will save at least 1.5 lives.¹

The same authors have also estimated that, by 2010, the number of fatalities prevented per year in Australia as a result of road improvements will be 453:

- 144 saved from black spot expenditure
- 309 saved from general improvements expenditure.¹

“If it is decided that, during the next decade or so, safety should be given more priority than mobility, then some expenditure could be reallocated from projects in the (general improvements) category to those in the (black spot programs). Such reallocation would also be likely to occur automatically if ‘willingness to pay’ were used to calculate the statistical value of a human life ... rather than the present ‘human capital’ method. If such reallocation of expenditure did occur the number of fatalities saved per \$100 million invested in all road construction would increase”.¹

3. A REVIEW OF THE RESEARCH

3.1. How effective are black spot programs?

From the very outset black spot programs have been rigorously evaluated, whether at jurisdictional or national level. To give three recent examples:

- The 1992-1996 program in Victoria showed a reduction of 26.4 per cent in casualty crash numbers and a reduced casualty crash cost of 29.6 per cent at treated sites.⁴ Over its full life, the program will return benefits worth 4.1 times the program costs (rising to 5.1 times if seven high-cost treatments funded by the program for additional, non-safety reasons were excluded). These findings are in broad agreement with previous evaluations of earlier versions of the program.^{5,6}
- The 1996/1997-2001/2002 Federal black spot program showed casualty crash reductions of 31.2 per cent and 48.2 per cent at metropolitan and other sites, respectively, during the first three years.³ The overall benefit-cost ratio was 14:1. Again, these positive outcomes, at least in their general direction, were in accordance with earlier evaluations.²
- As at March 2003, NZ’s programme has been credited with achieving reductions of 34 per cent in injury crashes at the treated sites. This reduction corresponds to an estimated saving in social cost of approximately \$3 billion (at June 2002 prices) using the willingness-to-pay values of statistical life and injury.

As might be expected, the specific measures of effectiveness vary from study to study according to the criteria used for selecting sites, the suitability of the treatments selected, the balance of treatments implemented, the pre-treatment crash levels, the duration of the post-treatment periods used in gathering 'after' crash data and so on. Again, considering the 1992-1996 program in Victoria and its sub-programs, it was found that sub-programs that were more systematically developed and based on proven treatment types had a greater impact on crashes and showed higher economic benefits per dollar invested, relative to sub-programs using less rigorous procedures.⁴

3.2. How effective are individual types of treatments in reducing crashes?

The two recent evaluations cited above^{3,4} have also been used to indicate the possible impact of individual treatments on casualty crashes. Treatments that returned a significant change in casualty crashes, at least at either an urban or rural level, in at least one of the studies, are listed in Table 1 (over page).

At a total program level, both evaluations have shown reasonably consistent results, with the national results being somewhat higher for both urban and rural areas.

Looking just at the results of the Victorian program, intersection treatments (roundabouts, signal remodelling, new signals, etc.) and route treatments (pavement resealing, road delineation, shoulder sealing, etc.) had the biggest impact on crash levels. Equivalent grouped data were not available for the national study but it appears that the intersection treatments were the best performed.

Table 1 also suggests that general program benefits were greater in rural areas, compared to urban results:

- For Victoria, this difference in benefits was consistent at both program and most treatment-type levels – but in no instance was statistically significant. The only type of treatment that seemed more effective in urban areas was the collection of intersection treatments, but again, the differences were not statistically significant.
- The overall program benefits at a national level were also greater in rural areas. However, the differences were not tested for statistical significance.

Table 1: Casualty crash reductions attributable to the TAC Victorian or to the Federal black spot programs.

Treatment	Casualty crash reduction (per cent)			
	TAC program in Victoria, 1992-1996		Federal black spot program, 1996/1997-2001/2002	
	Urban	Rural	Urban	Rural
WHOLE PROGRAM	23.5	30.6	31.2	48.2
TYPE OF TREATMENT				
1. Intersection treatments	27.8	26.9		
2. Pedestrian facilities	8.8*	46.4*		
3. Route treatments	22.6	30.8		
4. Treat road features	3.5*	15.3*		
TREATMENTS				
Roundabout	72.3	67.4	69.9	75.1
Signal remodel – controlled right turn	25.8	5.7*	42.9	37.3
New signals	34.6	7.0*	47.1	76.0
Other intersection improvements	17.4	11.5*		
Pavement re-sealing (route)	56.2	30.4*	37.5	-26.7*
Roadway delineation	59.6	25.7	-7.0*	33.4
Curve realignment	-43.43*	74.9		
Shoulder sealing	15.6	38.4	12.8*	28.8
Pavement widening	30.9	37.0*		
Signs			15.8*	53.8
Lighting	11.2*		-26.9	63.2

NOTES: * indicates that a change was not statistically significant. Other changes were significant; The Victorian program used post-treatment casualty crash histories of between 2.5 and six years, depending on the implementation dates of individual treatments; the national program used a sample of 608 black spot treatments implemented during the first three years of the program. It was not possible from the report to determine the length(s) of the post-treatment crash histories. Specific treatment details and definitions may vary across the two studies.

The benefits of the individual treatments in reducing crash numbers varied across the two studies, in terms of exact measurement and sometimes in terms of direction of change. However, overall, there was reasonable consistency in the results:

- roundabouts – showed crash reductions at least at the 70 per cent level
- introduction of fully-controlled right-turn phases at intersection signals – in three of the four instances showed reductions in excess of 25 per cent
- new signals – which in three of the four instances showed reductions of 35 per cent or more
- pavement re-sealing in all four instances showed reductions exceeding 25 per cent (although in two instances the reductions were not significant)
- roadway delineation – in three of the four instances showed reductions of 25 per cent or more
- shoulder sealing – which in all instances showed reductions of 13 per cent or more (although in one instance the reduction was not significant).

3.3. Cost-effectiveness of individual types of treatments in reducing crashes

The various treatments implemented as part of the 1992-1996 Victorian black spot program were analysed to estimate benefits and costs over the life of each treatment. Treatments that returned benefit cost ratios exceeding 1.0 at 95 per cent confidence levels, are listed in Table 2.

Table 2: Estimated benefit:cost ratios returned by the TAC black spot program.

Treatment	TAC program in Victoria, 1992-1996, Benefit:cost ratio		
	Point	Lower CL	Upper CL
WHOLE PROGRAM:	4.1	3.3	4.8
	5.8	4.6	6.8
TYPE OF TREATMENT			
1. Intersection treatments	5.3	3.8	6.6
2. Pedestrian facilities*	1.9	-9.6	7.8
3. Route treatments	5.8	4.3	7.2
4. Treat road features*	7.9	-7.4	20.3
TREATMENTS			
Roundabout	5.2	4.1	5.8
Signal remodel – fully controlled right turn	12.6	5.6	17.7
Other intersection improvements	8.9	2.7	13.6
Pavement re-sealing (route)	18.3	1.9	24.4
Roadway delineation	32.8	21.7	42.5
Shoulder sealing	4.3	2.7	5.7

NOTE: * indicates that benefit cost ratios were not significantly above 1.0. Other changes were significant; the two sets of ratios for the whole program respectively include and exclude the 7 high-cost non-safety treatments.

Excluding the non-safety treatments, the total program yielded a benefit:cost ratio between 4.6 and 6.8, due particularly to the effectiveness of its intersection and route treatments. Specific treatments provided even more positive results, although the confidence levels were usually considerably wider.

3.4. The need to qualify the relative crash-reduction and economic comparisons

It needs to be stressed that the above comparisons need to be treated as indicative only. To repeat a previous point, specific measurements are likely to be influenced by at least the following considerations:

- the criteria used for selecting sites
- the severity of the initial problem, reflected in 'before' crash levels
- individual site circumstances
- the suitability of the treatments selected and the completeness of implementation

- the balance and number of treatments implemented
- the duration of the post-treatment periods used for collecting ‘after’ crash data.

Further, it is likely that, as successive black spot programs are implemented, there will be some diminution in the benefits as increasingly difficult sites and/or sites with lower ‘before’ crash levels find their way into the programs.

It needs also to be recognised that some individual treatments failed to show significant reductions in either study and were not included in Table 1 (examples included school-crossing warning signs and street lighting). These treatments may have failed to produce statistically significant benefits for a number of reasons, and in different circumstances may prove to be better performed.

3.5 New directions for improving roads

Specific treatments within black spot programs, or as part of more general road improvement programs, have resulted in road safety improvements throughout Australasia. At the same time, emerging priorities in this area will require road and traffic engineers to take more explicit account of:

- the limitations of humans in being able to survive the violent forces experienced in many road crashes
- the changing but still limited capability of vehicles to protect occupants in the event of crashes
- the inherent crashworthiness of the road infrastructure
- most importantly, the role of speed in crash and injury risk.

It is expected that, in the future, intrinsically safer road infrastructure will be created through attention to the overall crashworthiness of the system – be it through infrastructure design, systems operation or both. Well-designed barrier systems on high-speed roads represent one specific and current example of improved infrastructure design, enabling the separation of traffic moving in opposing directions and the prevention of impacts with roadside trees and poles.

4. POLITICAL, SOCIAL AND OTHER FACTORS

Formal road design standards exist to promote effective, efficient and safe movement on road networks. These standards need to address multiple objectives, including:

- providing adequate access and mobility
- ensuring that the system has adequate safety standards
- ensuring that the system does not have undue environmental impact
- efficiently moving people and goods to maximise society’s economic performance.

In balancing these various objectives, safety standards are frequently compromised to ensure that, in particular, high standards of mobility and accessibility are met. To state it more abruptly, fatalities and serious injuries are often implicitly regarded as an inevitable price to be paid for mobility. Consider for example the title of the following presentation: “Why the road toll is no accident – we have designed it so”.⁷

There is often a reluctance by engineers to implement safety changes that may compromise mobility, particularly if the road is in full compliance with existing design standards. However, the major difficulty in implementing safety improvements is undoubtedly due to financial considerations – and hence the importance of road safety auditing at the planning and design stages as a cost-saving measure.

Customarily, road treatments in a black spot program have been required to promise at least a 2:1 benefit:cost ratio. However, society's willingness to invest in safety-driven road improvements is ultimately a value judgement rather than an economic decision. Sweden's Vision Zero, for example, maintains that it is unethical to consider human life and health as tradeable: the system must place priority on preventing death and serious injury ahead of all other considerations, even if this entails radical changes to the current road and traffic system.⁸

5. CONCLUSIONS

Over the last 20 or so years in Australasia, there has been a growing awareness of the importance of the road infrastructure in determining safety outcomes. The existing road engineering standards are no longer entrusted to deliver the required levels of safety and, increasingly, targeted black spot programs are being implemented.

Accident black spot programs involve a systematic identification of high crash locations across the road network, followed by targeted engineering treatment of hazardous locations. Evaluations have consistently shown that these programs reduce casualty crashes by in the order of one quarter to one third, and that these gains are typically accompanied by reductions in the severity of injuries sustained when crashes do occur. Economic evaluations have shown that positive benefit:cost ratios (typically five to eight times the initial investment costs) are returned.

It also needs to be recognised that black spot programs, however effective, are essentially reactive: sites are selected for treatment only after experiencing high numbers of fatalities and serious injuries. Arguably, future improvements to the road network will be best achieved through a number of strategies, at least some of which need to be preventive – with high quality road safety auditing being foremost amongst these strategies.

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