Towards Safe System infrastructure investment on New Zealand roads – a technique for maximising serious trauma savings

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Abstract

The Macro Estimates for Target Setting (METS) modelling technique developed at MUARC has been used extensively to estimate the savings in serious casualties (fatalities and seriously injured) for road safety strategies in a number of Australian states and territories. In this application, the New Zealand Transport Authority (NZTA) sought to focus specifically on exploring opportunities for improved road safety outcomes for the nation's road infrastructure investment programs. METS was adapted to investigate several scenarios involving not only reallocating expenditure among existing programs, but also the introduction of three new "Safe System Transformation" programs. These programs, involving a notional amount of up to NZ$100m of investment per annum, targeted serious casualties at urban intersections, rural intersections, and head-on and run-off-road crashes on rural routes. Between 2007 and 2009, these three categories comprised half of all serious casualties on New Zealand roads.

New techniques were developed, consistent with Safe System principles, for maximising serious casualty savings at intersections and along routes, using the comprehensive crash data available from the NZTA. Each of the three scenarios was predicted to prevent between 1000 and 1700 additional serious casualties compared with the 'business-as-usual' case over a ten-year period.

This paper illustrates the application of the optimisation process for serious run-off-road crashes on rural routes.

Key words: strategy modelling, road safety, road infrastructure investment, serious trauma, METS.

1. Introduction

The Safer Journeys road safety strategy for New Zealand targets "a safe road system increasingly free of death and serious injury" (Ministry of Transport, 2010). One of the priority areas identified in the document is to focus safety improvement programs on high risk rural roads and high risk urban intersections.

The objectives of this project were to assist the NZTA to develop investment strategies and levels of service for the NZ State Highway network targeting infrastructure improvements. The existing investment strategy was modelled, along with the assessment of refocused and enhanced strategies to examine the performance that could potentially be achieved through greater levels of investment, and the introduction of innovative new programs more closely aligned with the goals of the Safe System.

The Macro Estimates for Target Setting (METS) model was developed initially to assist with the development of the Victorian, '*arrive alive!*' road safety strategy. METS is an advanced, semi-automated Excel workbook with a number of linked worksheets. The model is a numerical implementation of concepts developed in the late 1990s by Peter Vulcan (e.g. Vulcan & Corben, 1998). It starts with a base number of annual serious casualties (killed and hospitalised) derived generally from police-reported data. The effectiveness of individual countermeasures in reducing the proportion of total serious casualties – based upon appropriate scientific studies – is used to predict serious casualty numbers from the effects of the countermeasure in isolation by year for the duration of the strategy. Overall trends are also taken into account by modelling the underlying effects of both traffic growth (in vehicle kilometres travelled) as well as other effects not easily quantifiable individually but able to be determined from trends in serious casualties per vehicle kilometre travelled. Countermeasures are then combined into strategy 'packages', either additively or multiplicatively, the latter avoiding double-counting of savings when different initiatives act upon the same 'pool' of serious casualties.

A unique feature of the METS model is its ability to allow different levels and combinations of initiatives to be relatively easily compared and adjusted, some 'on-the-fly'.

One of the components of the overall project was a 'Safe System Transformation' (SST) of rural routes. Head-on and run-off-road crashes in rural areas made up around one-third of all deaths and seriously injured persons between 2007 and 2009. In contrast to the traditional 'Black Spot' approach, where individual locations or isolated road lengths are selected for treatment on the basis of their crash history, the SST approach aims to effectively common and foreseeable driver errors along entire rural routes, with respect to serious injuries. While flexible roadside and mid-barriers shape as the most effective means of achieving Safe System performance for these high priority categories of road trauma, clearly it is not feasible to install full flexible barrier protection throughout the entire rural network in the short term. Hence, an optimisation process was developed that, rather than specifying a threshold for treatment in terms of BCRs, ranked road sections in decreasing order of treatment priority as measured by numbers of serious casualties able to be saved per unit of investment.

2. Source data

A dataset was provided by MWH Global, on behalf of the NZTA. An Excel spreadsheet comprising every state and local rural route in the country, divided into 10 km sections, was generated. In total, 10,944 km of road were included, collectively sustaining a total of 1234 serious and fatal head-on and run-off-road crashes over the most recent available five-year period. Head-on crashes predominated, making up 60% of the total.

3. Optimisation process

3.1. Determine treatment effectiveness

The optimisation process consisted of a number of steps, as detailed in the following sections. Three different barrier configurations were submitted to the optimisation process:

(a) Side barrier, comprising two continuous runs of flexible barrier along the outer edges of the carriageway, along with provision for shoulder sealing where necessary;
(b) Mid-barrier, consisting of a single continuous run of flexible barrier, along with widening and shoulder sealing where necessary;
(c) Combined mid- and side flexible barrier (three continuous runs).

Side barrier was assumed to prevent 80% of serious and fatal run-off-road crashes, mid-barrier 40% of run-off-road (to the right only) and 80% of head-on crashes and the combination of both, 80% of all head-on and run-off-road crashes.

The barrier configurations, (a) and (b) above, are not truly Safe System, but rather major steps towards Safe System performance. Therefore, in these cases, careful monitoring of future road safety outcomes will be needed to determine whether further barrier installation would be required to meet the full aspirations of the Safe System.

3.2. Optimise treatments

The first step in the optimisation process was to rank the dataset of road sections in decreasing order of total head-on and run-off-road crash incidence, ensuring that the sections with the greatest serious crash problem are addressed first. Then, for each section, the estimated number of serious casualties saved per annum was calculated for each of the three barrier options, along with the corresponding costs. This permitted calculation of the cost effectiveness by option, quantified in serious casualties saved per annum per NZ$100m of investment. Finally, the most cost-effective option was chosen and designated for each section.

Using proposed annual investment levels over the planned ten-year strategy duration, investment funds could be allocated down the list, recommending the sections to be treated each year.

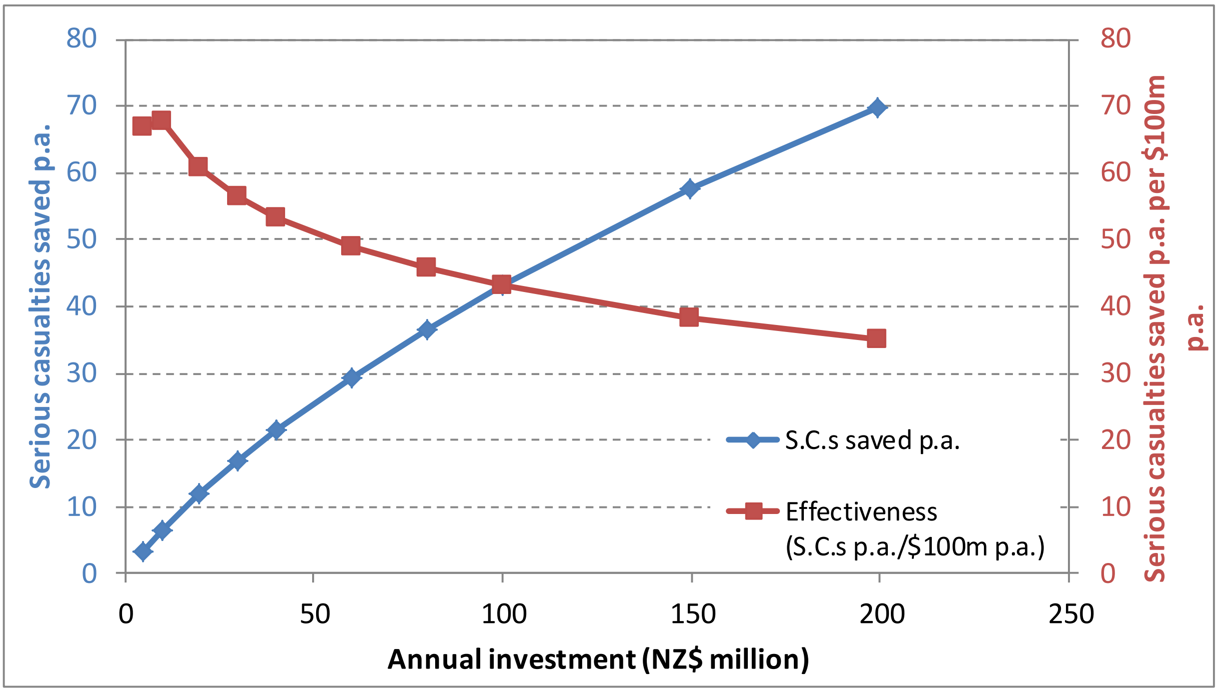
4. Results

To demonstrate the method, typical barrier costs were nominated for each of the treatment types, guided by the NZTA. Note that these costs assume that shoulder sealing would be necessary to facilitate barrier installation and that these costs would be reduced significantly – and coverage increased substantially – if installation could be effected with either no or a seal of less than one metre in width.

- Side barrier: NZ$700,000 per km;
- Mid-barrier: NZ$800,000 per km;
- Combined mid- and side flexible: NZ$1,500,000 per km.

A range of annual investment levels was input into the optimisation model, yielding the results shown in Figure 1 below.

Figure 1. Annual serious casualties prevented and treatment effectiveness.



Clearly, serious casualties saved increase with increasing investment level, but the ordering of the sections from worst to best means that the slope flattens as it rises. Treatment effectiveness peaks at the small investment levels where the worst of the problem is addressed and drops away as more of the network is covered. In the project conducted for the NZTA, an investment level of NZ$84m per annum was used from the larger budget allocated to the Safe System Transformation sub-programs, yielding a good balance between effectiveness and coverage. At this level, a total of 380 serious casualties were projected to be saved over ten years with a total of 1070 km of barrier, made up of 910 km of mid-barrier and 160 km of side-barrier. Average effectiveness was 45 serious casualties saved per annum per NZ$100m of investment, comparable with other current programs undertaken by the NZTA.

For the overall project (Corben, Logan, Healy and Mulvihill, 2011), several options were explored, yielding estimated additional serious casualty savings of between 2500 and 3400 compared with 'business-as-usual' over the ten-year strategy life at similar levels of expenditure. Furthermore, estimated costs per serious casualty saved were projected to be 32-39% lower than business-as-usual.

Figure 2 shows the relationship between length of barrier fitted over the ten-year strategy duration and investment level.

Figure 2. Total length of barrier fitted over 10 years by barrier type. Note that with the current crash distribution and barrier costs, full side plus mid barrier protection was never the most cost-effective choice.

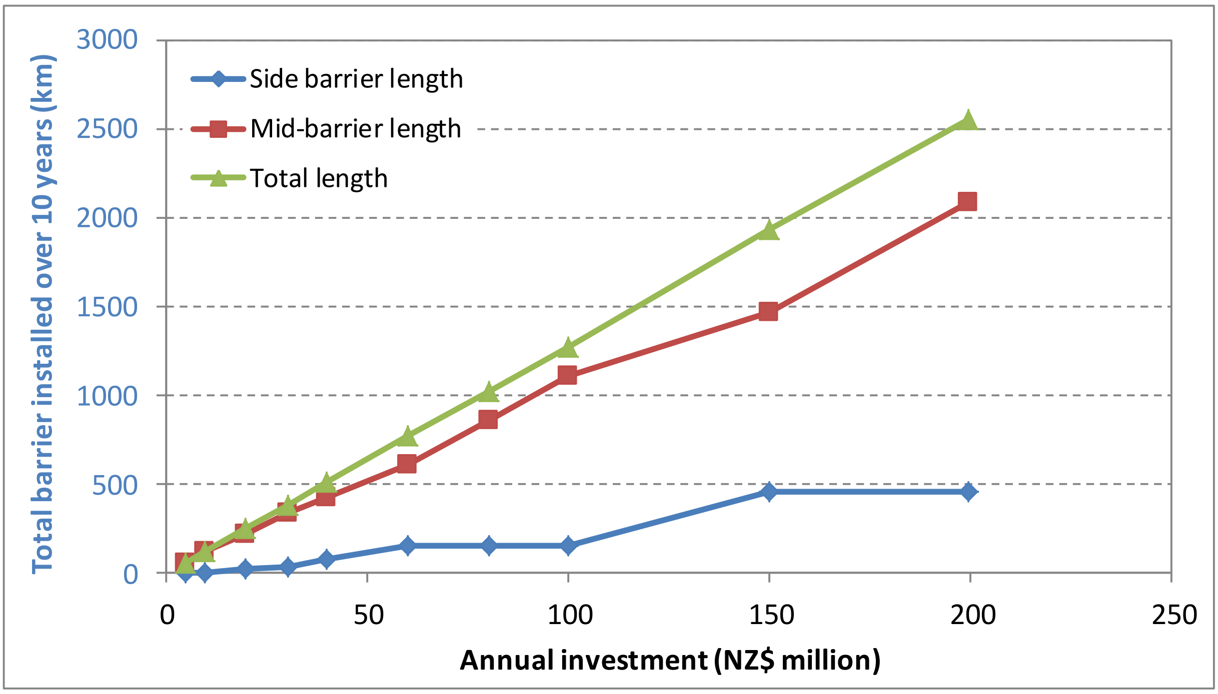


Figure 2 shows that for the first 1270 km of road length, mid-barrier is the most cost-effective, forming the majority of total length recommended for fitment (1110 km). The next 750 km of rural route lengths to be treated then experience a higher proportion of run-off-road crashes, with side barrier increasing to 460 km of 1930 km in total at an annual investment level of NZ$150m over ten years. With the serious crash distributions observed, coupled with the relative costs of the different treatments, full side and mid-barrier was never identified as the most cost-effective of the three options.

5. Discussion

This work highlights that it is critically important to minimise the overall cost of barrier fitment to maximise the coverage and effectiveness of rural route treatments. The total cost of flexible barrier implementation is heavily influenced by the cost of shoulder sealing. Innovative installation techniques to minimise this need for shoulder sealing, without compromising barrier performance, will significantly boost cost effectiveness levels, as would the adoption of specialised barrier installation equipment such as that used in Europe. An example of this equipment in operation on Swedish roads is shown in Figure 3, below.

Figure 3. Specialised barrier installation equipment.

This study showed a way by which a comprehensive road asset dataset can be used to optimise road infrastructure safety investment, with NZTA to be commended on the level of detailed road data available for this exercise.

This study was a preliminary exercise and has a number of restrictions and limitations. First, only Safe System solutions were considered and the basic assumption was made that all of the roads included in the exercise were of a similar level. Future optimisations could include interim measures such as tactile edgelining and shoulder sealing alone, as well as take account of the level of safety infrastructure already fitted, where this information is available. Another possible future inclusion to improve the model would be to allow costs to be varied by road section to reflect specific geographic and topographical challenges. In this exercise, the optimisation process was limited to Safe System solutions, given the stated commitment of the Safer Journeys strategy to this new and more ambitious vision.

6. Conclusion

This paper briefly describes a method for selecting and optimising the fitment of flexible barrier along a complete network of rural routes, allowing available investment levels to be directed to yield the greatest numbers of serious casualties saved.

Rather than using a ‘threshold’ approach, where sections have to fulfil a set of criteria in order to warrant treatment, the method instead ranks every road section so that the most dangerous sections from a historical viewpoint are treated first.

This study also adopted a more ambitious aim, in line with the Safe System road safety vision, of dramatically reducing the risk of death or severe injury as a result of the most common crash types occurring along New Zealand’s most problematic rural routes. It does not operate on a highly reactive approach, in which only those sections of road with a demonstrated crash history over recent years and a benefit-to-cost ratio above a minimum value are eligible for treatment. Instead, it acknowledges that run-off-road and head-on crashes are large, entrenched sources of death and serious injuries on New Zealand’s major rural roads and that the location of crash occurrence is, to a large extent, random. Thus, our current knowledge leads us to conclude that to achieve Safe System performance we must be willing to crash-proof entire lengths of rural road, regardless of the spatial occurrence of crashes over recent years. In reality, there are few locations where a vehicle travelling at normal rural speeds, for example 100 km/h, can have a head-on crash with another vehicle, or leave the road, and expect to be able to protect its occupants from death or severe injury, given the predominance of unforgiving features characterising rural roadsides in New Zealand, and indeed, Australia.

It is acknowledged that this technique does not lead necessarily to full Safe System for all barrier configurations analyses, but rather highlights the practical considerations associated with making real progress towards Safe System ideals. Pursuing this approach in the long term will result in an order of magnitude reduction in serious casualties on New Zealand’s highest priority routes.

This first iteration of the technique has the potential to be improved and/or made more comprehensive, through the inclusion of alternative treatment types and additional optimisation variables to further improve its utility.

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