

SafetyNET – Breathing Life into Road Safety Analysis

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Abstract

Road controlling authorities put great effort and expense into collecting large quantities of high-quality transport related data. However, the true value of this data is often unrealised because of the narrow range of applications for which the data is used. Abley Transportation Consultants is adding value to the New Zealand Transport Agency and local government organisations by bringing together a variety of transport datasets and combining it with industry knowledge inside a geospatial environment to improve road safety.

This paper describes SafetyNET, an innovative online interactive road safety tool that Abley Transportation Consultants has developed for the New Zealand Transport Agency. SafetyNET allows the New Zealand Transport Agency and its consultants to readily identify those parts of the State Highway network where road safety performance is good or poor compared to national averages, where it is out of character with the expected safety performance, and where it has engineering and operational features that suggest it may be a high risk site in the future. By displaying this information in a spatial manner, users of SafetyNET and funding agencies can effortlessly identify those high risk parts of the State Highway network that warrant attention and target their investigations and investments accordingly.

This paper will be of interest to everyone involved with the targeted identification, prioritisation and funding of road safety improvements, and those seeking to unlock the true value of transport datasets.

Key words: Abley Transportation Consultants; SafetyNET; NZTA; KiwiRAP, spatial analysis; GIS; safety performance; value for money; risk profile.

1. Introduction

1.1. Changing the approach to road safety in New Zealand

Safer Journeys, New Zealand's Road Safety Strategy 2010-20 has a vision to provide a safe road system increasingly free of death and serious injury. It adopts a safe system approach to road safety focused on creating safe roads, safe speeds, safe vehicles and safe road use (MoT, 2010). These four safe system pillars need to come together if the Government's vision for road safety is to be achieved.

Improving transport infrastructure to create a safe road environment is one method for reducing the number of people killed and seriously injured on New Zealand's roads. However, the traditional approach to treating crash sites in New Zealand has been to focus efforts on reducing crash occurrence at sites with the greatest number of observed crashes. This reactive approach to road safety has often been the subject of criticism by the general public. "Do we have to wait until someone dies or is seriously injured before this gets fixed?" is an all too common phrase.

The Government has sought to redress this reactive approach over the past decade through their support of proactive and risk-based industry initiatives, such as crash prediction modelling, Road Infrastructure Safety Assessments (RISA) and Road Safety Risk Manager (RSRM). Some of the initial actions of Safer Journeys have already been produced,

including the publication of the 'High-Risk Rural Roads Guide' and the 'High-Risk Intersections Guide'¹. These guides shift away from the wholly reactive approach to road safety and provide a better balance between performance (reactive) and risk (proactive) profiling approaches.

Despite these measures to move towards a more proactive approach to road safety, the NZTA's Investment Revenue Strategy 2012 – 2015 categorises proposed projects in terms of their strategic fit, effectiveness and economic efficiency by activity class. For the activity classes of 'New and improved infrastructure for state highways' and 'New and improved infrastructure for local roads', a road safety project will only be considered a high strategic fit if there is potential to reduce the 'actual' crash risk on / at a high-risk rural road, high-risk urban intersection, high-risk motorcycle route or safe system demonstration project (NZTA, 2012). An 'actual' crash risk is defined as a site with an observed history of fatal or serious crashes above a defined threshold. This creates a disconnect between the Government's support of new techniques to address road safety issues and the NZTA's Investment Revenue Strategy that funds those projects.

1.2. Implementing Safer Journeys

The High-Risk Rural Roads Guide is one of the first actions of Safer Journeys (MoT, 2011). It incorporates a number of safety initiatives produced by the NZTA in recent years, including KiwiRAP where Risk Maps and Star Rating protocols have been produced. KiwiRAP is part of an international family of Road Assessment Programmes (RAP) under the umbrella of the International Road Assessment Programme (iRAP).

Road Assessment Programmes internationally consist of three protocols.

1. **Risk Mapping** – uses historical traffic and crash data to produce colour-coded maps to illustrate the relative level of risk on sections of the road network.
2. **Star Rating** – road inspections look at the engineering features of a road (such as lane and shoulder width or presence of safety barriers). Between 1 and 5 stars are awarded to road links depending on the level of safety which is 'built-in' to the road.
3. **Performance Tracking** – involves a comparison of crash rates over time to establish whether fewer or more people are being killed or injured and determine if countermeasures have been effective.

The Risk Maps published in the document 'KiwiRAP How Safe Are Our Roads?' (NZTA, 2008) are based on traffic and crash data for the five-year period between 2002 and 2006. The report includes all State Highways in New Zealand with a speed limit of 80km/h and above.

Two measures of risk based on traffic and crash data are published, namely:

- **Collective Risk** is based on the average annual number of fatal and serious crashes occurring per kilometre of State Highway.
- **Personal Risk** is based on the average annual fatal and serious injury crashes occurring per 100 million vehicle kilometres travelled.

Star Ratings measure and rate the safety of roads by considering a number of built-in road and roadside features. It involves a thorough visual assessment of many road and roadside features including but not limited to: lane and shoulder width, horizontal alignment, sight distance, and the location and nature of roadside objects. The visual assessment is carried out and recorded at 100m intervals while the published Star Ratings are reported on segment

¹ The High-Risk Intersections Guide' was in the process of being finalised, following receipt of submissions on the consultation draft, at the time of writing this paper.

lengths of at least 5km (KiwiRAP, 2010). The detailed Star Rating information is recorded in the NZTA's KiwiRAP Analysis Tool (KAT). KAT enables road safety practitioners to search road segments of interest, identify the factors contributing to the Star Rating score and carry out 'what-if' analyses to understand how the Star Rating score would change from a road safety improvement project.

Star Rating is a predictive measure of the personal safety on a road segment. Research published in the High-Risk Rural Roads Guide shows there is a strong correlation between the Star Rating and crash performance. However unlike Risk Mapping, Star Ratings do not take into account a road's crash history. Accordingly, Star Ratings can be seen as a proactive approach to identify where crashes may occur in the future.

1.3. Defining high-risk rural roads

The New Zealand Transport Agency's High-Risk Rural Roads Guide defines a number of assessment techniques and risk metrics to determine whether a road is a 'high-risk' road.

High-risk rural roads are lengths of road with a higher than average crash risk, and by implication are roads where targeted safety improvements are most likely to reduce trauma on New Zealand's roads. High-risk rural roads provide an opportunity where the greatest reduction in severe casualties can be achieved, which is why they represent one of the Government's highest priorities for investigation (MoT, 2011)

The High-Risk Rural Roads Guide defines a rural road as being high-risk when:

- The current **Collective** (fatal and serious crash density) or **Personal** (fatal and serious crash rate) Risk Rating is 'Medium – High' or 'High'; and/or
- The **Collective** (fatal and serious crash density) or **Personal** (fatal and serious crash rate) Risk Rating published in KiwiRAP is 'Medium – High' or 'High'; and/or
- The **KiwiRAP Star Rating** is 1-Star or 2-Stars or the Road Protection Score (RPS) is greater than 10; and/or
- An equivalent process, such as **RISA** where personal risk is greater than 2.5.

The High-Risk Rural Roads Guide specifies that risk metrics should be applied to road segments with a crash history of 3 or more fatal and serious crashes over a 5-year period or 5 or more fatal and serious crashes over a 10-year period. Desirably, road segments being considered should be corridors (maybe 10km or longer) or adjoining road segments with similar characteristics, traffic volumes, environment and road-use purpose.

The definitions provided in the High-Risk Rural Roads Guide provide useful guidance on what constitutes a high-risk rural road for the purposes of targeting road safety improvements. However, because the definition requires any section of road to meet only one of the risk metrics, subsequent analysis of the country's entire rural State Highway network shows that approximately 57% of the network would be classified as high-risk.

With such a large proportion of the country's rural State Highway network being classified as high-risk the high-risk metrics offer limited value for identifying those specific sections of the network where road safety improvements are required most and where reductions in road trauma are likely to be most achievable. Furthermore, there are clearly insufficient funds to address all high-risk sections of the country's rural State Highway network quickly and effectively.

1.4. Bringing it all together

Given the finite resources available to improve road safety it is imperative that road safety investigations and investments are targeted at the highest risk parts of the network to

maximise the likelihood that projects will deliver the greatest road safety benefits and help achieve the desired outcomes of Safer Journeys.

So where should road safety investigations and investments be targeted? That was the question Abley Transportation Consultants (Abley) was asked to answer for the NZTA. The answer would inform a large project to develop a standardised framework for prioritising the NZTA road safety programme.

2. Development of SafetyNET

2.1. How it started

The project the NZTA Wellington Regional office originally commissioned Abley to carry out was to develop a safety works programme for the three-year period encompassing 2012/13 – 2014/15 for the Wellington Region for capital projects, minor safety projects and safety retrofit projects. The key outcome sought by the NZTA was a robust, prioritised and time-staged programme of works intended to deliver the government's road safety objectives, as set out in Safer Journeys.

The prioritised programme was to be developed by assessing projects put forward by the NZTA's network consultants and other consultants engaged by the NZTA to review the safety of specific sections of the State Highway network. Abley was to develop a standardised assessment methodology that assigned greatest priority to those projects most likely to help the NZTA achieve the government's desired outcomes.

When developing the assessment methodology Abley was to review the State Highway network from both a crash performance and risk perspective. Principally this was to check that projects put forward by the NZTA's consultants addressed those parts of the State Highway network where crash risk is greatest, as these are the areas where road safety projects are likely to have the most significant impact on road safety performance. Abley was also requested to review the nature of projects put forward using the KiwiRAP Analysis Tool and to test the appropriateness of the solution being put forward in comparison to other solutions.

When developing a standardised assessment methodology it is important that the methodology is robust, repeatable and objective.

- A robust methodology stands-up to industry scrutiny, and produces sensible outputs that do not favour the assessment of a particular input variable above another.
- A repeatable methodology means all assessments are carried out in the same manner.
- An objective methodology means the assessments rely solely on input data and not the subjective opinion of the person applying the methodology.

The main hurdle encountered when developing the assessment methodology was factoring in the safety performance and risk profile of the section of State Highway. In the Wellington region, more than 90% of the network exceeded one or more of the High-Risk Rural Roads Guide high-risk thresholds. This meant most projects in the network would be in a high-risk section and therefore there would not be sufficient differentiation across the network. There was obviously a need to develop a finer-grain set of indicators.

True to the typical engineer's approach to solving analytical problems involving large volumes of data, the initial approach to developing the indicators was to interrogate and analyse the data using a spreadsheet. This proved to be inefficient and cumbersome for a number of reasons, not least of which was the non-continuous nature of the input data. This made referencing between datasets difficult and resulted in the data having to be manually manipulated to a greater extent than was desired.

Carrying out the analysis in a simple, repeatable and non-manual manner was important for the project, as the intent was to develop a standardised approach to prioritising a road safety programme – a process that would be repeated on an annual basis, informed by new datasets as they become available. This stumbling block required a different approach to solving the problem. The different approach was arrived at by reviewing the particular attributes of the data.

With the benefit of hindsight, it is not unsurprising that data collected on transport networks is by its very nature spatially referenced i.e. relative to a known point or length of the network. This meant that instead of analysing individual datasets within a non-spatial spreadsheet the use geospatial software (ArcGIS Desktop, Model Builder and Server) was a much better platform upon which to carry out the analysis. This not only addressed the problem of some data being non-continuous, but also provided the framework for data to be readily updated and the outputs calculated in a repeatable and largely automated manner.

The outcome is SafetyNET. SafetyNET is an innovative online interactive road safety tool that brings together a number of transport datasets and combines this data with industry knowledge. SafetyNET combines microscopic data, such as exact crash locations and 100m interval Star Rating information, with known statistical relationships to produce a number of performance and risk-based indicators at a meso-scope level of detail. SafetyNET builds on the structure provided by the High-Risk Rural Roads Guide and provides a more detailed means as assessing the State Highway network so high-risk areas that warrant attention can be readily identified. This then enables investigations and investment to be targeted effectively.

2.2. SafetyNET indicators

SafetyNET provides a number of performance and risk-based indicators. Some of the indicators are derived directly from KiwiRAP protocols, including the Collective Risk and Personal Risk as performance based indicators, and the Star Rating RPS as a risk based indicator.

Other SafetyNET indicators utilise relationships between Star Ratings and crash performance that are published in the High-Risk Rural Roads Guide to develop indicators comparing the safety performance of a road segment with predicted performance. Two of these indicators focus on comparative performance for a 5km road segment: one for fatal and injury crashes and one for fatal and serious injury crashes. The third of these indicators provides a comparative performance for a 500m road segment. The latter is designed to enable the NZTA to pinpoint any specific locations along a longer road segment, such as a corridor, that may be contributing to overall poor safety performance of the road segment.

The threshold metrics that have been defined for each indicator are:

1. The **Collective Risk** threshold is a risk rating of 'High' or 'Medium – High',
2. The **Personal Risk** threshold is a risk rating of 'High' or 'Medium – High',
3. The **Star Rating** threshold is a RPS value greater than 10 i.e. a 1 or 2-Star Rating.
4. The **injury performance indicator** threshold for a **5km** road segment is where the actual number of reported injury crashes (annually averaged over the past 5 years) is greater than the predicted number of injury crashes derived from the relationship specified in Figure C-2 of the High-Risk Rural Roads Guide.
5. The **fatal and serious injury indicator** threshold for a **5km** road segment is where the actual number of reported fatal and serious injury crashes (annually averaged over the past 5 years) is greater than the predicted number of fatal and serious injury crashes derived from the relationship specified in Figure C-2 of the High-Risk Rural Roads Guide.

- The **injury performance indicator** threshold for a **500m** road segment is where the actual number of reported injury crashes (annually averaged over the past 5 years) is greater than the predicted number of injury crashes derived from the relationship specified in Figure C-1 of the High-Risk Rural Roads Guide.

The six indicators have been combined to create a summary indicator, known as the Investigation Priority Rating (IPR) indicator. The IPR indicator provides an overview of the overall performance and risk profile of a road segment against the defined threshold metrics.

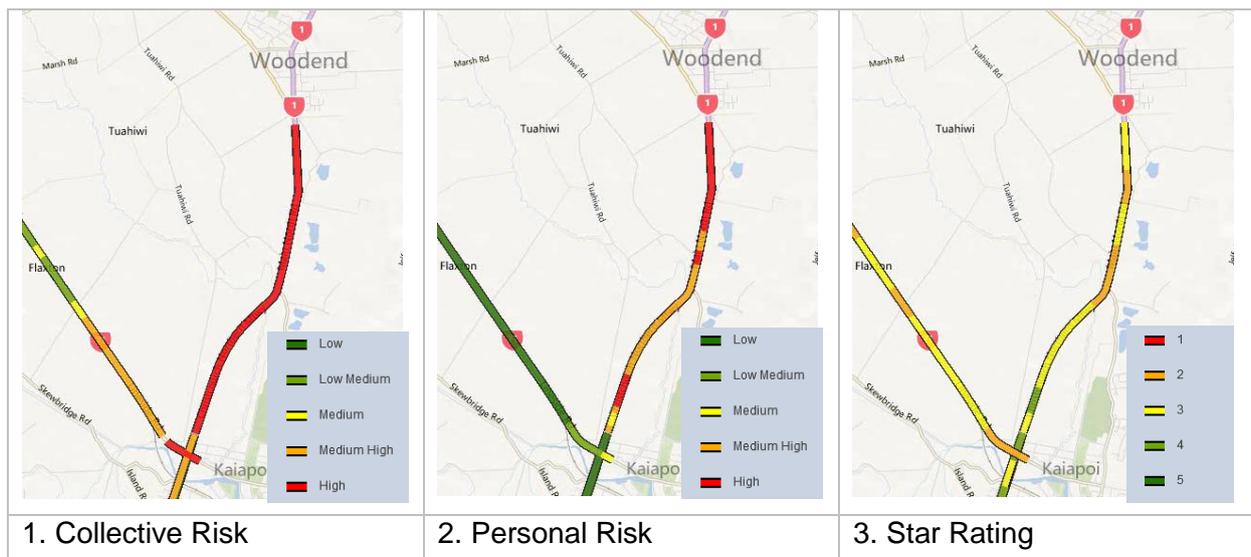
For the IPR indicators, each individual indicator, aside from Collective Risk, is assigned equal weighting. Collective Risk is assigned three times the weighting of the other indicators. This recognises and aligns the Collective Risk indicator with the NZTA Investment Revenue Strategy focus on achieving the greatest reduction in actual road safety trauma on New Zealand roads. As a result, parts of the network with high Collective Risk are likely to justify greater investment than other parts of the network a lower Collective Risk.

To maintain consistency with the KiwiRAP protocols for other indicators, a 5-tiered classification structure has been applied to the IPR indicator. If an indicator exceeds the threshold it is assigned a value of one, except for the Collective Risk indicators where a value of 3 is assigned if the threshold is exceeded. The 5-tiered classification structure of the IPR indicator is:

- **Low** = 0 i.e. no indicators exceed threshold
- **Low – Medium** = 1 or 2
- **Medium** = 3 or 4* (must include Collective Risk indicator)
- **Medium – High** = 4* (must exclude Collective Risk indicator) or 5
- **High** = 6 to 8

The IPR classification structure means that in order to for the IPR indicator to be classified as ‘High’, the road segment must have a ‘High’ or ‘Medium-High’ Collective Risk. An example of how each of the indicators is displayed in SafetyNET is provided in **Figure 1**.

Figure 1: SafetyNET example outputs



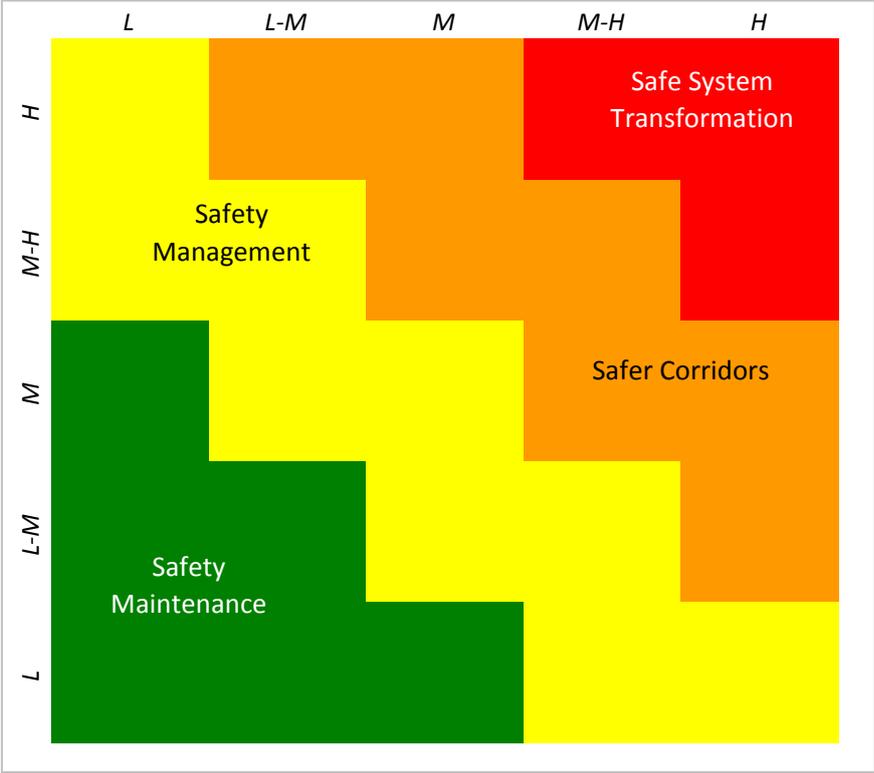


The High-Risk Rural Roads Guide includes a treatment philosophy figure to guide road safety practitioners towards the treatment strategy that is most likely to be appropriate for a road segment based on a variety of risk metrics. This generic figure has been refined as part of the development of SafetyNET and resulted in the development of Proactive and Reactive Treatment Strategy indicators.

- The 'Proactive Treatment Strategy' indicator is informed by the predicted Collective Risk derived from the RPS and traffic volume (horizontal axis) and the RPS (vertical axis).
- The 'Reactive Treatment Strategy' indicator is informed by the Collective Risk (horizontal axis) and Personal Risk (vertical axis) indicators.

The shape of the treatment strategy indicators are based on the 5x5 matrix shown in **Figure 2**. The figure shows the different treatment strategy approaches that are most likely to be appropriate based on the risk metrics used to inform each indicator. The scale of treatment (from most significant to least significant) runs from the top right of the figure to the bottom left.

Figure 2: SafetyNET Treatment Strategy Matrix



2.3. How SafetyNET is being used

The NZTA is using SafetyNET to inform the development of its long term road safety programmes. Ultimately the NZTA is seeking to align its investment in road safety with the intended function of each State Highway, as defined by the State Highway Classification System. The Classification System enables the NZTA to prioritise investment and make State Highways safe, fit for purpose and increase their capacity to improve productivity (NZTA, 2011).

The Classification System has four categories:

- **National Strategic** State Highways make a significant contribution to the social and economic wellbeing of New Zealand by connecting major population centres, international ports or major airports.
- **Regional Strategic** State Highways contribute to the social and economic wellbeing of a region, and connect regionally significant places, ports or airports. They are also major connectors between regions.
- **Regional Connector** State Highways link different regions, economic areas or tourist spots, and contribute to community wellbeing,
- **Regional Distributor** State Highways represent the remainder of the State Highway network and generally distribute people within a region (and in a few instances between regions).

The NZTA is in the process of establishing a target Star Rating for each State Highway classification. Current thinking is that National Strategic State Highways should ideally have a 4-Star Rating, especially in high volume areas with Regional Strategic State Highways having a 3-Star Rating and the Regional Connectors and Distributors a 2 to 3-Star Rating.

These Star Rating targets are being combined with a Proactive Treatment Strategy indicator to guide the long-term treatment philosophy of State Highways at a corridor level. The current performance of a corridor is not being ignored though. The Reactive Treatment Strategy indicator is also being used to ascertain if performance is better or worse than anticipated by the Proactive Treatment Strategy indicator.

Where performance is better than expected i.e. the Reactive Treatment Strategy indicator rating is closer to the bottom left of the SafetyNET Treatment Strategy Matrix (Figure 2) than the Proactive Treatment Strategy indicator, then the Proactive Treatment Strategy indicator takes precedence. Where the Reactive Treatment Strategy indicator is worse than the Proactive Treatment Strategy indicator i.e. closer to the top right of the SafetyNET Treatment Strategy Matrix then a combination of treatment approaches is likely to be necessary. In such instances, the Reactive Treatment Strategy is likely to be applied in the short-term to address current safety issues.

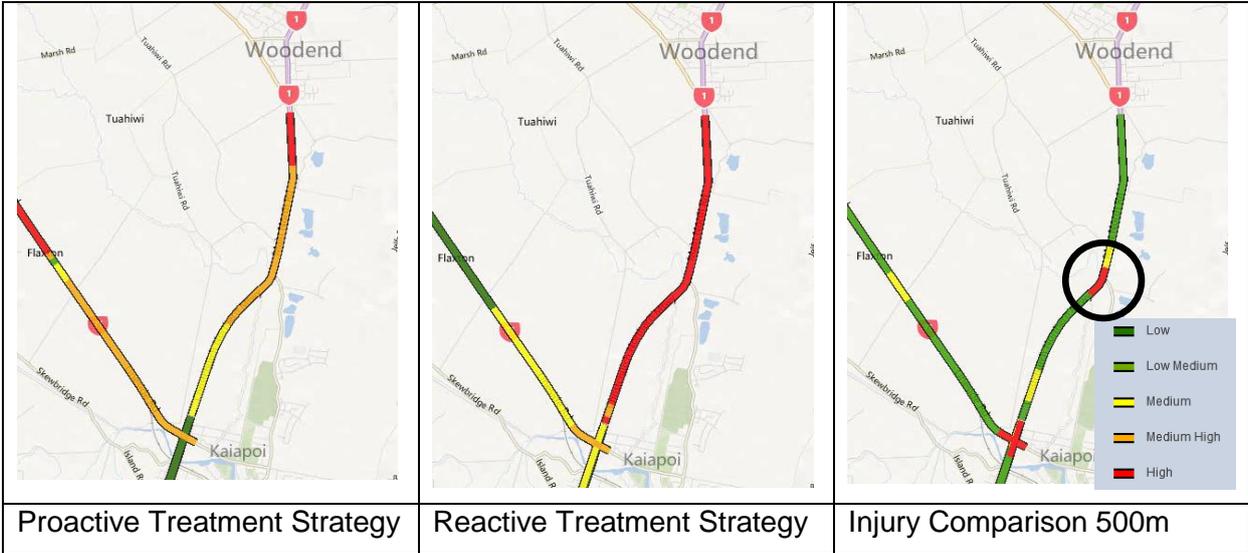
2.3.1. Example application of treatment strategies

The National Strategic State Highway corridor between Woodend and Kaiapoi on State Highway 1 (to the north of Christchurch) provides a useful demonstration of how the treatment strategies are being applied, and the power of SafetyNET to highlight and pinpoint safety issues. This corridor has a KiwiRAP 3-Star Rating with some shorter sections that are 2-Star and 4-Star, as shown in Figure 1.

When the RPS is combined with the traffic volumes using this corridor the Proactive Treatment Strategy indicator suggests that a Safer Corridor approach is likely to be the most appropriate long-term treatment philosophy for the corridor, as shown in **Figure 3**.

In contrast the Reactive Treatment Strategy suggests a Safe System Transformation is required. This indicates the corridor has a ‘High’ Collective and Personal Risk profile and that it is performing worse than predicted by the Proactive Treatment Strategy. However, the Injury Comparison (500m) indicator demonstrates that the poor performance of this corridor is attributable to the safety performance at one intersection along the corridor (identified by the circle in Figure 3). Accordingly, the appropriate treatment strategy for the corridor in the short-term is not a Safe System Transformation of the corridor as a whole, but a Safe System Transformation of the intersection followed by a Safer Corridor approach to the corridor as a whole in the longer-term. This example identifies how SafetyNET can be used to inform decision making and optimise outcomes in a constrained funding environment.

Figure 3: SafetyNET Treatment Strategy Matrix



2.4. Realising the true value of data

Road controlling authorities tend to collect large quantities of high-quality data. Often this data is collected with a specific purpose in mind, which results in the full potential of the data never being realised.

Exploring the potential of existing data sets is a smart way of creating value. SafetyNET provides an excellent demonstration of the value that can be added to data collected by road controlling authorities. The approach of creating value from existing datasets is similar to the recent high-profile and highly valued safety indicators developed as part of the KiwiRAP protocols; namely the Risk Mapping and Star Rating.

The development of SafetyNET would not have been possible without the use of a geospatial analysis platform. SafetyNET has been developed using ArcGIS Desktop and Model Builder and ArcGIS Server has been used to bring the information online. Geospatial analysis software, such as ArcGIS is an incredibly powerful tool for analysing large quantities of data from different sources. However, aside from the highly flexible environment geospatial analysis software provides when it comes to analysing data, a major benefit often overlooked is that rerunning of the analysis when input datasets are updated, such as historic crash data and traffic volumes, is very simple.

It is possible that this benefit will be seized by the NZTA and used as a form of performance tracking tool, which is the third of the KiwiRAP protocols.

2.5. Future enhancements of SafetyNET

At the time of writing this paper, a Collective Risk indicator for all intersections on the State Highway network commensurate with the guidance provided in the High-Risk Intersections Guide is in the process of being developed. This element will further assist road safety practitioners to target improvements at intersections, which is where 38% of all injury crashes occur in New Zealand (NZTA, 2012).

3. Conclusions

SafetyNET (Safety Network Evaluation Tool) is an online interactive road safety tool developed for the New Zealand Transport Agency. The purpose of SafetyNET is to provide the NZTA and its consultants with a visual means of understanding those parts of the State Highway network that have a historic safety performance that is poor compared to national averages, and/or is out of character with the expected safety performance, and/or has engineering and operational features that suggest a part of the network may be a high risk site in the future.

Displaying the information in a spatial manner enables users of SafetyNET to readily identify those high-risk parts of the State Highway network that warrant attention and target their investigations accordingly. Hosting this information online allows users of SafetyNET to interrogate the input data and examine the outputs at a range of desired levels of complexity.

The development of SafetyNET is a major breakthrough in the advancement of road safety in New Zealand. It is currently being used by the NZTA to inform the development of long term road safety programmes by aligning its investment in road safety with the intended function of each State Highway in New Zealand. SafetyNET therefore provides an excellent demonstration of the value that can be added to data already collected by road controlling authorities.

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