Urban KiwiRAP: Road Safety Assessment Programme

Brodie, C.[1] Durdin, P.[1] Fleet, J.[1] Minnema, R.[1] Tate, F.[1]

[1] New Zealand Urban KiwiRAP Technical Committee

Abstract

Road Assessment Programmes have been around for well over a decade now, however typically they have focussed on rural corridors and townships these pass through. Urban KiwiRAP looks to apply road risk ratings to major urban networks. The first stage was to develop risk maps for road links, intersections and network zones for motorised vehicles (cars, trucks, motorcyclists) and vulnerable road users (pedestrians and cyclists) using reported crashes and converting these into estimated death and serious injury casualty equivalents. These have now been completed for several cities in New Zealand. The second stage, to be commenced late in 2013, will be to trial the iRAP v3 star rating model for various road user groups on the arterial and collector links in these cities.

This paper presents the process adopted for the first stage of the Urban KiwiRAP project and examines the extent to which the risk mapping process assists with the identification of parts of urban road networks where road safety efforts and investment should be targeted.

Key words: Urban KiwiRAP, Road Assessment Programmes; Safer Journeys; safety performance; corridor safety; intersection safety; risk profile.

Introduction

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, 2011). 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 road safety 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?" has been a much too commonly heard 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'. 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. The other change has been to move away from all reported crashes and to focus on death and serious casualty outcomes.

KiwiRAP – the New Zealand Road Assessment Programme

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** – using 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 to 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** – involving 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.

Risk Maps for the high-speed sections of New Zealand's State Highway network were first published in the document 'KiwiRAP How Safe Are Our Roads?' based on traffic and crash data for the five-year period between 2002 and 2006. In 2012, the document was republished as a risk mapping and performance tracking report using crash data for the five-year period between 2007 and 2011.

Two risk metrics were mapped as part of KiwiRAP, 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, supplemented by high speed data measurement, is carried out and recorded at 100m intervals while the published Star Ratings are reported on segment lengths of at least 5km. 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.

The High-Risk Intersections Guide

The 'High-Risk Intersections Guide' (NZTA, 2013) provides practitioners with best practice guidance to identify, target and address key road safety issues at high-risk intersections. It has been prepared by the NZTA to provide guidance on the Government's Safer Journeys 2020 Strategy initiative to focus efforts on high-risk intersections.

The High-Risk Intersections Guide focuses on identifying intersections with an established or estimated occurrence of fatal and serious injury crashes, as opposed to crashes that result in less severe outcomes. The incorporation of proactive techniques allows high-risk intersections to be identified before people are killed or seriously injured, which is a positive step for promoting and providing a safer road environment in New Zealand.

High-risk intersections are broadly defined as those intersections that have a history of Fatal or Serious crashes or an estimated number of Death and Serious injury (DSi) casualty equivalents, based on all injury crashes, that suggest a disproportionally higher than normal risk that someone will be killed or seriously injured in the future (NZTA, 2013). It is important that these intersections are identified because they are the places where targeted safety improvements are likely to be most successful at preventing deaths and serious injuries from occurring in the future.

The High-Risk Intersections Guide sets out the technique for estimating the DSi casualty equivalents for an intersection. It does this by combining knowledge of the inter-relationship between speed environment, the intersection form and control type and crash movement type factors. Severity indices have been calculated for each primary crash movement type, for five different intersection forms and control types in both urban and rural speed environments. A ‘Severity Index’ is the expected ratio of Death and Serious injury (DSi) casualties to all injury crashes.

Severity indices indicate which crash movement types for a specific intersection type in a defined speed environment are more or less likely to result in a high-severity outcome. The Severity Indices tables acknowledge that different crash movement types are more or less likely to result in road users being killed or seriously injured. For example, crashes involving drivers turning right out of a side road typically result in more severe injuries than rear end collisions.

Different intersection types and controls also affect the typical severity of a crash. Roundabouts in particular have a lower crash severity profile than priority or signalised intersections because the crash impacts in multi-vehicle crashes are minimised through controlled entry speeds and the angle of collision.

Severity indices can be applied to each observed injury crash at an intersection to derive a DSi casualty equivalent value for an intersection. This technique is especially effective in identifying intersections with a moderate absolute crash rate that have a high risk of the next crash being high severity.

The High-Risk Intersections Guide defines two main types of risk metric: Collective Risk and Personal Risk.

- **Collective Risk** is measured as the total number of fatal and serious crashes or deaths and serious injuries per intersection in a crash period.
- **Personal Risk** is the risk of Death or Serious injuries to each vehicle entering the intersection.

There are two methods for defining Collective Risk.

According to the High-Risk Intersection Guide, the simplest definition of Collective Risk is to consider the number of fatal and serious crashes that have occurred at an intersection in a period of time; normally five or ten years. However, using these crashes alone can be fraught with the risk of reaching false conclusions about crash risk based on small numbers. It can easily result in road controlling authority’s addressing randomly occurring crashes within the network (NZTA, 2013).

For this reason, the criteria are set fairly high to minimise the risk of falsely identifying sites that are not high-risk. To be confident that an intersection is high-risk there needs to be three or more serious and/or fatal crashes in five years (or five or more serious and fatal crashes in ten years). However even with such thresholds, only about 80 intersections in New Zealand have three or more fatal and serious crashes in a five-year period.

The second definition involves the estimation of the number of DSi casualty equivalents based on all injury crashes that have occurred at an intersection. It involves the multiplication of each injury crash at an intersection by the corresponding Severity Index ratio. The second method acknowledges that actual fatal and serious crash data alone is not a good indicator of the underlying risk of a high-severity crash at many intersections.

Intersections that are assessed as having a ‘Medium High’ or ‘High’ Collective Risk are deemed to be high-risk intersections (NZTA, 2013).

Urban KiwiRAP

In August 2012, the NZTA established a new KiwiRAP technical committee charged with overseeing and directing the risk assessment process for roads in urban areas and the development of an Urban KiwiRAP model. The existing KiwiRAP technical committee was set up for the star rating model development for rural State Highways.

The new committee consisted of representatives from the NZTA, Auckland Transport, the Tauranga, Christchurch and Dunedin City Council’s as well as the consulting industry. Each of the local authorities represented on the committee have participated in a trial to develop and test risk assessment processes for urban corridors on their networks.

Derivation of the Urban Risk Assessment Process

There are two components of the risk assessment model; an intersection component and a corridor component. The risk assessment process for intersections is defined by the High-Risk Intersections Guide and is applicable to intersections in urban and rural environments. The corridor assessment process needed to be defined from scratch.

One of the first tasks for the Urban KiwiRAP Technical Committee was to agree whether corridor risk would be assessed using a fatal and serous crash based approach, such as that adopted for KiwiRAP on the rural State Highway network, or an estimated DSi casualty equivalents approach, such as that published in the High-Risk Intersections Guide.

Given fatal and serious crashes tend to be more rare and random events in urban environments than in higher speed rural networks the decision was made to adopt the estimated DSi casualty equivalents approach. However, as the estimated DSi casualty equivalents approach was a relatively new assessment technique, the committee sought reference from Intersection Safety Intervention Studies (ISIS) that Abley Transportation Consultants had completed for road controlling authorities throughout NZ.

An ISIS project completed for Auckland Transport in May 2012 identified the Glenbrook Road / Kingseat Road intersection as being the highest risk intersection in the Auckland Region and the highest priority for Safe System Transformation works. The Glenbrook Road / Kingseat Road intersection is a priority controlled crossroads in a high speed (rural) environment.

At the time of the analysis two serious injury crashes and ten minor injury crashes had occurred at the intersection in a five year period from 2007 to 2011. Although the intersection did not exceed the threshold to be classified as a high-risk intersection, based on the incidence of actual fatal and serious crashes, application of the severity indices to the crash movement types of all observed injury crashes at the intersection indicated the intersection had a very high-risk of being the scene of a future fatal or serious injury crash.

In July 2012, two people were killed in a crash at the Glenbrook Road / Kingseat Road intersection. This followed a serious injury crash, which occurred some four weeks earlier. These unfortunate crashes went some way to validating the reliability of using estimated DSi casualty equivalents as a means of calculating the risk of fatal and serious crashes occurring in the future. Subsequently other intersections identified as high-risk using this approach in Auckland and other areas, were also reviewed and found to have been the scene of subsequent high-severity crashes in 2012 and 2013 providing greater confidence that the estimated DSi casualty equivalent approach is both valid and robust.

Having adopted the estimated DSi casualty equivalents approach for assessing risk, the next task for the Urban KiwiRAP Technical Committee was develop a standard method for defining a corridor that could be applied across any road controlling authority's transport network. The critical factor in developing a methodology that can be applied across any road controlling authorities' network is to base the influencing variables on information that is common to and/or applicable to any area.

The agreed process for defining a corridor was based on the hierarchical classification of the road and the intersecting road. Although New Zealand is yet to have a nationwide road hierarchy, all road controlling authorities have a formal road hierarchy for roads in their District.

In New Zealand the lowest order public roads are generally classified as 'Local Roads'. The next hierarchical classification category is usually referred to as 'Collector' although some Districts use 'Distributor'. For the purpose of this study, the term 'Collector' has been used to describe the next category of roads above 'Local Roads' in the hierarchy. A wider range of terms are used to describe higher order roads in New Zealand.

The process used to define a Corridor as a contiguous group of streets of the same road hierarchy that split where they intersect:

- A road of higher hierarchy
- A road of the same hierarchy (except on Local Road corridors);
- A road one step lower in the hierarchy (except on Local Road and Collector corridors); and/or
- A change in speed environment from urban to rural (and vice versa).

As with intersections, Severity Indices were developed for primary crash movement types for mid-block sections with different lane attributes in urban and rural speed environments. The indices were calculated by extracting all midblock crashes from the NZTA Crash Analysis System (CAS) and determining the average number of DSi casualties for each injury crash in each category.

Calculation of Corridor Risk Metrics

The Collective Risk of a corridor is calculated in two parts; an intersection component and a mid-block component.

The intersection component only relates to crashes that occur at the intersection. Because crashes at intersections typically involve the collision between two vehicles travelling on different, often adjacent legs of an intersection, a means of apportioning an intersection crash to the corridor had to be agreed.

The initial approach adopted by the committee involved apportioning an intersection crash to all intersecting legs; however this produced some anomalous results where a local road intersected a higher order road, particularly in terms of Personal Risk on the Local Road. This is because crashes on local urban roads, typically roads through residential neighbourhoods, generally have very few crashes and if there are crashes in these areas they commonly occur at intersections.

As a result where an intersection included roads other than Local Roads, the committee modified the method so crashes were apportioned between the non-Local Road legs of the intersection only. This meant Local Road corridors were assessed in a slightly different manner to higher order roads although safety issues at intersections of Local Roads with higher order roads were still identifiable from the intersection risk mapping component.

The intersection component of the corridor Collective Risk is calculated by summing the DSi casualty equivalents of all intersections along the corridor.

The mid-block component of a corridor included all sections that were not classified as an intersection. All injury crashes along mid-block sections were multiplied by the corresponding severity index based on the crash movement type, the lane configuration and speed environment.

The mid-block component of the corridor Collective Risk is calculated by summing the DSi casualty equivalents of all mid-block sections along the corridor.

The overall Corridor Collective Risk is calculated by adding together the Collective Risk values of the corridor's intersections and mid-block sections and dividing by the total corridor length in kilometres. Dividing by corridor length enables direct comparisons to be made between corridors.

Network Wide Analysis

Transport data by its very nature is spatially referenced i.e. relative to a particular point or length of the transport network. For this reason, different sets of transport data can be brought together inside a geospatial environment and used for a variety of purposes, such as calculating the risk profile of every intersection and road in a transport network.

Geographical Information Systems (GIS) makes calculating the risk profile of all corridors in a town, city or region highly cost-effective and time-efficient compared to the manual equivalent. Aside from the economic efficiencies GIS offers, GIS also enables networks to be assessed in a standardised and equitable manner, which in turn allows informed decisions to be made about countermeasure investments in a way that is aligned with the Safe System approach to road safety. In larger urban areas, it is simply uneconomical and inefficient to carry out this type of assessment without the use of GIS.

Traditional methods of focussing efforts on parts of the network with high crash concentrations are unlikely to find all high-risk corridors. The estimated DSi casualty equivalents approach means some corridors with a modest absolute number of injury crashes can be high-risk based on the type of crashes and the environment in which they are located. GIS ensures that opportunities to identify, target and address key road safety issues are not overlooked.

Development of Risk Threshold Categories

Risk threshold categories were developed by reviewing and analysing the distribution of Collective Risk values across the contributing network areas. The objective of the threshold was to achieve the iRAP vision of targeting the highest risk 10% of roads where typically 50% of crashes occur.

An iterative approach was taken to develop the Urban KiwiRAP Corridor Collective Risk thresholds. The agreed Corridor Collective Risk categories are shown in Table 1.

Table 1

Corridor Collective Risk categories

Risk Category	Corridor Collective Risk Thresholds (estimated DSi casualty equivalents per km)
Low	<0.1
Low Medium	0.1 - <0.5
Medium	0.5 - <1.0
Medium High	1.0 - <2.0
High	≥2.0

Analysis of Results

The Urban KiwiRAP risk mapping results for the four contributing Council regions show highly encouraging results. Table 2 shows that over all four regions, 8.3% of the networks by length are classified as high-risk i.e. has a Collective Risk profile of Medium-High or High. These high risk corridors account for 63.1% of all injury crashes, which significantly exceeds the iRAP target.

Table 2

Regional corridor collective risk statistics

Region	High-Risk Network by Length	Proportion of Injury Crashes
Auckland	9.0%	58.8%
Tauranga	5.4%	31.0%
Christchurch	10.6%	72.6%
Dunedin	3.5%	53.2%
Average	8.3%	63.1%

On a regional basis, Auckland, Christchurch and Dunedin all exceed the iRAP target. However, Tauranga fails to achieve the target with only 5.4% of its network by length identified as high-risk, accounting for 31.0% of all injury crashes in the region. Further detailed analysis of this region’s results goes some way to explaining why the Tauranga network doesn’t meet the iRAP target. One may be a function of the size of the network. It is a comparatively small network, less than one third the size of the next smallest network Dunedin. Another may be that many of the high traffic volume carrying routes are designed to a very high standard, such as expressways.

The results are equally encouraging when fatal and serious crashes are considered. Here 50.7% of all fatal and serious crashes are located on the high-risk corridors.

Mapping of Results

The risk mapping outputs have been provided to Councils in a number of formats, including map books, interactive web-portals and as GIS shapefiles.

Figures 1 shows an example of the corridor risk mapping outputs that have been produced for Auckland.

Figure 1

Example Corridor Risk Maps - Auckland

Process Refinement

The initial outputs from the Urban KiwiRAP risk mapping process represent have been derived from a collaborative and iterative approach to developing the assessment framework. Naturally as the regions have begun analysing the risk mapping outputs, a number of refinements to the assessment framework have been identified.

The need for different risk thresholds in urban and rural speed environments and to have thresholds that vary as a function of corridor length are two refinements that have been identified by the committee and will be incorporated into the risk assessment process in the near future. Both enhancements recognise that corridor length and frequency of intersections along a corridor have a significant influence on the Collective Risk profile, and need to be better incorporated into the assessment process to enable equitable comparison between corridors of different lengths and in different speed environments.

Conclusions

The Urban KiwiRAP Technical Committee has developed and tested an assessment process for assessing the road safety risk of urban transport networks in Auckland, Tauranga, Christchurch and Dunedin.

The process uses the estimated death and serious injury casualty equivalents approach to assess risk. This approach acknowledges that the likelihood of a person being killed or seriously injured in a crash various as a function of the crash movement type, the speed environment and the form of the road where the crash occurs.

Collective Risk has been calculated for intersections and mid-block sections along all roads. It is reported at a corridor level, which has been defined based on the hierarchical classification of the road and the intersecting road.

The initial risk mapping outputs are highly encouraging. On average, 8.3% of the networks by length are classified as high-risk and these corridors account for 63.1% of all injury crashes. These results significantly exceed the iRAP target of identifying 10% of roads by length as high-risk and having 50% of injury crashes on these high-risk corridors.

A number of refinements to the assessment process have been identified to facilitate a more equitable comparison between corridors of different lengths and in different speed environments.

References

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