A Multi-Agency Risk-Targeting Model: The New Zealand Perspective

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ABSTRACT

The C.R.A.S.H (Crash Risk Analysis by Sectored Highway) Book project was commenced by New Zealand Police in 2001. Its purpose was to assess areas of risk within the road environment, in order to deliver appropriate Enforcement, Engineering, and Education initiatives aimed at reducing crashes.

Organisationally, New Zealand Police is divided into twelve separate geographical districts. Each district has a C.R.A.S.H Book which covers the road system of that district. Within each book the district's highway network is divided into sectors (containing roughly 15 kilometres of road). Each sector is represented on a single page and contains a map together with various historical data about that stretch of highway. The books include sector data such as daily traffic volumes, road characteristics, and crash histories. This information is used to generate a risk rating for each section of road.

The information contained within the books has assisted police managers (at district level) to devise appropriate risk-targeted patrol plans which are used for staff deployment. It was also helped frontline staff to better understand and police the local road network. Additionally, the availability of C.R.A.S.H Book data has enabled the broader road safety community (including road controlling authorities, engineers, educators, and Police) to better understand and target local road safety risks and work together to address them.

Information contained within the C.R.A.S.H Books is drawn from traffic crash reports which are collated into a database called the Crash Analysis System (CAS) and books are periodically refreshed to provide the most up-to-date intelligence available.

The purpose of this paper is to provide a detailed analysis of the C.R.A.S.H Book system as operated by New Zealand Police, including the background, development, operationalisation, and utility for policing of the road environment.

KEY WORDS

New Zealand, C.R.A.S.H, Police, Risk-targeted policing, road policing, crashes, Land Transport New Zealand, sector codes

1. INTRODUCTION

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2. BACKGROUND

2.1. NZ fatality rates over time

New Zealand, following similar trends to most OECD countries, has shown a sustained reduction in the road toll from a high in 1973 of 843 deaths to 393 in 2006. (The lowest Road Toll in New Zealand since 1960) Fatality rates have also decreased from the 1973 high of 27.9 per 100,000 population (5.9 per 10,000 vehicles) to 9.4 per 100,000 of population in 2006 (1.3 per 10,000 vehicles). By comparison, the United Kingdom in 2005 had 14.7 deaths per 100,000 population (1.8 deaths per 10,000 vehicles). A chart showing comparative rates per 10,000 vehicles in 2005 is attached as figure 1 (MOT, 2006)

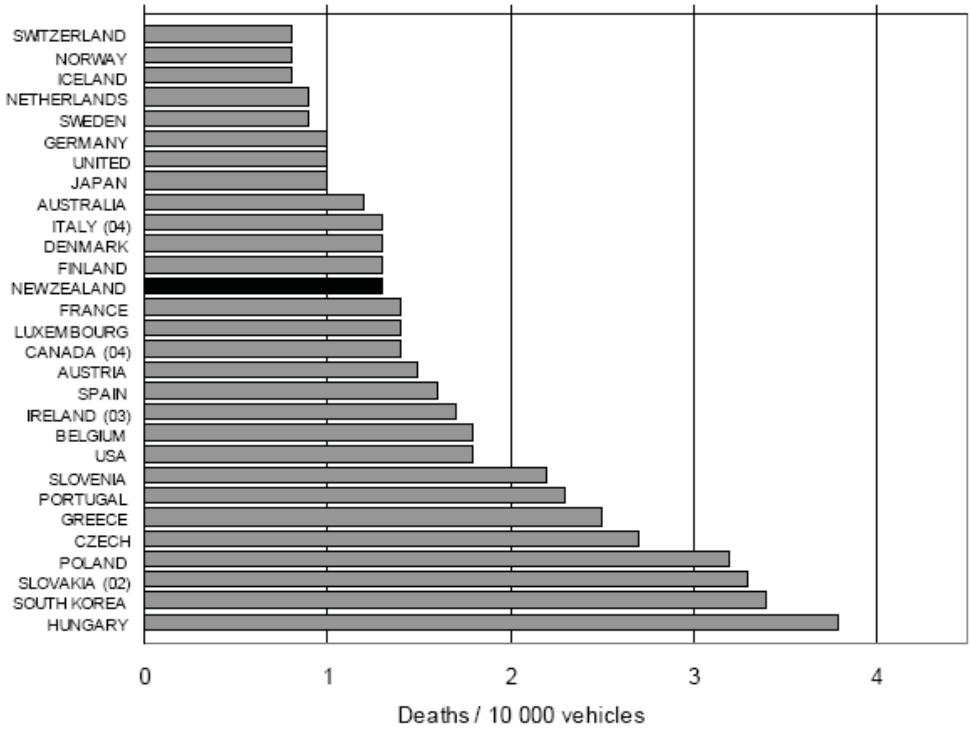


Figure 1: Deaths per 10,000 vehicles in 2005 (MOT 2006)

The New Zealand Government's *Road Safety to 2010* Goals are to have fewer than 300 deaths, 2,200 hospitalisations for no longer than one day and 1,400 hospitalisations for no longer than three days in the twelve months ending 31 December 2010. At this rate, this equates to about 1.1 deaths per 10,000 vehicles.

New Zealand has a high proportion of rural roads, and whilst the major population centres of Auckland, Wellington and Christchurch are comparable to other large cities across Europe, the unique, often mountainous terrain in New Zealand poses its own unique road safety challenges, particularly when coupled with a high default rural speed limit of 100 km/hr. Whilst the rural winter mean speed in New Zealand in 2006 was 96.4 km/hr, down from 101.9 km/hr in 2001, (MOT 2007), the unforgiving nature of New Zealand's rural network means that fatalities are far more likely when crashes occur.

2.2. Police Enforcement

Prior to 1992, road policing services in New Zealand were in the main conducted by the Ministry of Transport Traffic Safety Service and local council traffic officers, separate from mainstream policing. In 1992, all of these activities were merged under the New Zealand Police umbrella, with New Zealand Police for the first time becoming fully responsible for road policing.

For the 2007/2008 year, funding of almost $260 million has been approved by the Land Transport New Zealand Board for road policing activities, of which approximately $33 million is allocated for crash attendance and investigation. Police resources have been grouped into four outputs under which Police deliver a number of activities:

- **strategic road policing** – speed control, drinking and/or drugged driver control, restraint device control, visible road safety and general enforcement, and commercial vehicle investigation and road user charges enforcement;
- **community engagement on road policing** – Police community services and school road safety education;
- **road policing incident and emergency management** – crash attendance and investigation, and traffic management; and
- **road policing resolutions** - sanctions and prosecutions, and court orders.

2.3. Crash Reporting

Police are responsible for all crash attendance in New Zealand, and all crashes attended are documented on forms known as a Traffic Crash Report (TCR). The original copy of this form is forwarded to Land Transport New Zealand, which is the Government body responsible for *"allocating resources and undertaking functions in ways that contribute to an integrated, safe, responsive and sustained land transport system"* (Land Transport NZ 2007)

On receipt of the TCR, Land Transport New Zealand staff enter the data on the crash into the Crash Analysis System (CAS). CAS is an integrated computer system that provides tools to collect, map, query and report on road crash and related data. This system is intended for Land Transport New Zealand's road safety partners, including:

- police;
- road controlling authority engineers and safety planners;
- traffic engineers and consultants;
- researchers;
- central government;
- health authorities;
- insurance companies;
- news media; and
- general public

Once the data is extracted from the TCR, the actual document is imaged, and the data and imaged document can be retrieved for subsequent analysis.

An example of one of the maps available from CAS is shown in figure 2 on the next page.

2.4. Prior to 2001

Prior to 2001, whilst data was readily available in CAS, particularly for individual queries, there was no coordinated way of using the data to show trends and risk over larger areas. Police did not make optimal use of the system as a method of deploying staff to risk at this time. Whilst there was always engagement with partners, the Police role was largely confined to sticking to enforcement, whilst engineers generally had their own priorities.

The need to develop better targeting to risk by all parties was clear.

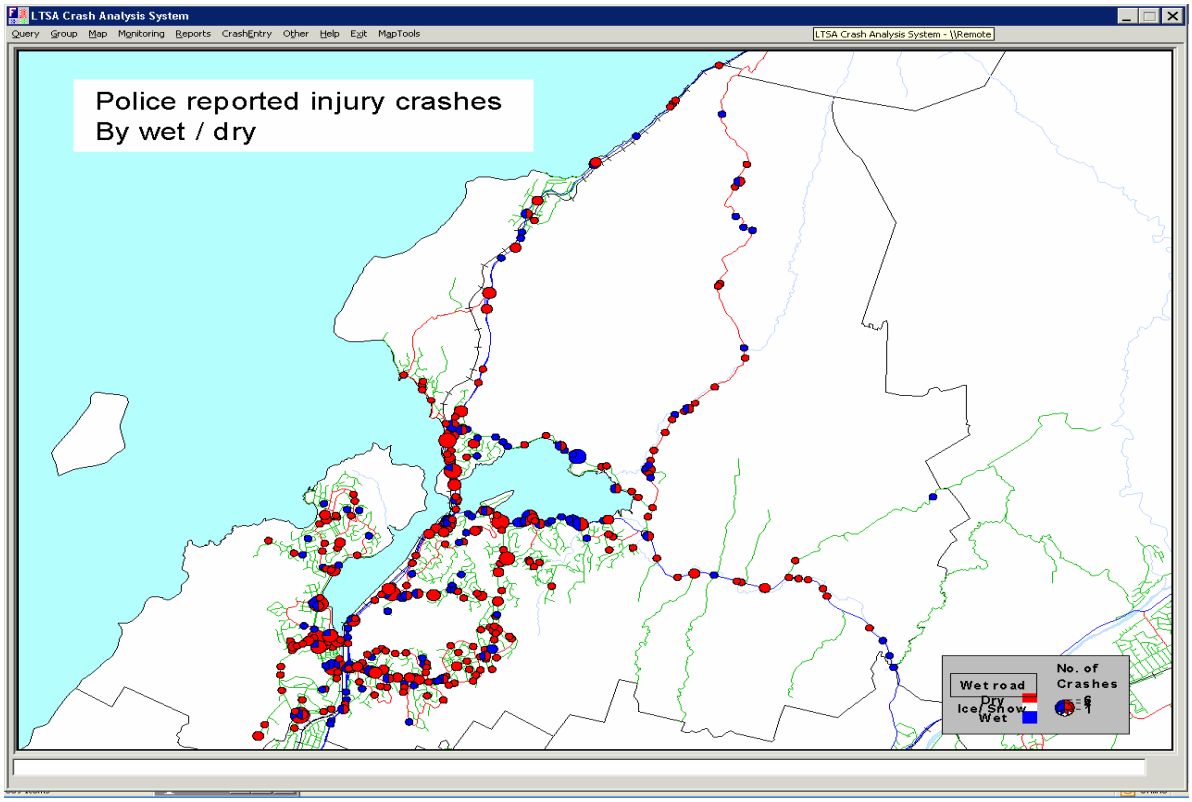


Figure 2: CAS image showing Police reported injury crashes by wet/dry

3. CURRENT POLICE RISK TARGETING

3.1. From 2001 Onwards: Risk Targeted Patrol Planning

Since March 2001, a risk targeting model utilising Risk Targeted Patrol Plans (RTPPs) was developed by Police to ensure that strategic road policing enforcement was directed towards the higher risk locations and behaviours in order to maximise the effect on road trauma promoting behaviour and subsequent outcomes. To be effective, this system required good data.

The New Zealand Police is a national Police organisation, divided into 12 separate geographic areas referred to as Police Districts. Each District, under the comman of a District Commander, is responsible for outcomes in accordance with the overall national strategic direction of policing. In 2002, the Southern Police District developed a "C.R.A.S.H" Book (Crash Risk Analysis by Sectored Highway). This involved an in-depth analysis based on CAS data as to crashes by season and by location. C.R.A.S.H Books are analytical documents that are intended to provide long-term risk profiles of stretches of roads, groups of intersections and geographical features within a Police District or area. There are three primary types of sector:

- **Linear:** Meaning a sector that goes from point to point along a road or roads. Usually defined in CAS as a polygon with a 10-metre buffer on either side of the centre line.

- **Area:** Meaning a sector that defines a geographical area, such as a suburb or scene station and including all roads within that sector.

- **Point:** Meaning a sector created around a single intersection, usually including all crashes within a 50-metre radius of that intersection.

This book developed into a nationwide implementation during 2004/2005, with the first priority being the development of a highway C.R.A.S.H Book. This is now completed, with most Districts now also having completed an urban C.R.A.S.H Book.

This approach enabled crash data to be plotted against particular sectors to enable analysis of the level of risk for each section of state highway. The Road Policing Analyst, in conjunction with the local Land Transport NZ engineer, using an algorithm determined a level of "risk" per sector based on the total number of fatalities and injuries recorded against it. Daily traffic volumes, road characteristics, and a number of other factors have been considered alongside the crash history to base crash risk ratings of each road sector. These risks were rated from "1" (High risk), through to "4" (low risk), and graphically represented on maps as coloured segments determining the relative risk of each sector of highway.

Police officers could then see at a glance where the higher risk sectors of the network were, which considerably simplified the planning process. As crash trends change only slowly over time, maps remained current for extended periods. These maps have also proved to be of significant public interest, as a link could be drawn between enforcement and risk, and this helped graphically demonstrate that Police were focussed on reducing trauma. A benefit of this system is that it enables the identification of sectors where it is clear that enforcement is having little effect, which then supports proposals for an engineering solution to be considered.

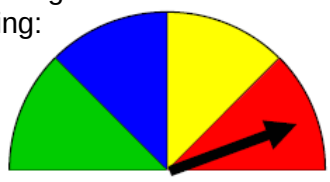
The C.R.A.S.H map itself is just the graphical user interface for a complex spreadsheet that allows for a deeper analysis. (See figure 3 on pg. 8) The New Zealand Police Infringement notice system allows a field for a sector code, so all infringement notices written against a particular sector can be analysed and compared with crashes for that sector. An analysis can thus be conducted of the effect of enforcement in a particular sector against crashes.

The primary benefit of the entire system is that it brought the otherwise unsorted data together from CAS in a way that showed risks both spatially and over time.

3.2. Algorithm and Risk Ratings

Crash data from the previous five years for each sector is analysed to produce a profile of the risk in the sector. From this information, risk ratings are determined for each sector. These are ranked according to a four-scale rating:

- Priority 1 (extreme crash risk) = RED
- Priority 2 (high crash risk) = YELLOW
- Priority 3 (medium crash risk) = BLUE
- Priority 4 (low crash risk) = GREEN



The gauge highlights crash risk for each sector. The idea is for it to be instantly recognisable, so it has been designed to resemble the fire danger indicator boards seen on highways.

Crashes are weighted according to their severity and all types of crashes are counted. The recommended algorithm is a simplified version of Land Transport NZ's social cost measure. It is called the star triple 5 (*555) measure and, as its name implies, each injury type is worth five times more than the previous type. A non-injury crash has a weighting of 0.2, minor injury is 5 times more with a value of 1, serious is weighted at 5 and fatal is weighted at 25.

Table 1 shows a view of a spreadsheet with the raw data and the scores based on the weightings:

	Count				Weighted Score				Weighted
Sector	Fatal	Ser	Min	Non	Fat 25	Ser 5	Min 1	Non 0.2	Total
4611	1	4	14	41	25	20	14	8.2	67.2
4612	4	12	26	62	100	60	26	12.4	198.4
4613	2	8	10	18	50	40	10	3.6	103.6
4621	3	14	8	36	75	70	8	7.2	160.2
4622	2	7	12	24	50	35	12	4.8	101.8

Table 1: Example of scored and weighted sectors

As can be seen in Table 1 the number of crashes for each injury type is multiplied by the relevant weighting to calculate the weighted score. Each of the weighted scores is summed to get the total score for that sector. For linear sectors, the final weighted score is divided by the road length (in kilometres). This ensures that if two sectors have similar scores and one is half the length of the other, then it will be shown that the risk of a serious crash is greater in the shorter sector. Some example data is shown in Table 2 below.

Sector	Fatal Score	Serious Score	Minor Score	Non Injury Score	Weighted Score	Length (km's)	Length Adjusted Total
4611	25	20	14	8.2	67.2	11	6.11
4612	100	60	26	12.4	198.4	21	9.45
4613	50	40	10	3.6	103.6	10	10.36
4621	75	70	8	7.2	160.2	11	14.56
4622	50	35	12	4.8	101.8	17	5.99
4631	0	20	9	2.8	31.8	5	6.36

Table 2: Length adjusted scores

In all cases, qualitative analysis is carried out on these results. The score from the algorithm is used as a starting point only; and is not the sole means of ranking sectors. Consideration is given to:

- impact of seasonal traffic flows around holiday periods;
- types of road users;
- road purpose;
- engineering solutions (past or planned);
- road environment (ditches either side, sheer drops, undulating etc); and
- anecdotal intelligence / local knowledge from front line police (NZ Police, 2007)

After consideration of the qualitative data, a picture then emerges of the relative risk. The risk values vary from district to district and that is why there is no minimum score for an "extreme" ranking. The analysis carried out to assist with the ranking process can then be included in the intelligence section of the profiles in the Crash Book. It is recommended that analysts drive the sectors with an experienced staff member when gathering data for qualitative analysis, allowing for a first-hand assessment.

3.3. Sector Codes

In 2001, Police also initiated the sector coding of highways with regards to the issuing of infringement notices. This involved taking the risk sectors as detailed in the C.R.A.S.H books, and applying a 4-digit sector code to each segment. Segments were delineated by natural boundaries to enable Police on the road to readily identify where each sector lay. The 12 Police Districts have been allocated four-digit sector codes to allocate to both highway and non-highway sectors.

The sector codes are used as a monitoring tool to measure road policing activity within each sector and to determine the impact of policing activities on crashes in each sector. Police staff use the relevant sector code on each notice issued in the District.

This system allows Police to use the C.R.A.S.H Book as an information and targeting source, and the analysis of the notices by sector allows a direct analysis of enforcement activity by location.

The map shown in Figure 3 demonstrates the prioritisation of sectors in the Southern Police District. These maps were made public and placed in the foyers of Police stations. Local media also showed copies of the maps in local papers, and many police staff, particularly in the Highway Patrol, used them to demonstrate to motorists that they were enforcing in higher risk areas where appropriate.

3.4. Locational Versus Behavioural Theory

It should be noted that the underpinning principle of the New Zealand Police road policing enforcement programme is to change behaviours across the network generally, so enforcement, whilst prioritising high crash sites, will also cover lower risk locations as part of an overall behaviour change. An analysis of crashes demonstrates that approximately half of all serious and fatal crashes occur where there has been none before, so it is generally believed that behaviourally targeted enforcement is as important as locationally based enforcement. The logic behind this argument is that improved driver behaviours (for example reduced speeds), will lead to less crashes and overall trauma reduction in both high priority areas and areas where crashes have yet to occur.

It is generally considered ineffective to simply target "black spots" whilst not addressing undesirable behaviours elsewhere.

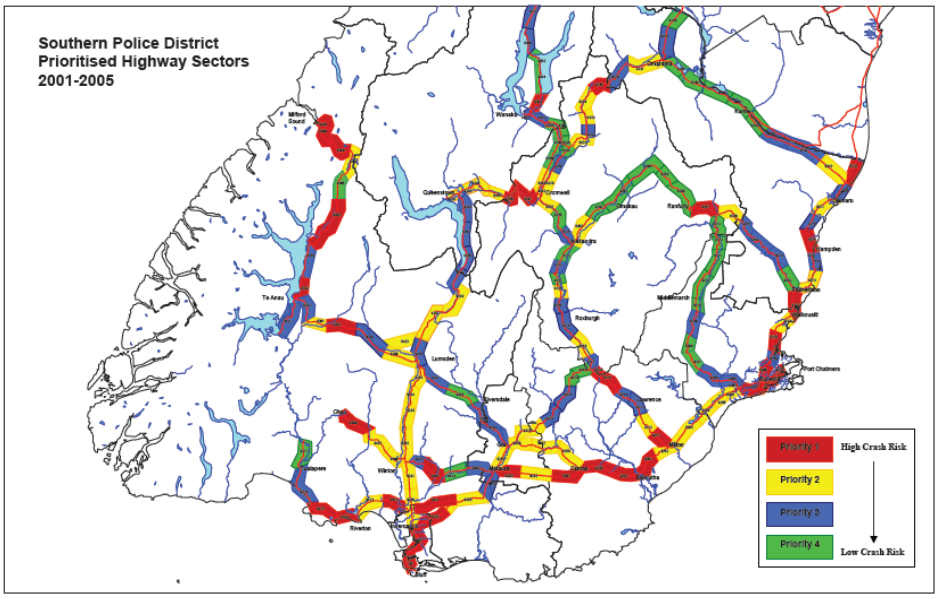


Figure 3: Southern District CRASH map showing sector priorities

Each sector has a detailed page that can be used by enforcement staff as a "menu" of risks and tactics to be used. They are designed to be easily read at a glance and guide tactical responses as shown in figure 4 below:

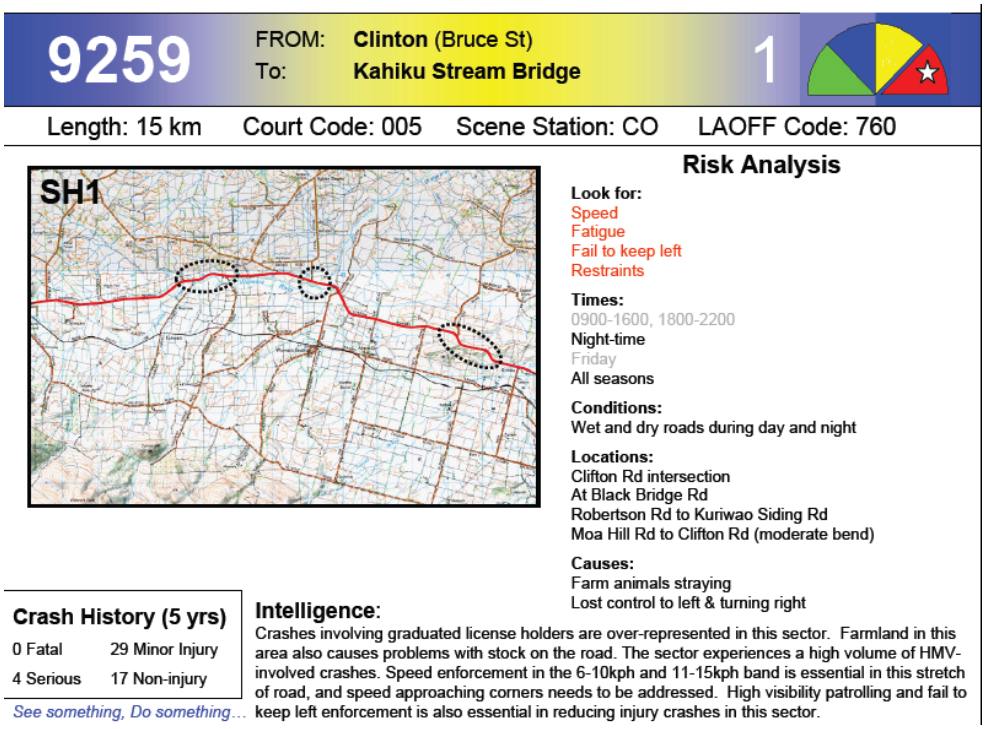


Figure 4: Sector detail

The urban environment differs in that sectoring is generally spatial as shown in figure 5:

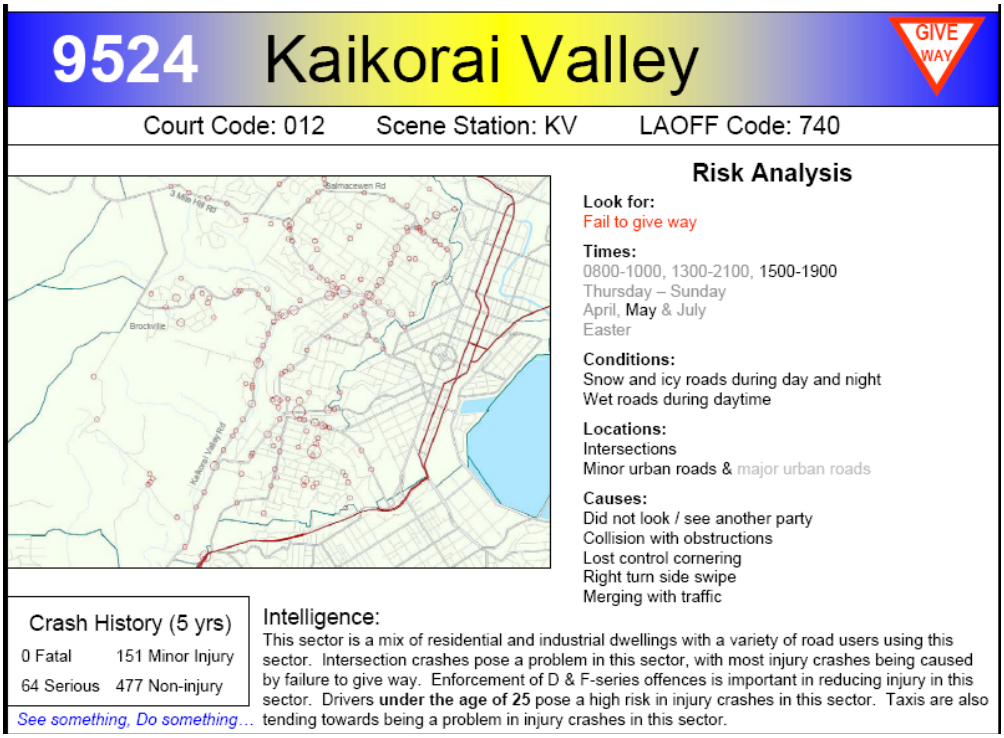


Figure 5: Spatial sectors in urban environment

An important part of these documents are the tactics required of police officers when patrolling in the allocated sector. An example from the rear of figure 5 is shown in figure 6:

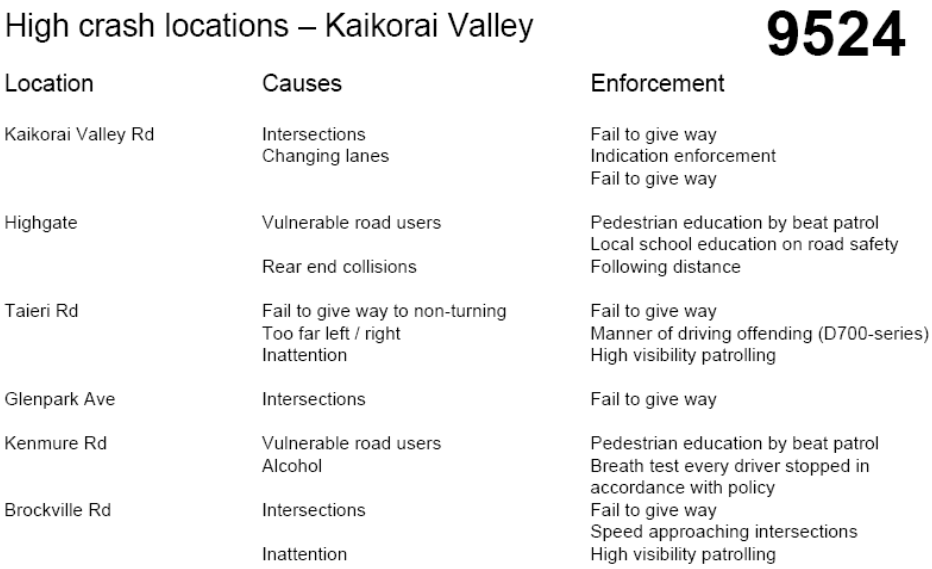


Figure 6: Enforcement tactics for a sector

3.5. The Tasking Process

The C.R.A.S.H Books are integrated into the Risk Targeted Patrol Plan (RTPP) process. Road Policing Intelligence staff identify the risks within the sectors that need to be addressed, and summarise relevant sector information in the C.R.A.S.H Book, along with tactical suggestions which is then provided to managers and tactical coordinators. For the non-highway C.R.A.S.H Books, other information such as local council speed counts, public event calendars, and road improvement plans is integrated into this process alongside the information provided in the C.R.A.S.H Book. The products produced are generally referred to as risk profiles.

The manager's role is to form Patrol Plans and to direct patrols towards sectors of higher risk and identify tactical responses to target specific driving behaviours or problems associated with sectors identified as risk targets.

A cross reference at the back of the book highlights the higher risk sectors for a given crash factor or condition such as day of week, dark/light, wet/dry or season.

Copies of feedback regarding the road and traffic environment are returned with the sector information to the road policing analyst to provide more data when the sector is reviewed. The analyst will be able to include information on tactics that work (or don't work) in the next update of the C.R.A.S.H Book, which should occur every three years.

4. ROAD SAFETY ACTION PLANS AND NETWORK SAFETY COORDINATION ON STATE HIGHWAYS

4.1. Road Safety Action Planning

Road Safety Action Plans (RSAPs) are developed at the territorial local authority level, or at the level of territorial local authority clusters or at Police district level. They are a collaborative process whereby the key road safety partners, namely Transit NZ, local authorities, Land Transport NZ, Police and community representatives "agree on risks, identify objectives, direct tasks, set targets, develop plans and monitor and review progress." (NZ Police 2007) RSAPs are a partnership agreement in which partners accept individual and collective accountability. They are a jointly owned document of the key partners.

This joint approach recognises that the combined benefits of education, enforcement and engineering solutions are required to reduce crashes. The C.R.A.S.H books in particular are used by these groups to determine risks and the appropriate interventions to mitigate them.

4.2. Network safety coordination on state highways

The Network Safety Coordination projects are similar in action to the RSAPs in that they identify a selection of worst corridors at a regional level by carrying out a detailed analysis of crash trends along particularly high-risk stretches of the State highway.

Regional meetings of Transit NZ, Land Transport NZ and NZ Police develop a coordinated approach to focus engineering, education and enforcement activities at targeted specific problems along those predetermined stretches of highway. The project development, implementation and monitoring are part of the RSAP process and the C.R.A.S.H books form an integral part of this process.

For both the RSAP and Network Safety Coordination processes, Police have supplied electronic copies of the C.R.A.S.H book to partners to allow joint mitigation of risk. Use of the C.R.A.S.H book and analysis of offences by sector helps all of the partners determine an appropriate response; for example:

- Speed-related crashes in the absence of consistent speed enforcement may demonstrate a need for increased targeted enforcement in that area;
- Speed-related crashes in wet conditions despite heavy enforcement may demonstrate a need for re-sealing or surface treatment;
- Fatigue related crashes may signal the need for "rumble strips" and appropriate signage and education as to the dangers of fatigue.

This multi-agency approach allows all parties to work together with a mutual understanding of the risks and allows for an improved degree of coordination.

5. RELATIONSHIP TO KIWIRAP AND EURORAP

5.1. Broad Assessment Programmes

New Zealand is now party to the Road Assessment Programmes under the umbrella of the international road assessment programme, iRAP. Similar RAP programmes have been implemented in Europe (EuroRAP), Australia (AusRAP) and the United States of America (UsRAP). The New Zealand version (KiwiRAP) has as its objectives:

- to reduce deaths and injuries on New Zealand's roads by systematically assessing risk and identifying safety shortcomings that can be addressed with practical road improvement measures;
- to put risk assessment at the heart of strategic decisions on road improvements, crash protection and standards of road management;
- to provide meaningful information on where the greatest levels of risk are faced, and in turn to influence behaviour.

KiwiRAP in appearance is broadly similar to the New Zealand Police C.R.A.S.H Book maps, with highways given risk ratings. Road Assessment Programmes internationally consist of three 'protocols' or stages/projects:

- Risk Mapping – colour-coded maps showing both the risk and concentration of crashes on different roads, based on crash data and traffic flow data. The maps are intended to effectively illustrate the safety performance of the road;
- Performance Tracking – identifying whether fewer people are being killed or injured on a road over time and identifying countermeasures that are more effective;

- Star Ratings – assessing the engineering features of a road. Between 1 and 5-stars are awarded to road links depending on the level of safety which is 'built-in' to the road.

The New Zealand CRASH Books, whilst broadly similar, have been developed as an aid to deployment and contain a significantly higher level of detail than the KiwiRAP process. The CRASH books show particular risks by sectors on average 10 - 20 km in length whilst KiwiRAP aggregates risks along a large range of disparate sectors, ranging from 2.3 to 318 km. The effect of the larger sectors used by KiwiRAP is to aggregate clusters of high risk and low risk sectors into an armorphous lower risk in some areas. For this reason, there are marked differences between the Police CRASH maps and the KiwiRAP maps.

Whilst KiwiRAP is of interest to Police and is generally informative to the public, it is not at a sufficient level of detail to be useful as a deployment tool for enforcement purposes, although it does add to the overall picture of risk for particular areas.

6. CHALLENGES FOR THE FUTURE

Police are continuing to develop the methodology behind risk targeting. This system is unique through Australasia, and there has been considerable benefit for Police in working in close partnership with Land Transport New Zealand. A better understanding of risk is sought, and it is only through detailed analysis and by considering the outcomes of targeted enforcement that this will be achieved.

The specific challenges for Police are bridging the gap between the C.R.A.S.H books as an informing product and the actual implementation in the field (the tactical products). Continual development is going into tactical deployment frameworks that contribute to a "whole of policing" approach whilst holding staff individually and collectively accountable for outcomes.

7. SUMMARY

The C.R.A.S.H books have been an invaluable tool to assist Police in improving deployment to risk. Other benefits include:

- provision of detailed information for engineering activities to improve the road environment and overall survivability of the network;
- a better understanding by front line police officers and their managers as to the outcomes and activities that are being sought;
- a better way to explain to the public the rationale behind enforcement activity;
- better information for planning purposes as part of the Road Safety Action Planning and Network Safety coordination processes;
- assistance to partner agencies in terms of planning and reducing duplication of analytical work;
- assistance to partner agencies in terms of ensuring interventions are to risk and not the result of public pressure; and
- media information

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