TECHNICAL PAPER

NORTH CANTERBURY SH NETWORK, CRASH HISTORY GIS WEBSITE

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Abstract

On behalf of NZTA and the North Canterbury State Highway Network Maintenance Consultant, a Geographical Information System (GIS) analysis tool to analyse crashes for the last ten years was produced.

This showed graphically various attributes of crashes including crash type and crash severity. Layers of high risk rural roads by collective and personal risk, kiwiRAP star rating, and an economic evaluation manual social cost were developed to provide a range of assessment methodologies of crash history. Crash density mapping was developed using Arc model builder scripting to provide a better visual presentation of areas of significant crash risk.

In order to identify the relevance of the individual items in the proposed programme of works including minor improvement projects, area wide treatments and reseals were mapped to allow spatial analysis to be carried out.

The GIS was then uploaded onto a website to make the data easily accessible. The system is capable of selecting individual crashes for analysis or groups of crashes as relevant. The system is being used to ensure the most efficient use of limited resources in order to reduce crash levels.

Introduction

In collaboration with NZTA and the North Canterbury State Highway Network Maintenance Consultant, a Geographic Information System (GIS) analysis tool was developed to display crash trends for the last ten years (2002-2011). The ultimate goal of the system was to provide a simple and clear display of multiple measures of crash type and severity, which would assist confirmation of the validity of programmed safety schemes and identification of potential new locations where safety improvements would be most beneficial.

A crash map booklet and interactive PDF were produced and subsequently all of the data was uploaded to a website. The system was created to provide an innovative approach to road crash data presentation using GIS tools to convert raw crash data sourced from the New Zealand Transport Agency Crash Analysis System (CAS) into a series of thematic maps. This paper describes the spatial layers of information that were displayed, the reason for their inclusion and the potential uses of the system to be used on other networks.

It was determined that the crash data provided would not be unacceptably sensitive. The location of fatalities is a matter of public record via the coroner so the key factor to avoid a sensitive subject, was that individuals were not named.

Crash Classifications

CAS coded reports in excel format were converted into a comprehensive series of themed diagrams that provide a thorough overview of the network's crash history. The range of themes are summarised below:

Movement Types

- Straight loss of control head on
- Bend loss of control head on
- Crossing Turning
- Head On
- Overtaking
- Rear End
- Run Off Road

Causative Factors

- Alcohol Involved
- Fatigue
- Road Wetness
- Too Fast
- Treatable Hazards Struck

Vehicles Involved

- Truck Involved
- Motorcycle Involved
- Cyclist Involved
- Pedestrian Involved

The following severity types were analysed. It would be a simple process to cross reference the crash type and severity types to identify more specific trends:

- Fatal
- Serious
- Minor
- Non-Injury

An example of all overtaking crashes taken from the website is shown in Figure 1 below:

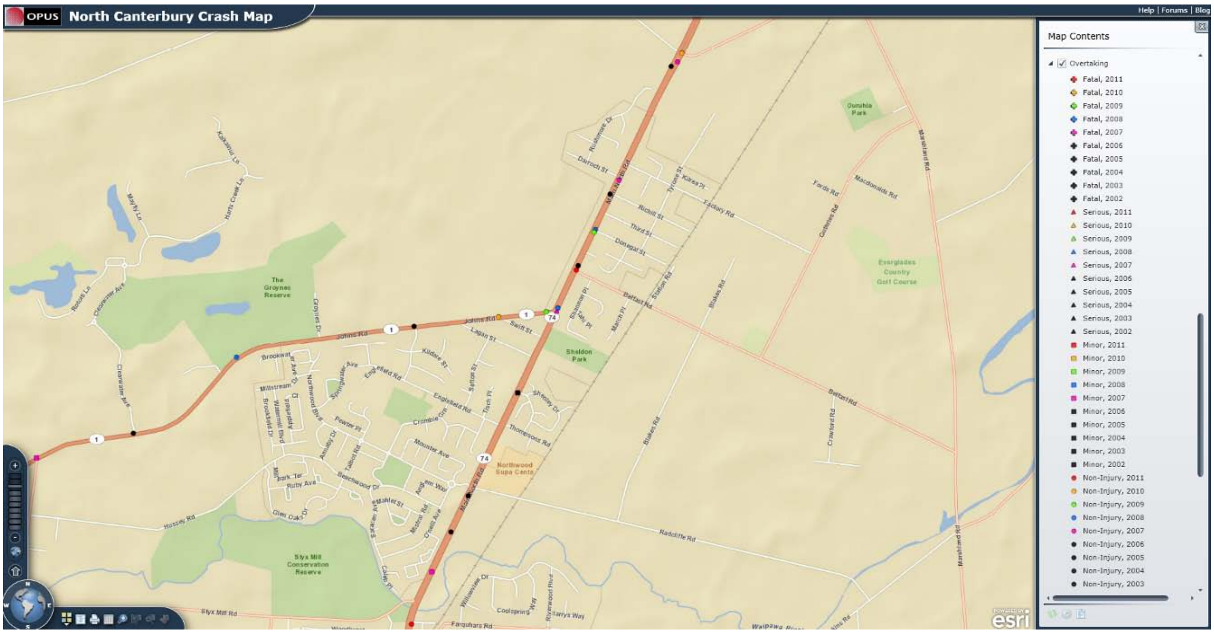

Figure 1 – Overtaking Crashes 2002–2011

The following crash density layers were produced for crash types that were identified as being of high importance.

- All Crashes
- Fatal and Serious
- Head On
- Run Off Road

They were based on the total number of crashes and did not take into account the crash severity (therefore a fatal and serious crash have the same weighting). Figure 2 below highlights concentrations of crashes that assist strategic targeting of high risk locations.

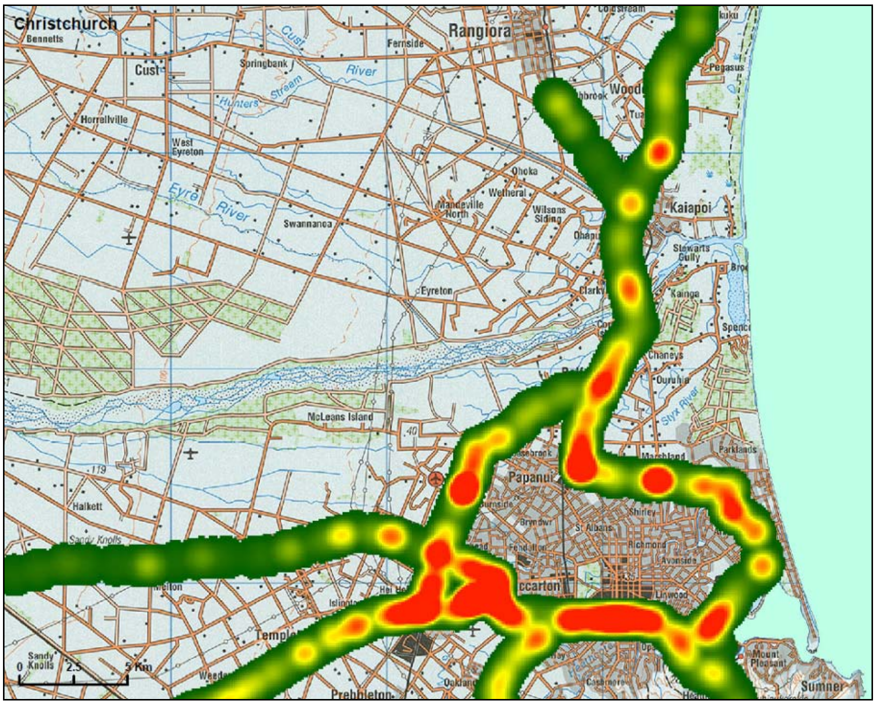

Figure 2 – All Crashes 2006-2010 Crash Density

In addition to the layers of specific crash types several other spatial layers of data relating to safety were incorporated into the system as listed below:

- KiwiRAP (NZTA 2012) star rating;
- Economic Evaluation Manual (NZTA 2010) social cost;
- High risk rural roads by collective risk (NZTA 2011) (2006 – 2010);
- Minor improvement projects; and
- Area wide treatments and reseals.

These are described in greater detail in the following sections.

KiwiRAP (NZTA 2012) Star Rating

The New Zealand Road Assessment Programme (KiwiRAP), analyses the road safety of the state highway network. KiwiRAP uses a star rating system to attribute a score to specific sections of road. Between 1 and 5 stars are awarded to road links, depending on the level of safety 'built-in' to the road.

The Star Rating approach focuses on the elements influencing the three most common and severe types of crashes on New Zealand's rural state highways which account for over 80% of all fatal and serious injury crashes on our rural roads:

- Run-off road crashes (which account for over 50% of all crashes);
- Head-on crashes; and
- Crashes at intersections.

The Star Rating system looks at not just the design and engineering elements of the road itself, but also any intersecting road that meets with it. The table below describes the categories for KiwiRAP classification.

Rating scale	Description of features	
	Divided road	Undivided road
5-Star *****	Straight with good line marking, wide lanes and sealed shoulders, safe roadsides and occasional grade separated intersections. Roads with a local, minor or major at-grade intersection cannot achieve a 5-Star Rating.	No undivided road can achieve a 5-Star Rating.
4-Star ****	Deficiencies in some road features such as lane width, shoulder width or roadside hazards.	Straight with good overtaking provision, good line marking and safe roadsides. Such a road will not achieve a 4-Star Rating if it has high traffic volumes.
3-Star ***	Major deficiencies in some road features. These may include poor median protection against head-on crashes, many minor deficiencies and /or poorly designed intersections at regular intervals.	Deficiencies in some road features such as alignment, roadsides, and /or poorly designed intersections at regular intervals.
2-Star **	Many major deficiencies such as poor alignment, poor roadside conditions and median protection, and poorly designed intersections at regular intervals.	Major deficiencies in some road features such as poor roadside conditions and /or many minor deficiencies such as insufficient overtaking provision, narrow lanes, and /or poorly designed intersections at regular intervals.

1-Star *	Poor alignment, in mountainous terrain, narrow lanes, narrow shoulders, severe roadside conditions and many major intersections.	Poor alignment, in mountainous terrain, narrow lanes, sealed shoulders, poor line markings and severe roadsides conditions.

Table 1 – KiwiRAP Categories

Minor Improvement Projects

Minor improvement projects on the state highways are safety driven projects that will cost under $250,000. The 43 minor improvement projects programmed for the following financial year were mapped spatially to allow simple comparison of the location of the treatments in relation to the recorded crash history as shown in the Figure 3 below.

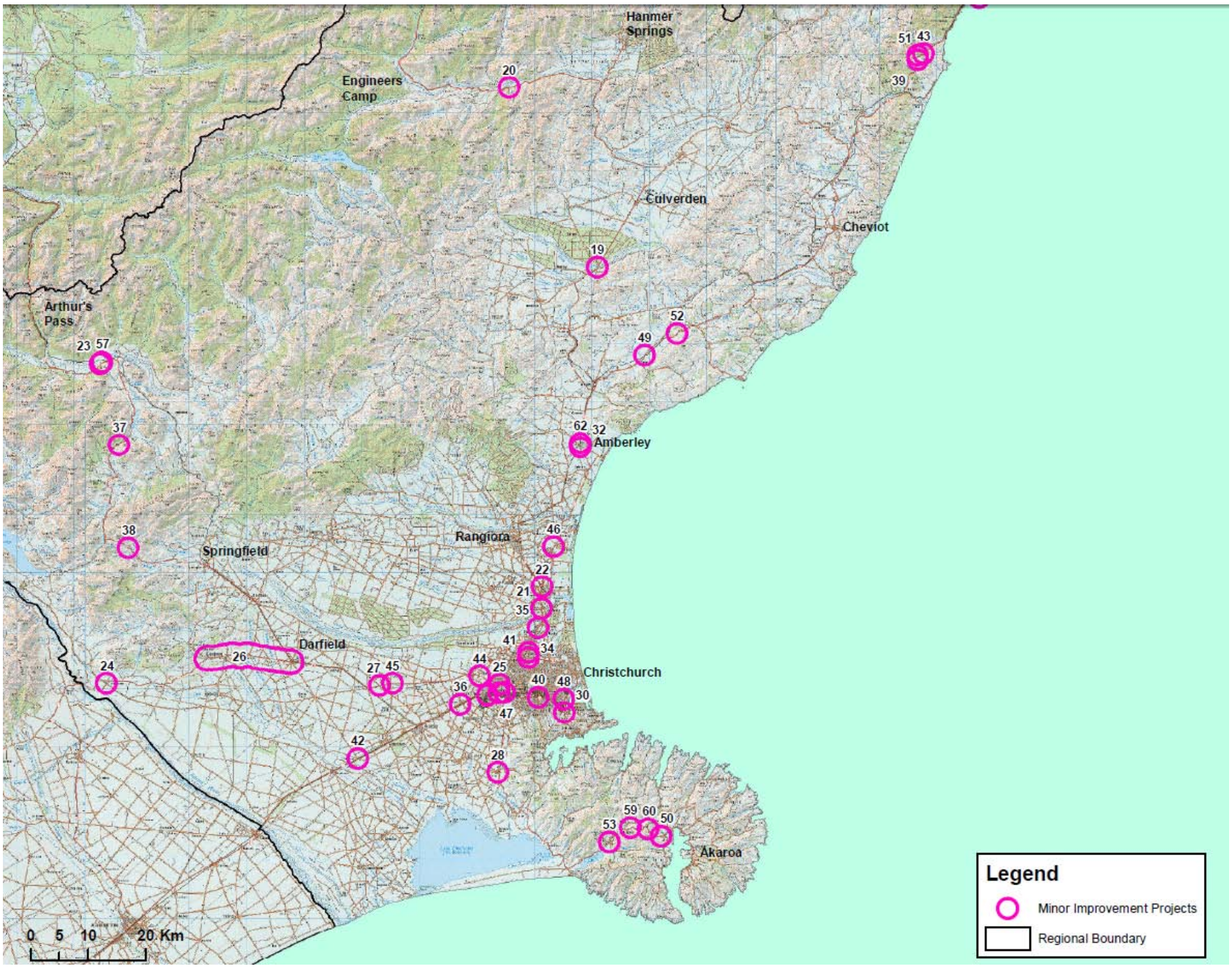

Figure 3 – Minor Improvement Projects

Area Wide Treatments and Reseals

Area wide treatments are structural pavement treatments applied to substantial lengths of roads, including large areas requiring digout and replace, overlay or recycling (NZTA 2007). They are generally driven by safety concerns and high maintenance costs to retain safe conditions. Reseals are a simpler process of replacing only the top layer of the pavement. The area wide treatments and reseals programmed for the following two financial years were mapped spatially to allow simple comparison of the location of the treatments in relation to the recorded crash history as shown in the Figure 4 below.

Figure 4 – Area Wide Treatments and Reseals

Social Cost Model using the Economic Evaluation Manual (NZTA 2010) Method

The GIS was used to generate a spatial output of social cost of crashes across a network. A spatial model was developed to automate the calculation of social cost using the crash by crash analysis method outlined in the Economic Evaluation Manual (NZTA, 2010) (EEM). The method requires crash data for a five year period and uses EEM cost values for each severity and each speed limit. The model calculates the total number of crashes in each category along each road length. The model then determines the social cost based on a series of criteria involving speed limit, crash severity, and number of crashes. The length of a section of road was determined by using the RAMM database carriageway sections. This ensures that the nature of each section was similar along its length. If there are three or more fatal crashes per kilometre the calculation applied is:

- Social Cost = (SF x CF) + (SS x CS) + (SM x CM) + (SNI x CNI)

Where

- SF = sum of fatal crashes
- SS = sum of serious crashes
- SM = sum of minor crashes
- SNI = sum of non-injury crashes
- CF = cost of fatal crashes
- CS = cost of serious crashes
- CM = cost of minor crashes
- CN = cost of non-injury crashes

For roads with less than three fatal crashes per kilometre a slightly different equation is applied:

- Social Cost = [(SF + SS) x (CF x RF)] + [(SF + SS) x (CS x RS)] +(SM x CM) + (SNI x CNI)

The only additions are the fatal to serious crash severities for all movements, where RF is a ratio of fatal/(fatal+serious), and RS the ratio of serious/(fatal+serious). It is important to note that each speed limit will have its own unique set of cost values per severity and may also differ in fatal to serious crash severity ratio values. The speed limits were extracted from the RAMM database using specific carriageway sections from the carriageway table.

The social costs for the various sections of road are not entirely comparable. The next step will be to convert the social cost into a per kilometre value, to normalise it. This will allow fair comparison of routes of varying length, whilst recognising the varying nature of the road. This will be done for the next phase of crash analysis.
The results generated from the EEM social cost model were made available in a detailed table or presented in a thematic layer of social cost. The model also has the ability to calculate the social cost across a road network for two back to back, five year periods and work out the difference between the two periods to generate the social cost change with time. This additional functionality makes it easier to readily identify roads of increasing and/or decreasing social cost.

High Risk Rural Roads for State Highways

The High Risk Rural Roads Guide (NZTA 2011) (HRRRG) was published with the aim to provide practitioners and policy makers with best practice guidance to identify, target and address key road safety issues on high risk rural roads. A high risk rural road (HRRR) is classified as a road which has a high or medium-high crash density (collective risk), or high or medium-high fatal and serious crash rate (personal risk). State highways use the kiwiRAP assessment whereas local roads are assessed independently. A spatial model was developed using the criteria and metric calculations outlined in the HRRRG to identify HRRR's in the GIS and visually present these in a thematic layer.

To successfully identify HRRR by personal risk the model requires posted speed limits and average annual daily traffic. The only other input required is the crash spatial data. Crash data for five years was used although crash data for ten years could also be used.

The HRRR spatial model applies an order of operations to identify roads with a speed limit of 80km/h or above with a fatal and/or serious crashes above a threshold for the given period of time and either a high or medium-high collective risk (>0.09), and/or a high or medium high personal risk (>7). In order for a road to be considered a HRRR it should have three or more fatal and/or serious crashes within a five year period or five or more within a ten year period.

The model applies the following equations:

- Collective risk = [(sum of fatal and serious crashes/number of years)/road length in km]

- Personal risk = sum of fatal and serious crashes/ [(road length in km x number of years x 365 x ADT)/100,000,000]

The model generates two outputs: HRRR based on collective risk, and HRRR based on personal risk. The HRRR model for state highways is able to identify sections of road that meet the above criteria and the output can be compared to the KiwiRAP spatial data of personal risk and/or collective risk.

Data Presentation

Figure 5 below summarises the data processing required to produce the crash map booklet:

Figure 5 – Data Process

In order to provide the data in a legible simple format that could be easily analysed by first time users the analysis was presented in three different formats as shown in the table below:

Format	Benefits
Crash Map Booklet	A hard copy format of A3 plots of relevant layers that can be taken to meetings and on the road
Interactive PDF	A printable format which allows users to select relevant layers to allow comparison between any or all layers at the same time
Website	Using the cloud based GIS web mapping software Arc Server a web site was established that allows viewing of all of the spatial layers and interrogation of individual or clusters of crashes, under different crash types or crash severity. This has the benefit of being simple to provide to any interested parties.

Table 2 – Data presentation formats

Conclusions

The project demonstrated the power of the consultant/road controlling authority collaboration to achieve a safer network of state highways.

The analysis tool proved to be a successful validation tool for confirming that the minor improvement projects and area wide treatments and reseals were accurately targeting valid locations to maximise their crash reduction potential. This justified the prioritisation of the schemes and demonstrated that NZTA were investing their capital wisely.

The 2013 forward work programme is currently under development and the analysis tool is being used to determine a prioritised list of schemes for the next financial year. The 2012 crashes will be extracted from CAS once available and uploaded into the GIS.

The intention is to use the tool on other state highway regional networks to provide similar benefits to ensure the best use of available funds. Many of the techniques used are also applicable to all roads and could be used on local road networks.

References

New Zealand Transport Agency (2010). Economic Evaluation Manual

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New Zealand Transport Agency (2007). Land Transport Road Assets
http://www.nzta.govt.nz/resources/road-assets/ashburton/2007-assets-ashburton-district.pdf

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