Identifying optimal sites for static speed cameras in New Zealand

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Abstract

As part of a program to reduce speed-related crashes, the New Zealand Police is expanding its network of static speed cameras. To help identify optimum sites for speed camera placement, an independent, evidence-based assessment was undertaken based on analysis in a geographic information system. Using historic crash data and site suitability criteria, 628 sites were identified as high risk locations suitable for speed cameras. Potential social cost reductions resulting from speed cameras were calculated for each site. These social cost calculations were used to identify optimal camera locations within sites, and to prioritise the sites for treatment. The results of the analysis were presented in a web viewer. This enabled the Police to undertake further desktop analysis of potential camera sites.

1 Introduction

In 2015, 319 people died on New Zealand roads, and 12,270 people were injured (Ministry of Transport, n.d). Excessive speed is a causal factor in many of these crashes, and often makes the outcome of a crash more severe. Lowering driver speed, especially in high-risk areas, is a key strategy for saving lives and preventing serious harm on New Zealand roads (Ministry of Transport, 2016).

While undertaking an expansion of the speed camera program, the New Zealand Police ('the Police') approached Abley Transportation Consultants ('Abley') and Interpret Geospatial Solutions ('Interpret') to expand an existing methodology for identifying optimal speed cameras across New Zealand's road network. The changes to the previous methodology improved the way the model behaved at intersections, and introduced a ranking mechanism based on social costs. The methodology described in this paper was developed in collaboration with the Police and the New Zealand Transport Agency ('NZ Transport Agency').

The methodology needed to identify the top 600 potential camera sites[1] across New Zealand, based on the site's suitability for a speed camera and the potential benefits that could be gained from having a camera at that site. It also needed to provide robust evidence for the chosen placement of cameras to demonstrate that the sites were chosen to maximise potential safety benefits rather than to increase speed ticket revenue.

2 Methodology

[1] The Police requested that approximately 600 sites be identified as potential cameral locations. This was to provide sufficient sites to deploy their 56 cameras across the network, with the understanding that some sites would not be suitable for reasons outside the scope of this analysis.

This methodology is broken into discrete sections of analysis. The analysis was undertaken using a series of models and Python scripts in ArcGIS 10.3. These models undertook crash processing, segment scoring, site identification and site prioritisation. Once modelled, undertaking the analysis for New Zealand would typically take two to five days.

2.1 Inputs

The inputs to the analysis were crash data and a geometrically high-quality road network from TerraLink.

Crash data was sourced from NZ Transport Agency's Crash Analysis System (CAS). CAS is a database that records key road crash information, such as the location, types of vehicles involved, road environment, factors that contributed to the crash, and the crash outcome. Ten years of injury crash data were extracted from CAS for this project. This data range provided sufficient data for analysis while helping to ensure that the crashes were related to the current road network. For each of these crashes, the estimated death and serious injury crash equivalents (DSi) were calculated (NZ Transport Agency, 2013).

DSi is an index that gives the relative risk of a crash causing death or serious injury. It reflects the fact that the outcomes of crashes are based on speed, road environment, intersection type and crash movement type[2]. The actual outcome of the crash is a poor predictor for future crashes. Using DSi means that the analysis is based on the potential for poor crash outcomes, rather than the actual crash outcomes (NZ Transport Agency, 2013). This provides predictive approach to road safety modelling.

2.2 Crash Processing

Crashes were assigned a severity rating of minor, serious or fatal. Severity represents the most severe outcome from the crash, and is calculated from the injuries recorded in CAS.

Crashes in CAS have causal factors recorded against each crash. Crashes with cause codes 111, 112, 131, 132, 133, 151 and 431 (Table 1) were categorised as being speed-related crashes. Additionally, some crashes had a maximum crash speed recorded. If the maximum crash speed was above the posted speed limit, the crash was categorised as speed related. This classification was undertaken alongside consultation with the Police and NZ Transport Agency, and was in alignment with previous speed camera location identification work completed by Abley in 2013 (NZ Police, 2013).

Table 1: Cause codes and descriptions from CAS (NZ Transport Agency, 2016)

Cause Code	Description
111	Inappropriate speed: Entering / on curve
112	Inappropriate speed: on straight
131	Lost control when turning
132	Lost control under braking
133	Lost control under acceleration
151	Overtaking line of traffic or queue
431	Showing off: Racing

The DSi of crashes that occurred within the last five years were double-weighted ('weighted DSI'). This was to highlight locations with worsening crash trends, which indicates a need for intervention. Roads with a crash reduction in recent years are becoming safer, possibly because of adjustments to the road environment or nearby intersections, and therefore are less optimal locations for speed cameras.

2.3 Segment Scoring (SS)

The analysis completed using a geometrically high-quality New Zealand road dataset, split into segments of approximately 100 meters. The 'catchment' of each segment was identified as the road extending a defined distance on either side of the segment's midpoint. These distances were 500 meters for rural roads (speed limit > 70 km/h) and 250 meters for urban roads (speed limit <= 70 km/h). These values were determined from the documented 'halo' effect that exists both upstream and downstream around static cameras, as drivers slow down to anticipate the camera site. In contrast, mobile cameras tend to have a 'downstream only' effect, where motorists slow after the camera but not before (Elliot and Broughton, 2005).

Crashes within each road segment's catchment were assigned to that road segment. For each segment, key values from these crashes were summed to the road segment. These included the total weighted DSi, the number

2 Crash movements are defined in the Guide of the Interpretation of coded crash reports from CAS (NZ Transport Agency, 2016).

of fatal or serious crashes and the number of speed-related crashes. These three values were combined to form a segment score (SS). These three factors are not of equal importance in determining the optimal location of speed cameras, so these were assigned different weightings.

The weightings prioritise the number of speed related crashes and the weighted DSi score over the number of fatal and serious crashes. The prioritisation of speed related crashes highlights areas that are suitable for treatment with speed cameras. The prioritisation of DSi gives the model a predictive element, highlighting areas that have a higher potential for fatal and serious crashes, even if no fatal or serious crashes have occurred in the last ten years. The count of fatal and serious crashes is included to account for factors that are not included in the DSi but which affect crash outcome. This count is given less weight in the model, so as not to bias the results towards the random occurrence of fatal and serious crashes. The final weightings values are the result of extensive testing and peer review by the NZ Transport Agency, the NZ Police and third parties.

The formula used to calculate the segment score is shown in Figure 1.

$$SS = (SR * 0.4) + (wDSi * 0.4) + (FS * 0.2)$$

Where:
- SS = segment score
- SR = count of speed related crashes
- wDSi = weighted DSi
- FS = count of fatal and serious crashes

Figure 1: Segment score calculation

As segment lengths varied slightly, the segment score was then normalised to reflect 100 metre segments. Note that the segment score is a relative measure and does not have any units. The segment score is a tool designed to be used to highlight sections of road with a high number of speed-related, high severity crashes, as this is where a speed camera could provide benefit.

2.4 Site Analysis

The Police required this analysis to result in a minimum of 600 possible speed camera sites. As well as being good candidates for reducing death and serious injury through speed reduction, these sites had to meet the following site suitability criteria.

Sites needed to be at least 300 meters long, to provide sufficient options for camera placement. Winding or twisty sites were excluded, as drivers would be unlikely to exceed the speed limit in these areas. The alignment of sites was sourced from the One Network Road Classification (ONRC) data. Sites were assigned the predominant corresponding ONRC classification. Any site identified as winding or twisty (ONRC classification of ‘tortuous’) was removed from the analysis.

At a minimum, 25% of crashes in the site needed to be speed related. This ensured that a speed camera would be a suitable treatment for the site. Finally, the site had to have less than 75% of crashes occurring at intersections. This criterion was to exclude sites where alternative treatments, such as red light cameras or intersection upgrades, would be more suitable.

An iterative process was undertaken to define the potential sites. This process ensures that the most high-risk sites were present in the results, that all potential sites met all of the site criteria, and that the required number of sites are produced. The process assessed the segments against an adjustable SS threshold, where segments below the threshold were excluded from the analysis.

For a given SS threshold, contiguous segments with a segment score above the threshold were dissolved into a single site. Sites were assessed against the above additional criteria. Those that did not meet these criteria were removed. If this process did not return approximately 600 sites, the threshold was adjusted up or down as required, and the process was repeated.

The benefit of this system was that, with any required number of sites, the highest-risk sites were always included in the site analysis.

This process resulted in a SS threshold of 2.9, producing 628 sites which fulfilled the criteria.

2.5 Site Prioritisation

Sites were prioritised based on the benefit that would be gained by placing a speed camera at the site. Benefit was categorised as the likely reduction in social costs resulting from a speed camera. Social costs are defined as “a measure of the total cost of road crashes to the nation … [including] loss of life and life quality; loss of productivity; and medical, legal, court, and property damage costs.” (Ministry of Transport, 2016). Social costs were calculated for each crash, based on speed environment and crash movement type (Ministry of Transport, 2014).

To understand the maximum possible reduction in social costs, hypothetical cameras were generated every 100 meters along each of the potential camera sites. For each hypothetical camera, a catchment area was generated. This was 250 meters either side of the camera in urban areas, and 500 meters in rural areas. This catchment represented the area that would be influenced by a camera at that specific site, and was equivalent to the previously mentioned ‘halo’ effect (Elliot and Broughton).

Crashes with each catchment were summed and attributed to the hypothetical camera. This value represented the total social cost of all the crashes that could have been influenced by a speed camera in that location. However, speed cameras do not prevent all of the crashes within their catchment. Existing research suggests that crash reductions due to speed cameras installation range between 20% (Mara, Davies and Frith, 1996) and 42% (Transport for NSW, 2015). Using this data, two social cost reduction values were calculated for each hypothetical camera. These were the optimistic reduction, at 42% of the total social cost, and the conservative reduction, at 20% of the total social cost.

Within each site, the hypothetical camera with the highest potential for social cost reduction was identified as that site’s optimum location. Note that this process is the same no matter which social cost reduction value is used.

The 628 sites were then prioritised based on the potential social cost reduction offered by the site’s optimum speed camera location.

3 Results

The end result of this analysis process was a prioritised list of 628 sites. Each site had a variety of analysis information attached to it. This included a detailed breakdown of crash information and social cost reduction. Each site had a point location identified as the optimal site for the location of a speed camera to reduce social cost.

These results were presented to the Police using an interactive website (Figure 2). This had the functionality for the Police to add comments against sites, and to assess the sites against factors that were not accounted for in the methodology.

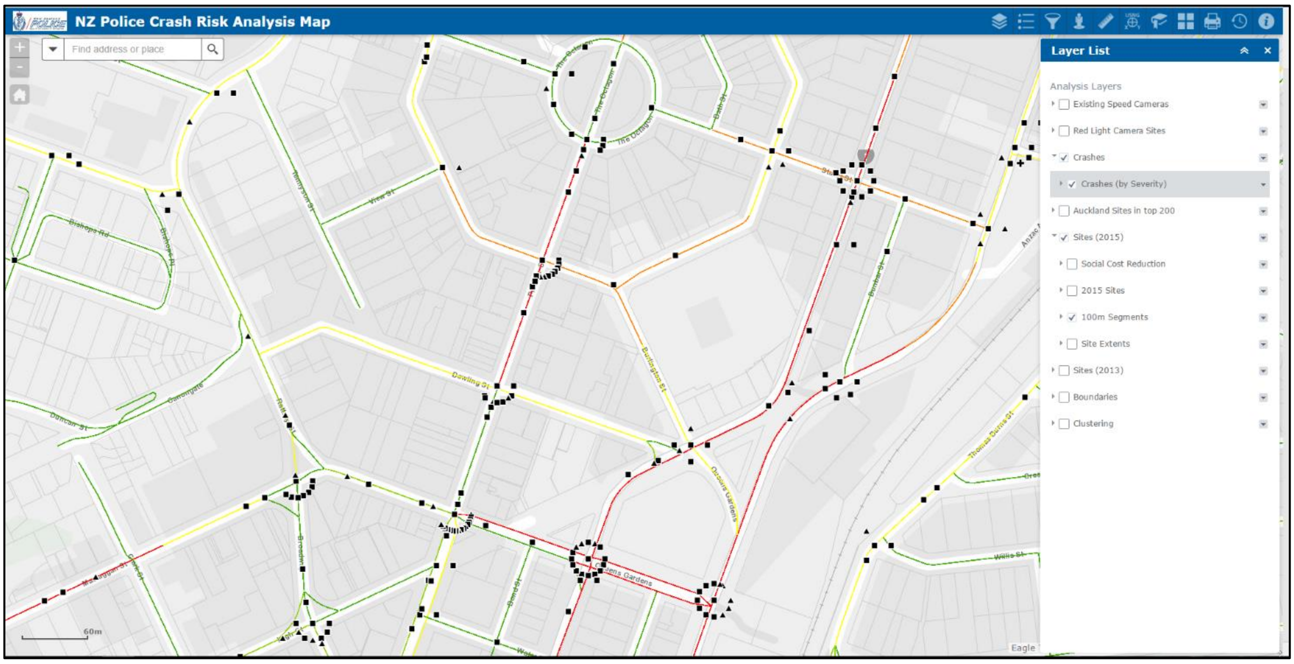

Figure 2: Analysis results website

A separate website has been created to facilitate stakeholder engagement (Figure 3). This presents the analysis methodology in a clear and accessible way, to promote discussion and demonstrate that sites have been selected to prioritise safety rather than revenue gathering.

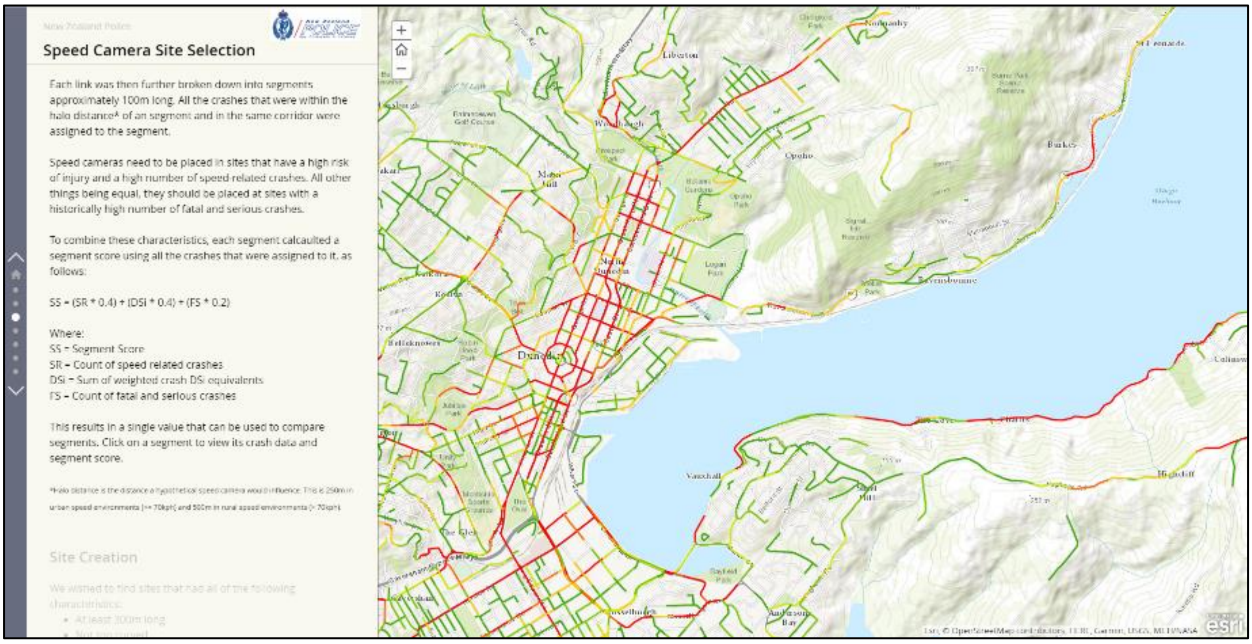

Figure 3: Site selection demonstration website

The Police have released a list of the locations of the first 15 speed camera sites to be implemented as a result of this analysis (NZ Police, 2016). These are located in Northland, Auckland and Wellington. However, due to the sensitive nature of this project and ongoing consultations with stakeholders, the full list of potential site locations and social cost values have not been included in this paper.

4 Discussion

The Police speed camera program's aim is to reduce deaths and serious injury on New Zealand road. This aim is met by reducing the number of fatal and serious injury crashes, where speed is a contributing factor.

The Police have a program for rolling out a limited number of static speed cameras. As is the case for all government bodies in New Zealand, the Police are required to demonstrate to the public that they are optimising this investment (NZ Treasury, 2015). This benefit is quantified as the expected social cost reduction based on potential crash reductions.

It is important to note that the speed camera program is not a revenue gathering exercise for the Police. Speed infringement fines are paid directly to the Crown, rather than to the Police, and the performance targets for the speed cameras are not based on revenue generated (Auditor-General, 2002). The Police state that they incur a cost to issue speed infringement notices (NZ Police, n.d). Given that the Police do not site cameras to optimise speed infringement fines, the benefits of deploying a speed camera are measured solely in terms of reduction in social costs, rather than by the camera's potential revenue.

However, common public perception is that speed cameras are located to ticket more drivers rather than to improve road safety outcomes (NZ Automobile Association, n.d). With this in mind, the Police aimed to make the process of locating speed camera sites transparent and justifiable. The site selection process is outlined on the Police website. In addition, a website has been prepared to walk stakeholders through the site selection process and explain the decisions that led to the identification of potential sites (NZ Police, n.d).

Other key road safety measures exist, such as collective risk and personal risk. These summarise the risk to an individual (personal risk) or to all road users (collective risk) travelling along a section of road. While these measures are useful indicators for targeting overall road safety improvements, they are not the most suitable way to calculate the optimal locations for speed cameras as they do not take into account the causes of the crashes (NZ Transport Agency 2011).

This methodology has the potential to be widely applied to situations where speed camera sites need to be located and prioritised. As the analysis uses only two simple inputs, it can potentially be used across different jurisdictions. Additionally, the use of an adjustable segment score threshold means that this methodology will result in the required number of sites, no matter what the range of the underlying segment scores.

One of the strengths of this model is its predicative ability. Rather than looking solely at where speed-related crashes occur, the model takes into account the likely severity, using the DSi index, as well as the actual outcome of the crash. This allows the site to assess the potential severity of a camera site, and to generate sites where the potential for social cost reduction is greatest.

5 Conclusion and Future Work

This methodology provides a cost effective and standardised process to identify optimal speed camera sites on any road network. It can be used nationally, as was the case in this study, or on smaller areas. The analysis is auditable and repeatable, and provides a data-based justification for the placement of a camera.

Future work will assess the impact on speed cameras on New Zealand's crash patterns. By comparing crash behaviour before and after the installation of a camera, the predicted reduction in crashes and social cost will be able to be calculated more accurately. This will provide an input into future speed camera location analysis.

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