

Investigation into the use of point-to-point speed cameras December 2011

M Lynch, M White and R Napier
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NZ Transport Agency
Private Bag 6995, Wellington 6141, New Zealand
Telephone 64 4 894 5400; facsimile 64 4 894 6100
research@nzta.govt.nz
www.nzta.govt.nz

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AECOM NZ Ltd, PO Box 27277, Wellington 6011, New Zealand
Telephone 64 4 382 2999; facsimile 64 4 382 2998

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Abbreviations and acronyms

3G	mobile communication that meets International Telecommunication Union specifications
ADSL	asymmetric digital subscriber line
ANPR	automatic number plate recognition technology
CAS	NZTA's Crash Analysis System
CCTV	closed circuit television
CPI	Consumer Price Index
GPS	global positioning system
HOTA	Home Office Type Approval
IR	infra-red
LAN	local area network
NZTA	New Zealand Transport Agency
OAG	Office of the Auditor General
OCR	optimal character recognition
P2P	point-to-point (speed camera/enforcement)
PCS	Police Calibration Services
PIB	Police Infringement Bureau
RTA	Road Transport Authority (New South Wales)
vpd	vehicles per day
WAN	wide area network

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Executive summary

Investigation into the use of point-to-point (P2P) speed cameras was identified as an action in the Ministry of Transport's 2010–20 *Safer journeys* strategy document. As a safety research priority for 2010–12, the New Zealand Transport Agency (NZTA) commissioned an investigation into P2P speed cameras. P2P devices are internationally recognised to provide advantages over traditional spot-speed enforcement as they encourage compliance over a greater distance. This report investigates the use of P2P cameras and the potential for the technology to complement the existing speed enforcement within New Zealand.

The fundamental principles behind average speed enforcement are common to P2P camera systems operating throughout the world. Time-stamped images are recorded at entry and exit points along an enforcement corridor of known length. The vehicles are identified using automatic number plate recognition (ANPR) software that provides a data read-out of the number plate. Each vehicle's average speed within the corridor is determined by dividing the total distance between the camera points by the time taken to travel between the points. The principles of operation are similar regardless of the supplier. Average speed enforcement is an established and proven technology since it was first introduced in 2001 and is currently used in the UK, The Netherlands, Italy and Austria. In areas where the P2P camera system has been implemented there have been reductions in serious-injury and fatal crashes and greater compliance with posted speed limits.

Existing speed enforcement within New Zealand utilises a combination of fixed spot-speed cameras, mobile speed camera vans and police officer initiated infringements. The introduction of P2P speed camera technology will need to complement the current speed enforcement techniques. There are 56 permanent mountings around New Zealand. Twelve cameras are used at these permanent sites and an additional 43 speed cameras are utilised in mobile enforcement operations. The New Zealand Police (NZ Police) currently have limited exposure to ANPR technology with surveillance camera vans. The Police Infringement Bureau (PIB) is responsible for the adjudication and issuing of speed enforcement infringements. The introduction of P2P speed enforcement will require the establishment of new procedures and methods; however, the changes are achievable.

Discussions with international jurisdictions and a literature review of P2P speed camera systems implemented overseas provided lessons for the potential use of the P2P system within New Zealand. These lessons included issues relating to implementation, integration, available technology, legislative considerations and corridor suitability criteria.

In the UK, P2P speed cameras established on corridors with a history of high-speed crash rates have led to reductions in fatal and serious-injury crash rates. Crash rate reductions were observed after the installation of P2P devices along a section of the A77 in southwest Scotland in July 2005. The 32-mile (51 km) section was identified as having a high number of speed-related crashes. A case study on the system assessed crash data three years prior to and since P2P enforcement and found, on average, a 19% reduction in all crashes, with fatal crashes falling by 46% and serious-injury crashes by 37%.

The introduction of an average speeding offence requires changes to the current New Zealand legislation to allow the enforcement. This report does not provide expert legal advice; rather the information is intended to give an understanding of possible legislative changes that would be required prior to the implementation of P2P enforcement. The system would need to be approved and the image requirements defined in the Act to allow any offence to be enforced. The report considers the potential implications for the Land Transport Act 1998, Public Records Act 2005 and the Privacy Act 1993. The NZTA should seek qualified legal advice before actioning the next steps. However the review of legislation suggests only

minor changes to the existing legislation may be necessary to allow the enforcement of an average speed offence.

The study found the principles behind the technology for P2P enforcement have been demonstrated by road authorities throughout the world. There are a number of suppliers of P2P systems who can provide the required hardware components, processing software and back-office support. This report provides information on supplier experience and industry best practice for roadside infrastructure. The P2P camera setup at the roadside will affect the number of vehicles successfully identified as they move through the enforcement zone. However, the capture rate may not be the critical consideration in the roadside design. While the research suggests a high capture rate is necessary to provide credibility to the device as a speed enforcement tool, an overt P2P system may influence driver behaviour and reduce speed within the enforcement zone. The study examined the roadside infrastructures that impact the capture rate including camera mounting, orientation, coverage and image trigger. The study found the highest capture rates were observed when:

- cameras were located directly above the lanes to reduce potential obstructions
- vehicle detector loops were used to trigger the camera to photograph vehicles entering and exiting the enforcement zone
- infra-red illuminators were used to identify vehicles at night
- a single camera per lane was installed.

International experience has shown that P2P cameras are effective in reducing the number and severity of crashes. Careful selection of sites is required to ensure successful outcomes are replicated within New Zealand. The review of current P2P speed camera research identified site selection characteristics for the implementation of a P2P enforcement system. An assessment of state highways throughout the North and South Islands identified potential P2P camera sites, which, according to the agreed criteria, included:

- state highway classification
- history of crash and casualty incidents
- KiwiRAP site ranking, 2008
- length of zone
- number and nature of intersections
- discrete speed zones
- traffic volume.

Proposed upgrades under the roads of national significance (RoNS) programme were not considered in the analysis.

The study identified 11 potential sites for the introduction of P2P cameras and assessed them against a range of traffic and safety related criteria, which included:

- casualty crashes per kilometre per year (2006–10) – the sites with the highest casualty rates were ranked favourably as they would benefit most
- crashes per kilometre per year (2006–10) – the sites with the highest crash rates were ranked favourably as they would benefit most
- KiwiRAP 2008 – high-risk sites in the KiwiRAP assessment were scored favourably based on the highest ranking benefiting most

- proportion of crashes where speed was a contributing factor – the sites with the highest proportion of speed-related crashes to total crashes observed were ranked the highest
- proportion of speed factor crash costs to total crash cost – the sites with the highest proportion were ranked favourably.

At the request of the NZTA three illustrative sites were selected from the potential site list. The illustrative sites were located in the Wellington, Auckland and Northland regions. The top-ranked sites from each region were included in the focus group discussions. The illustrative sites included:

Region	Road name	From	To
Wellington	Wellington Urban Motorway (SH1)	Johnsonville	Porirua
Auckland	North-Western Motorway (SH16)	Eden Terrace	Waitakere
Northland	Waro Drive (SH1)	Kawakawa	Whangarei

The P2P camera principles for average speed enforcement are internationally recognised with systems currently operating in the UK, Australia and Europe. Average speed enforcement systems regularly observe a high level of speed limit compliance and reduction in crash and casualty rates within the zone. The study suggested the use of P2P speed camera enforcement within New Zealand would probably provide benefits similar to those in systems operating overseas. The introduction of a phased implementation at an illustrative site would allow the P2P camera components to be tested under New Zealand conditions. The initial phase would give Police Calibration Services the opportunity for the necessary testing required to gazette the system as an approved surveillance device. Speed survey data collection is required to provide a base case for comparison. A future business case could present the results and determine the form in which P2P speed camera enforcement would be introduced in New Zealand.

Abstract

Road safety is an issue that impacts on all levels of government and population. Since a high of 843 fatalities in 1973 the overall crash rate has been declining and 384 fatalities were recorded on New Zealand roads in 2009. Although this represents a significant reduction in casualties, there is still a need to reduce the current rate of about one fatality per day.

Lessening the incidence of exceeding the speed limit is one way that can effectively reduce these rates.

Speed enforcement technology has now progressed to the current state of point-to-point speed cameras. P2P cameras operate by photographing all vehicles passing both the start and end of a section of road under consideration. The photographs are time stamped which allows travel time to be derived. Computer software identifies the number plates of passing vehicles and matches the images taken. The cameras are a known distance apart and hence the average speed can be calculated.

Photographs of vehicles exceeding the trigger speed can be forwarded to the infringement division for validation.

This research report comments on the technology and application of these devices to New Zealand, and sites that may be suitable for these devices.

1 Introduction

1.1 Report background

The NZ Transport Agency's research priorities for 2010–12 included research into passenger transport, freight, economic productivity and safety. This report is within the safety research area and concerns issues related to the implementation of point-to-point (P2P) speed cameras in New Zealand.

Investigation into the use of point-to-point (P2P) cameras was identified as an action in the Ministry of Transport's 2010–20 *Safer journeys* strategy document. P2P devices are internationally recognised to provide advantages over traditional spot-speed enforcement as they encourage compliance over several kilometres of road rather than several hundred metres as in the case of spot-speed cameras.

Internationally, spot-speed camera systems are acknowledged to be effective at reducing speeds at the camera site, but the research suggested drivers returned to their approach speed within 500m downstream. Research of P2P speed camera enforcement revealed a high level of speed compliance within the zone, although one theory suggested drivers accelerated downstream of the P2P camera zone, similar to observations at fixed spot-speed camera sites.

The paper presented to the European Transport Conference, Speed cameras – measuring the impact on driver behaviour, was featured in the journal, *Traffic Engineering & Control*, in an article entitled 'Speed cameras – how do drivers respond?' (Keenan 2004). The author presented a statistical analysis of driver behaviour for three spot-speed camera sites and one P2P camera enforcement site. The analysis of speed survey data at the entry, exit and midpoint along the P2P speed camera corridor showed vehicle 85th percentile speeds were at or below the posted speed. In comparison, the trend for the spot-speed camera sites was for the 85th percentile speeds to adhere to posted speeds adjacent to the camera locations only, while 500m before and after the camera 85th percentile speeds were 10% greater than posted.

P2P speed camera systems are fundamentally different from spot-speed cameras. They operate using two cameras and these devices photograph all vehicles regardless of their current speed. One camera is at the start of the section of road with the second at the end. The initial camera captures an image of a vehicle entering the sector, the second camera later photographs this vehicle as it leaves. The two images are matched using automatic number plate recognition (ANPR) software.

The length of road between the two cameras is determined during the camera installation process. The time the photographs are taken marking the vehicle's entry and exit are recorded. Using these values the system is able to determine the average speed of the vehicle through the sector. If the speed calculated is higher than the enforcement speed then an infringement notice can be created.

1.2 Report methodology

This report provides concise information about the implementation of the P2P speed camera system into the existing processing, policing, technical and legal frameworks, and delivers:

- a description of the existing speed camera enforcement system in New Zealand
- the principles behind P2P average speed camera enforcement
- an account of international experience with the P2P speed camera systems
- a brief overview of legislative amendments for consideration

- an assessment of the P2P speed camera systems and their integration into our existing speed enforcement systems
- suitable site selection methodology based on system capabilities, international experience and strategic objectives.

2 The existing speed camera system

This section provides a summary of current speed enforcement process employed throughout New Zealand.

2.1 Overview of current speed cameras

New Zealand's current speed camera system uses four approved devices. These are all spot-speed enforcement systems, used either at fixed sites or in mobile operations. There are 56 permanent mountings around New Zealand. Twelve cameras are used at these permanent sites and an additional 43 speed cameras are used in mobile enforcement operations. Throughout 2009, the 55 cameras were used at a total of 1693 sites, recording vehicles speeds for over 90,000 hours (Eriksen 2010).

The permanent installations typically comprise two parallel sensor strips installed in the traffic lane together with a detection loop. The sensors measure the speed of the vehicle by recording the time when each sensor is activated. The distance between the sensors and the change in time provides the vehicle's speed. The detection loop is to confirm the first sensor was activated by a vehicle rather than by any other object. If the vehicle is travelling faster than the trigger speed (the minimum speed at which an infringement occurs) a photo is taken and an infringement notice may be created (OAG 2002). The fixed cameras currently use wet film to record their photographs. There are plans to upgrade these cameras to digital technology.

Mobile cameras emit a radar beam which is used to calculate a vehicle's speed. If the speed is faster than the camera's trigger speed a photo is taken and an infringement notice may be created. The system takes less than one second to identify the vehicle, verify its speed and take the photo. The NZ Police's mobile cameras are relatively new and capture digital photographs. The mobile cameras are operated by both police officers and trained civilians.

Speed enforcement devices must be endorsed by the Police Calibration Services (PCS) as approved vehicle surveillance devices to meet the requirements of New Zealand's legislation. The PCS conduct rigorous tests on the devices and associated back-up software prior to their introduction into service. The testing is carried out at an off-road facility at Auckland's airport where various scenarios are enacted to ascertain the device response. Following controlled testing the devices are then field tested with the total testing process taking up to two years to complete. A report is subsequently prepared and then peer-reviewed before being presented to the Minister of Police. If the minister authorises the use of the camera then the PCS can proceed to acquire legal status for the system as an approved vehicle surveillance device.

The 55 cameras are spread among the 12 New Zealand police districts as shown in table 2.1.

Table 2.1 Existing regional speed enforcement operations

Police district	Camera operations
Northland	No fixed cameras, three mobile
Waitemata	Two fixed cameras, six mobile
Auckland city	One fixed camera, two mobile
Counties/Manukau	One fixed camera, four mobile
Waikato	One fixed camera, five mobile
Bay of Plenty	One fixed camera, four mobile
Eastern	One fixed camera, three mobile

Police district	Camera operations
Central	One fixed camera, five mobile
Wellington	Two fixed cameras, three mobile
Tasman	No fixed cameras, two mobile
Canterbury	One fixed camera, three mobile
Southern	One fixed camera, three mobile

The number of speed camera infringement notices issued in recent years:

- year ending 30 June 2010: 457,546
- year ending 30 June 2009: 388,056¹
- year ending 30 June 2008: 436,500.

Not all speed violations recorded by the fixed cameras are processed as infringement notices. The Office of the Auditor-General's 2002 report on the New Zealand speed camera system stated only 59% of photos were processed as infringement notices. The equivalent rate in Victoria, Australia at that time was 80%. The local rate has increased in recent years to around 70%. Reasons for the rejection of images include:

- the vehicle's number plate is obscured
- there are two vehicles on a dual-carriageway in the photo and the offending vehicle cannot be accurately defined
- the number plate is false.

2.2 Police Infringement Bureau

The Police Infringement Bureau (PIB) manages issues related to speed camera operation. Their primary role is to process the data captured by the existing fixed and mobile cameras and issue the infringement notices. However, they have a number of associated tasks:

- The PIB is involved in the selection of mobile camera sites. Generally, the local authority initially raises the issue. Then, representatives from the council, the NZTA, the Ministry of Transport, the Ministry of Health and the NZ Police consult to determine the most suitable locations for the cameras. Site criteria take into account the crash history at the location, data from speed surveys and whether it is practicable to use speed cameras at the site.
- The PIB manages the processing of speed camera infringements. Upon confirmation of the image and violation, the bureau sends out the infringement notices, and reminders if required. The notices are sent, in the first instance, to the registered vehicle owner. The PIB obtains up-to-date details through a direct link to the NZTA database located in Palmerston North.
- The PIB also administers infringements issued in the field by police officers. The bureau checks the offence, records the infringement and processes the notices and reminders.

¹ When digital speed cameras began operation in 2009, the PIB encountered a few start-up issues and as a result tickets issued throughout 2008/09 were down on previous and future years. The new system issues were primarily due to the new equipment recording incorrect speeds (high-sided vehicles such as trucks) and tickets had to be waived. In addition, the overall ticketing rate was down while Police staff learned the new system.

This research report is not aimed at addressing the potential issues resulting from a change in the current operations management approach of the PIB within New Zealand. Any possible changes would only be the result of a separate and detailed review, which should include the relative costs and risks associated with various funding and management models.

Observations through this research indicated some countries and agencies do contract out services of this nature. As in the case with average speed enforcement, most P2P speed camera suppliers are also able to provide back-office systems that can complete the first stage of processing. Through outsourcing the back-office function to a specialised company, greater efficiencies in the function of this enforcement, and subsequent financial benefits have been reported. Furthermore, this approach may also remove some risks from the operation if service contracts are drafted appropriately.

However, public opinion with regard to outsourcing should be carefully considered in the decision-making process. During this study, the public's reaction to the proposal was not tested but, in general, the focus groups indicated support for the installation of P2P speed camera enforcement.

2.2.1 Enforcement

Electronic information from speed cameras is received on a daily basis. DVDs are submitted from each mobile camera when it has recorded a suitable number of images to complete a disk; this generally takes up to a maximum of two days.

The process for fixed speed cameras is slightly different because these cameras use wet film. The film from the fixed camera is forwarded to the PIB from where it is sent to an external provider for loading onto a DVD, which is then returned to the bureau.

To illustrate the number of infringements that are processed, the PIB received approximately 12,000 mobile camera and 1 800 fixed camera images over seven days in September 2010. Approximately 13,800 records resulted in over 9000 infringements being issued to offending drivers. During the same week over 14,000 officer-initiated offence notices were received and processed. Larger numbers of infringements are recorded during holiday weekends: for the Queen's Birthday weekend period 2010 over 8000 speed camera tickets were issued in approximately three-and-a-half days. Table 2.2 illustrates the typical images received and infringement processing rate of the PIB during spring 2010.

Table 2.2 PIB infringement processing

	Records per week	Infringements processed per week
Mobile camera sites	12,000 images	9000 combined
Fixed camera sites	1800 images	
Officer-initiated infringements	14,000	14,000
Queen's Birthday holiday weekend		8000 (in 3.5 days)

After an image is received by the PIB staff, verification of the vehicle is necessary prior to the infringement notice being sent to the vehicle's owner. Details such as the vehicle make, model and, to a lesser extent, colour are checked to ensure the number plate in the image matches the vehicle description held on file.

Performance statistics on the cameras are maintained by the PIB. They record the offending rates at each camera location and the number of hours each camera has been deployed for each month. This information is relayed to the district headquarters so that any shortfalls in use can be identified. Each police district has a responsibility to meet the target for number of hours of camera use. These targets are detailed in the annual road policing programme. The 2010/11 Road Policing Programme states the yearly targets as over 20,000 hours for operating fixed speed cameras and over 80,500 hours for operating

mobile speed cameras. This equates to approximately 1700 hours/year per fixed camera and 1800 hours/year per mobile camera.

Therefore, the bureau plays a major role in New Zealand's road policing operations. The Auditor-General's report on the speed camera system noted the effectiveness of the PIB could be determined from:

- the accuracy of the infringement processing
- documented clear procedures within the adjudication process
- the timeliness for infringement processing
- the prosecution rate.

The report noted the bureau performed effectively in its role and stated: 'It meets its targets and has excellent procedures in place'.

2.3 Recent purchase of ANPR cameras

The NZ Police recently purchased four cameras with automatic number plate recognition (ANPR) technology. The cameras have been installed on two surveillance vans (two cameras per van). They are being used to locate individuals with outstanding arrest warrants, identify stolen vehicles and locate vehicles that may have been involved in illegal activities.

The cameras are capable of reading number plates from either a static location or while in motion. The number plate data is checked against a vehicle of interest hotlist on the police database. The system immediately alerts the operator when a vehicle of interest match occurs and a patrol car near the scene is sent to stop the relevant vehicle and investigate the matter.

These systems are currently operational in two police districts: Counties/Manukau and Wellington; however, due to success of the programme there are plans to expand the scheme with an additional van.

While these vans are unlikely to be used for P2P speed camera operations, the ANPR capability within the P2P camera system may allow the devices to carry out tasks in addition to speed enforcement.

2.4 Summary

The following conclusions may be drawn from the existing enforcement information:

- The PIB is responsible for the adjudication and verification of speed enforcement.
- The PIB infringement verification checks detail – vehicle make, model, colour and authenticity of the number plate.
- The PIB issues infringement notices to offenders.
- The road policing programme designates operational targets for fixed and mobile cameras.
- The NZ Police currently employs ANPR technology to identify vehicles of interest.

3 Point-to-point speed camera enforcement

This section outlines the fundamentals behind P2P speed camera enforcement.

3.1 Concept

Point-to-point (P2P) speed camera systems determine the average speed of vehicles as they travel between two points. The premise for introducing P2P speed cameras is that they encourage drivers to reduce their speed across an entire section of road, influencing behavioural speed changes over a greater area.

The cameras record images of all vehicles entering and exiting the P2P speed camera corridor and store them locally for a predetermined time period. The number plate recognition software matches the plates of vehicles entering and exiting the enforcement corridor. The time-stamped images allow the calculation of average speed for vehicles travelling between the two known locations a fixed distance apart. The average speed is determined by dividing the total distance between the two camera points by the time taken to travel between the points.

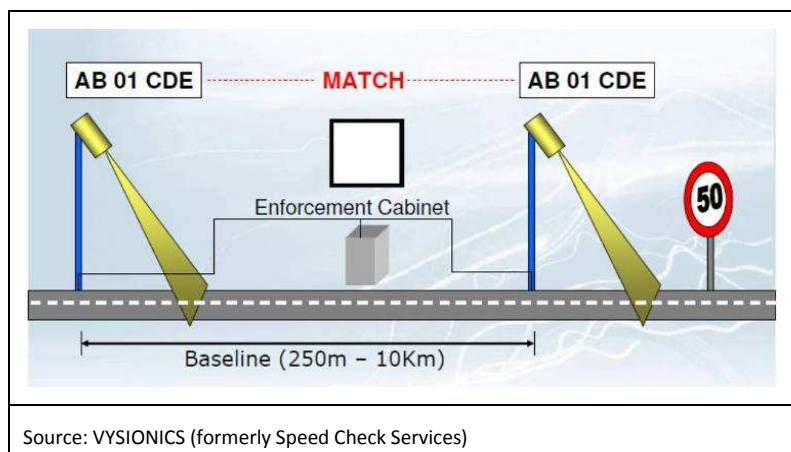
The P2P speed camera system has significant advantages over fixed point speed cameras in that it extends the speed enforcement coverage over a greater area. P2P cameras also produce a more uniform speed profile with driver speed compliance over the route rather than at a single point. Enforceable P2P camera systems are operational in Australia, notably in Victoria and New South Wales, and throughout Europe, including in the UK, Austria, Italy and The Netherlands.

Consider the example whereby the P2P camera system enforces the 100km/h posted speed limit over a 3km section of road. Images capture a driver entering the zone at 8:10:12am and exiting 1 minute 48 seconds later at 8:12:00am. The average speed over the enforcement length is therefore 100km/h. If the driver had passed through the zone in less than 108 seconds then the resulting average speed would be greater than the posted 100km/h; conversely if the time taken was greater than 108 seconds then the average speed would be below the posted 100km/h limit.

3.2 Principles of operation

The principles of P2P speed camera technology are common to the majority of suppliers. A graphical representation is shown in figure 3.1.

Figure 3.1 Point-to-point speed camera enforcement schematic



The principal features of a P2P speed camera system are as follows:

- Cameras are installed at the entry and exit points to a corridor of known length.
- A photo is taken of the vehicle as it passes over a detection loop, or similar, at the entry or exit point.
- Vehicle images and time stamps captured at corridor entry and exit points are saved to a local server.
- ANPR software reads number plates and saves a data file to a local server.
- Data files from the entry and exits points are transferred over the communications network either fixed or wireless to a central processing computer.
- Central processing computer determines if a speeding offence has been committed by matching entry and exit point data files and calculating the travel time.
- Average speeds are calculated using travel times over the known distance to confirm if the average speed along the corridor was greater than posted speed.
- Local server image files are requested by and sent to the central processor via the communications network.
- An infringement file is created and it contains the image files and all necessary information captured at the entry and exit points for matching and enforcement purposes.
- The infringement file is sent to enforcement adjudication for verification and issuing.

3.3 Summary

The following conclusions can be drawn from the information above:

- P2P speed cameras are a proven and established technology.
- The principles of operation of P2P systems are similar regardless of supplier.

4 International experience with point-to-point speed camera systems

This section outlines overseas experience with the implementation and operation of P2P speed enforcement.

4.1 Overview

Differences in international driving cultures and speed enforcement practices affect speed limit compliance.

In many countries there are bodies that debate the relative merits of many speed enforcement objectives, particularly speed cameras. Operators of these devices are often accused of 'revenue-generating' and not making noticeable improvements to road safety. Throughout the world where speed camera enforcement is in place it must be justified according to speeding patterns or, primarily, targeted to reduce crash rates in a particular area.

The following information relates to experience observed by overseas jurisdictions that have implemented P2P technology successfully and may provide guidance for New Zealand. The research indicates a country's local enforcement and education programmes may impact on overseas observations and, therefore, results may not be replicated.

The UK, The Netherlands, Italy and Austria have established average speed enforcement systems. In areas where P2P speed cameras have been implemented these countries have observed reductions in serious-injury and fatal crashes and observed a greater compliance with posted speed limits.

Several Australian states have begun using the technology or have conducted trials in recent years. Victoria has a system in place on a major arterial road. New South Wales has implemented a P2P enforcement programme that monitors heavy vehicle speeds to address the disproportionate number involved in speed-related crashes. The New South Wales P2P programme began operations with four enforcement sites in 2009 and will expand to 21 corridors by the end of 2012. Other Australian states and territories are looking to trial the technology in the coming years.

4.2 Victoria, Australia

4.2.1 Location of the P2P enforcement system

The Victorian scheme is installed along one major arterial road, the Hume Highway, which links Victoria and New South Wales. There are four adjoining sites on this highway; the enforcement zones vary in size, from 7km to 25km long. The length of each corridor was determined by the number of intersections within each zone. There are between two and three on- or off-ramps within each section and limited opportunities for vehicles to enter or exit the highway mid-zone and avoid enforcement. In addition to speed enforcement, these cameras are being used to locate unregistered vehicles. There are plans to enhance the system in the future.

4.2.2 System details

The Victorian Department of Justice (DoJ), which is tasked with road safety, purchased the P2P enforcement system. The cameras are mounted in the highway median and cover both directions of travel;

there is one camera for each vehicle lane at each entrance or exit node. However, the auxiliary lane on the sealed shoulder is not covered by a camera. There is a combination of forward-facing and rear-facing cameras in both directions. Vehicle triggers in the form of detector loops were installed in the pavement to help capture vehicles entering or exiting the enforcement zones.

The cameras themselves are maintained and calibrated by the chosen supplier. This group also hosts the raw camera data on their server before it is forwarded to a government-controlled processing division where infringements may be issued. The system is similar to the way that spot-speed infringements are processed in New Zealand, although the NZ Police are directly involved in the capture of offending vehicles.

4.2.3 System implementation and operation

4.2.3.1 Corridor selection

The Victorian experience shows that lower infringement rates are observed in the longer P2P enforcement zone. The longest enforcement zone contains a number of intersections and reduced speed advisory curves, thus there is a greater opportunity for a driver to travel below the posted speed. The comparatively low infringement rates observed on the longer corridors may be due to drivers reducing speed to negotiate particular obstacles along the zone.

4.2.3.2 Road environment

Infringement rates at this particular site are greater for southbound vehicles than northbound traffic. Southbound vehicles have entered the enforcement zone from an area with a higher posted speed. The DoJ indicated southbound drivers may not be adapting to the reduced speed quickly enough and therefore a proportionally higher number of drivers have received infringement notices. Northbound traffic, passing through three other P2P enforcement zones prior to entering the northernmost zone, has altered behaviour to comply with the posted speed limit.

4.2.3.3 Infringements

The infringement rate in Victoria is around 1%–2%. Approximately 1000 infringement notices are issued per day, with the average daily traffic volume between 50,000 and 100,000 vehicles per day. This infringement rate is higher than in European sites, as described below.

4.2.3.4 Enforcement halo effect

Discussions with DoJ have suggested that drivers comply with the speed limit when inside the P2P enforcement corridor; however, speeding may become an issue once vehicles leave the monitored zone. As mentioned previously, spot-speed camera research suggests drivers will often slow down when they are aware of a camera's location and then return to their original speed once they are clear. DoJ are investigating options to check traffic behaviour immediately outside a P2P enforcement zone.

4.2.3.5 Adjudication and verification

The back-office infringement processing is a critical step in the successful implementation of P2P speed enforcement. The verification of the two images is the single most important step in the enforcement process. Processing staff must confirm the two images are of the same vehicle. DoJ explained that the first legal challenge to the system in Victoria occurred when verification staff failed to notice an incorrect match in the system.

4.2.3.6 Credibility

Victoria's P2P enforcement system was withdrawn from service while checks were carried out after a time synchronisation issue occurred in September 2010. The Victorian government identified nine vehicles that received incorrect infringement notices since operations began in 2008. The issue occurred because the

time synchronisation between two adjacent cameras failed which led to an error occurring in the average speed calculation. The system showed the motorists passing through the enforcement zone in a shorter time than the vehicle had actually taken. The system is currently under review; however, it will resume operation once the auditor general is satisfied the time synchronisation issues have been rectified.

4.2.3.7 Future plans for the Victorian P2P enforcement system

- The Hume Highway P2P system will return to operation once faults are fixed and the Victorian Auditor General's Office completes the investigation.
- P2P enforcement sites may also employ spot-speed cameras to enforce greater compliance as vehicles travel through the zone.
- Data captured from the cameras will be held in roadside storage for 90 days. The current storage capacity will be increased to suit these requirements. The NZ Police may use this data in the course of their various investigations for non-speed-related traffic offences.

4.2.4 Lessons learned

Lessons learned for New Zealand from the Victoria, Australia experience with P2P cameras are to have:

- fewer intersections within enforcement zones
- a vehicle-activated trigger system to improve capture rates
- fit-for-purpose data storage at the roadside
- back-office adjudication procedures and training
- verification and systems check to ensure confidence
- time synchronisation calibrated regularly between site endpoints.

4.3 New South Wales, Australia

4.3.1 Location of the P2P enforcement system

New South Wales's Roads and Traffic Authority (RTA) has identified 21 dangerous corridors for the installation of heavy vehicle P2P speed enforcement. The preliminary operations began with four sites going live in 2009 with the remainder to become operational by the end of 2012.

The P2P cameras check the average speed of heavy vehicles with a gross vehicle mass greater than 4.5T, including buses. Speed surveys on major freight routes revealed nearly half of the heavy vehicles exceeded the speed limit. A P2P enforcement system, which requires compliance over a known distance, is viewed as an effective means of enforcing speeds within each zone. The lengths of the 21 enforcement corridors vary between 6km and 75km. Some sites are back-to-back, therefore providing an even longer enforcement corridor.

New South Wales historical crash and casualty data was a principal factor in site selection. Heavy vehicles were over-represented in crash statistics. While New South Wales heavy vehicles account for 3% of vehicle registration and they travel 7% of kilometres in the state, they are involved in approximately 20% of fatal crashes. The P2P enforcement system is designed to reduce the number and severity of crashes within enforcement zones.

4.3.2 System details

The initial RTA system created P2P speed camera infringement files using matching software provided by the camera supplier. The RTA then completed the adjudication and verification to issue the offence notice. The RTA audited the supplier's camera and processing systems to ensure accurate performance.

At the time of this research, the RTA were investigating changes to the P2P enforcement architecture to incorporate a plug and play protocol for all future camera sites. The proposed changes would allow the RTA to complete the matching, adjudication and verification process internally, therefore removing the reliance on supplier software. The supplier software matching process was suitable when the back-office operations were in their infancy; however, once the internal procedures and capability were in place the logical next step was for the RTA to complete the process internally.

The RTA uses overhead gantry structures that allow cameras to be mounted over each lane. These also provide an overt physical presence for entry and exit to P2P enforcement zones, which are defined by appropriate descriptive signage.

In New South Wales, the infringement notice is sent to the vehicle owner in all cases. If someone else was driving at the time of the offence then the owner needs to provide written proof in order to have the offence transferred to another party. This is similar to the existing speed camera enforcement process in New Zealand.

4.3.3 System implementation and operation

The RTA conducted two covert trials of P2P camera technology over varying road types before an enforceable system was implemented. At the time of this research, the RTA heavy vehicle P2P enforcement programme was still in its early stages with only four sites operational. However several operational issues were identified during early trials of the technology and the preliminary stages of heavy vehicle speed enforcement.

4.3.3.1 Corridor selection

Preliminary observations indicated that lengthy road corridors containing a number of reduced appropriate speed sections might not be ideal for P2P speed enforcement. Appropriate speed refers to travelling at a safe speed for the road environment conditions and may be considerably less than the posted speed, eg reduced speed advisory at curves.

4.3.3.2 Roadside

The trials indicated that the camera positioning affected the read rate of the ANPR technology. It was observed that cameras mounted on over-head gantry structures performed better than pole-mounted cameras at the roadside. The trials also found that the installation of loops in the pavement improved the vehicle capture rate.

4.3.3.3 Legislation

During the trials a number of legislative issues were considered before an enforceable system could be rolled out. The P2P speed camera system relied on three main components:

- calculation of a known distance between the two sites
- ensuring legislation supported the enforcement of an average speed offence
- ensuring time synchronisation at entry and exit points. This is a crucial factor for the average speed calculation.

A registered land surveyor was engaged to assess the shortest practicable distance between the zone entry and exit points at each site. The surveyor then provided the RTA with a certification for corridor length. The average speed certification was derived by dividing the known distance by the posted speed limit. An example of a practical distance certification of a P2P speed enforcement corridor can be found in appendix A. The potential time synchronisation issues were overcome by having the internal clocks monitored and correcting any variations. The maintenance and calibration of the P2P system was delegated to a third party to remove any possibility of conflict of interest if the supplier or police were to carry it out. In addition, the trials highlighted the potential issues of vehicles deliberately avoiding camera detection by driving on the road shoulder or on the other side of the road. Penalties for avoidance of P2P speed camera sites were subsequently proposed.

4.3.3.4 Infringements

The RTA website promotes P2P enforcement as a fairer means of speed enforcement than spot-speed cameras. The system is designed to penalise those drivers who continue to exceed the speed limit rather than the accidental lapse that can occur at spot-speed camera sites.

To that end, the New South Wales government considers average speed offences more serious than spot-speeding due to the deliberate nature of exceeding the speed limit over a prolonged period rather than at a single point. At this stage, drivers speeding within P2P enforcement zones will incur an additional demerit point, on top of the demerit points they receive for the speed infringement (in Australia, 12 demerit points result in the temporary loss of licence).

The format of the infringement notice was also considered during the trial stage. While it was in progress, the inclusion within the infringement notice of the actual ANPR 'read' by the system was debated as the system did misread some plates. A number plate may be incorrectly 'read' at the first site and then incorrectly read in the same manner at the second camera site. The vehicle match was successful but the actual 'reads' were not exact. If the wrong number plate is shown on the notice it may provide grounds for challenges to the system. An example of an incorrect number plate but a correct match is that of the ANPR system reading a phone number printed on a vehicle.

Future plans in New South Wales are to:

- continue the roll-out of the heavy vehicle P2P speed enforcement programme
- review the heavy vehicle P2P system for lessons learned that may enhance speed enforcement of light vehicles
- pending performance review, examine the potential for additional P2P enforcement sites.

4.3.3.5 Lessons learned

Lessons learned for New Zealand from the New South Wales experience with P2P cameras are to:

- establish enforcement zones in areas with high crash and casualty rates
- consider using a third party during the initial stages of P2P enforcement to perform ANPR matching and creating potential infringement files for adjudication by the PIB
- establish back-office procedures to verify third party infringement files
- implement certification for critical components of P2P enforcement, notably practical distance and time synchronisation.

The RTA promotes the P2P system as a fairer alternative to existing speed enforcement methods.

4.4 United Kingdom

The UK operates a considerable number of point-to-point speed enforcement systems. At first, permanent fixed P2P enforcement sites were typically deployed on sections of local or arterial roads. However, in January 2011 Transport for London (TfL) began a trial of the technology on an urban road.

This system allows for enforcement between multiple small sections along a corridor that features a large number of intersections, and therefore multiple entry and exit points. The TfL trial uses 84 cameras at 37 locations along the A13 corridor east of London. The trial is the first of its kind in the UK and at the time of the research the trial was underway and preliminary results were unavailable.

One significant benefit of using P2P devices in an urban setting is that this technology can be used to replace other relatively costly speed-control measures. For example, speed humps or chicanes can be replaced by the P2P system. The added advantage is emergency vehicles will not be delayed in responding to an incident by having to negotiate such traffic controls.

In all cases P2P enforcement zones in Britain are located either in corridors that have a history of speed-related crashes, or at road construction sites, to enforce a temporary speed restriction. Local authorities who deploy these systems have defined criteria for sections of road where P2P speed cameras can operate. For example, in the London criteria there is the requirement that in the latest three years of crash data there must be at least four fatal or serious-injury crashes per kilometre for average speed enforcement to be considered.

Figure 4.1 P2P speed enforcement along the A13 corridor



4.4.1 System details

ANPR systems are used throughout the UK for a number of intelligence and enforcement processes; however, legislation defines speed camera systems to have only one purpose – speed enforcement. As a result the data captured using P2P camera systems can only be used to prepare speed infringement notices.

4.4.2 System implementation and operation

The introduction of average speed enforcement in the UK has resulted in an observed change in driver behaviour with high compliance to the posted speed limit. Improvements were also noted in the crash and casualty rates.

A reduction in crash rates was observed after the installation along a section of the A77 in the southwest of Scotland in July 2005. The 32 mile (51km) section was identified as having a high number of speed-related crashes. A case study of the system assessed crash data three years prior to and since P2P enforcement and found, on average, a 19% reduction in all crashes with fatal crashes falling by 46% and serious-injury crashes by 37%.

Similarly positive results were observed at P2P enforcement sites within the Nottinghamshire County Council district. The Nottinghamshire Safety Camera Partnership was awarded an industry road safety award for the improvements observed as a result of implementing a P2P average speed enforcement system. The Nottinghamshire P2P systems were installed along corridors posted at 30mph (approximately 50km/h); enforcement of the low-speed environment saw a significant drop in fatal and serious crashes. The A610 and the A6514 recorded nine fatalities in the three years prior to installation, with VISIONICS (a P2P speed camera supplier) claiming only one fatality in the first seven years of operation.

The following is a summary of crash data at additional P2P speed camera sites:

- Nottinghamshire, 11 roads equipped with average speed enforcement from 2000. VISIONICS claimed a reduction in annual fatal or serious-injury crash rates by an average of 65% at the sites.
- Northamptonshire, average speed enforcement installed on the A43 at Lumbertubs Way and on the A428 from 2001. Annual fatal and serious-injury crash rates have reduced by an average of 60% and 85% respectively.
- South Yorkshire, average speed enforcement installed on the A616 Stocksbridge Bypass Trans Pennine Route in 2003. Annual fatal or serious-injury crash rates have reduced by an average of 82%.

4.5 Other European countries

4.5.1 Austria

Austria has implemented several P2P speed enforcement corridors, notably in the Kaisermühlen tunnel near Vienna. This tunnel has two separate tubes for vehicles which separate the traffic streams and each tube has three to four lanes. Over 90,000 vehicles use the tunnel every day. The speed limit through the tunnel for heavy vehicles is 60km/h; other traffic is limited to 80km/h. The system employs a laser scanner to differentiate between vehicle types.

The number of crashes in the tunnel has fallen following the introduction of P2P speed enforcement. All injury crashes (including fatal) reduced by 33% and fatal and serious-injury crashes fell by 50% compared with data for the three years prior to installation. There were no fatal crashes in the two years following implementation (Stefan 2006).

Compliance with the speed limit improved immediately. During the first year of operation, average speeds initially fell by 10km/h to 15km/h before levelling out at 5km/h below the applicable speed limit. The infringement rate in the initial year of operation was only 0.14%; 40,900 infringements out of the 29.4 million vehicles that used the tunnel (MUARC 2008).

4.5.2 The Netherlands

The Netherlands was the first country to implement *Section control*, average speed enforcement locally known as P2P. The technology has been adopted throughout the country to aid in vehicle speed enforcement and has helped to reduce both air and noise pollution.

There are currently 11 P2P enforcement sites in various locations around the country. The Netherlands is looking to increase the number of sites to 20 in coming years.

The existing sites operate 24 hours a day, seven days per week. Since digital technology is used, there is no need to replace rolls of camera film when they have expired.

Photographs of vehicles that are found not to have exceeded the speed limit are immediately deleted from the system. Pictures showing speeding drivers are sent to the infringement processing division where a fine is issued.

A section of the Dutch A13 motorway was placed under P2P speed enforcement in 2002. Prior to implementation the average speed of light and heavy vehicles was 100km/h and 90km/h respectively. The introduction of a strictly enforced 80km/h P2P speed camera corridor has reduced the incidence of speeding, observing an infringement rate of only 0.5%.

Additionally, at this same site the number of fatal and serious-injury crashes also reduced; however, the numbers are too small to draw valid conclusions (SUPREME 2007). The technology was also reported to have improved air quality near Rotterdam by around 10% to 15%.

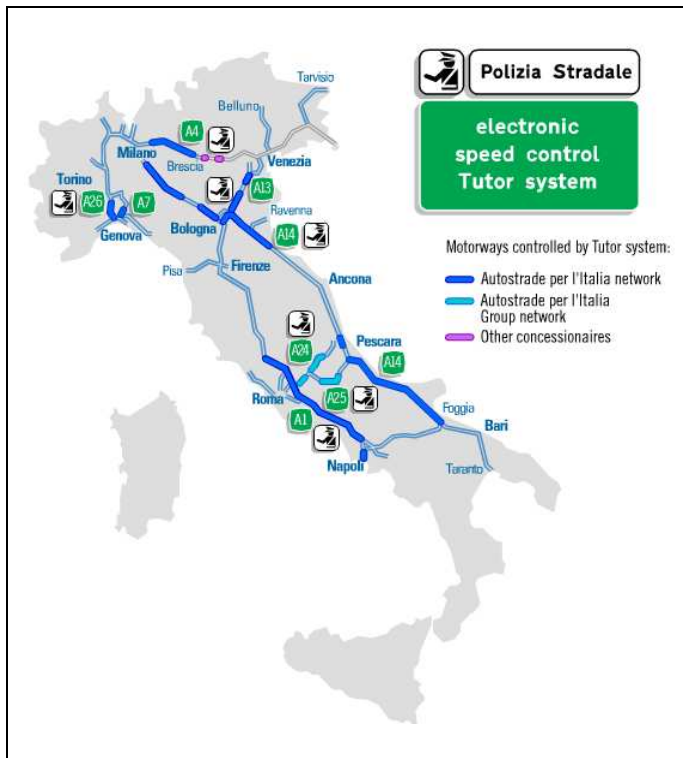
4.5.3 Italy

Tutor, the Italian version of P2P speed enforcement was first used in 2004. It is currently being used to monitor 2093 kilometres, or 31%, of the Autostrade per l'Italia's motorway network. The devices are placed to cover 27 individual corridors (occasionally on one side of the road only) and they have been positioned in areas where fatal crash rates are higher than the average rate. The enforcement zones vary in length between 2km and 243km, with the average corridor length being 56km. The location of the P2P enforcement corridors is shown in figure 4.2.

The impact on speeding has been significant. The speed limit on this network is 130km/h, dropping to 110km/h in wet conditions. A section of the A14 (Pescara - Canosa) recorded an average speed reduction of 15% while the peak speed fell by 25% (Autostrade 2009). The system has been able to bring about greater compliance with the posted limit.

Along with reduced speeds, crash rates have also dropped. It is believed excessive speed is a factor in 60% of fatal crashes on Italian motorways. The Autostrade's case studies suggest that on corridors enforced with a *Tutor* system, the overall crash rate has reduced by 19%, with serious and minor injury crashes falling by 27% and the number of fatal crashes decreasing by 51%.

Figure 4.2 *Tutor* average speed enforcement network



4.5.3.1 Lessons learned

Lessons learned for New Zealand from the European experience with P2P speed cameras are:

- systems are capable of handling high volumes (90,000 vehicles per day)
- digital cameras are capable of continual operation (24 hours, 7 days)
- high compliance rates are observed at sites with a history of speeding
- a reduction in crash rates is possible where speeding was previously a major contributing factor.

4.6 Summary

The experience of P2P systems in overseas countries shows:

- the systems are effective in reducing both the number and severity of crashes
- the systems are able to improve speed compliance within the enforced area and often reduce both average and 85th percentile speeds to the posted speed limit or below
- the systems produce smoother traffic flows and reduce speed differentials between vehicles
- infringement rates are typically low
- careful site selection is required
- the number of P2P enforcement corridors will increase in Australian jurisdictions over the next few years
- there is an observed reduction in crash and casualty rates.

5 Available technology

This section outlines potential suppliers of P2P systems.

5.1 Overview

As discussed previously, the principles behind the technology for point-to-point speed enforcement have been demonstrated by road authorities throughout the world. There are a number of suppliers of P2P systems that can provide the combination of hardware components, processing software and back-office support.

ANPR is a component of the P2P system and the NZ Police have embraced the use of ANPR cameras in the identification of vehicles of interest. The cameras are currently focused on locating stolen cars, persons wanted on charges, and vehicles that may be required for other investigations.

5.2 Suppliers

The following section provides some background and points of interest from discussions with P2P system suppliers.

5.2.1 VYSIONICS (formerly Speed Check Services) – United Kingdom

Website: www.vysionics.com

VYSIONICS is the primary supplier of Home Office Type Approved P2P systems throughout the UK. Gaining Home Office Type Approval (HOTA) involves a rigorous testing and verification process to ensure the camera is fit for purpose; the process is similar to the gazetting of devices by the PCS.

VYSIONICS currently has SPECS P2P devices deployed in various locations around Britain. The systems can be permanently installed on suitable rural or urban routes. SPECS devices are also used for temporary enforcement at road construction sites. Figure 5.1 illustrates the locations where VYSIONICS average speed enforcement devices are currently installed in the UK.

Figure 5.1 Existing VYSIONICS speed enforcement systems



(Source: VYSIONICS, February 2011)

As shown in figure 5.1, the cameras are typically mounted on cantilevered mast arm poles that extend over the traffic lanes. These systems read the number plates directly off a streaming video feed and the cameras are capable of covering multiple lanes. However, VYSIONICS recommend one camera mounted above each lane to achieve the highest capture rates.

The cameras are capable of transmitting data via hard-wired or wireless networks. Wireless networks are preferred as they will not limit the length of the enforcement zone.

VYSIONICS provided the following information based on their SPECS experience:

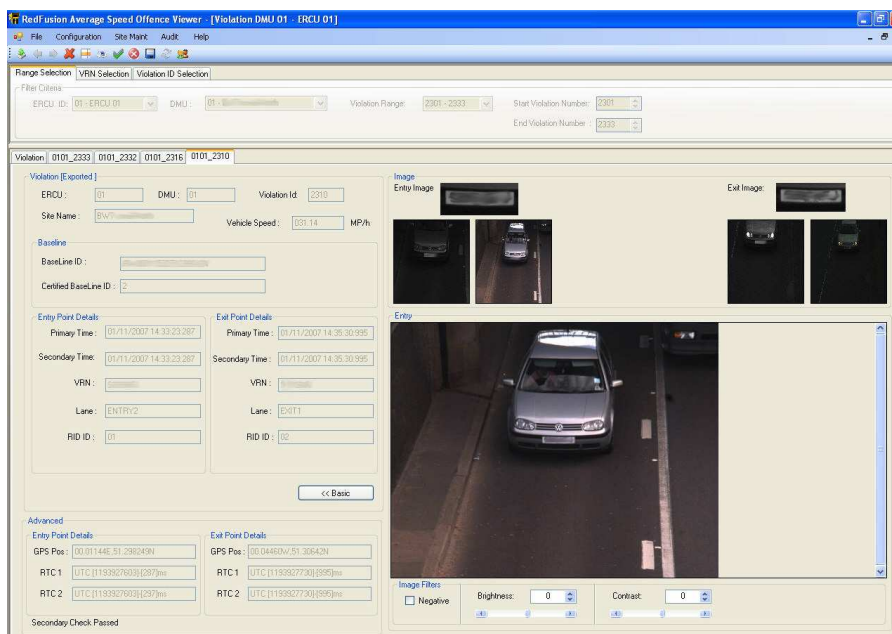
- Capture rate – streaming video systems capture approximately 80% of all vehicles; of those 97% of number plates are correctly read.
- Systems are mounted on cantilever structures on the verge or median; this reduces the possibility of number plates being obscured by other vehicles on multi-lane roads.
- Multiple data communications channels can be used (3G, WAN, LAN).
- Data shows benefits in traffic flow at high volumes with less deviation in mean speed.
- The SPECS system also has the potential to be used for calculating real-time journey time information but this functionality has not been implemented due to the aforementioned UK restriction on speed enforcement devices.

5.2.2 RedSpeed International Limited – USA and UK

Website: www.redspeed-int.com

RedSpeed provides a variety of camera enforcement systems utilising ANPR technology. Redfusion is their average speed enforcement product capable of providing roadside equipment and back-office processing software and management. The Redfusion package offers an offence viewer that assists in the adjudication of potential speeding offences. Figure 5.2 shows the offence viewer interface featuring entry and exit point images along with the location and time stamp data for adjudication.

Figure 5.2 Redfusion offence viewer



Source: RedSpeed International

At the time of reporting, TfL has commissioned RedSpeed to trial the use of Redfusion along an urban stretch of the A13 east of London (described above). The enforcement corridor will feature 84 cameras in 37 locations with multiple entry and exit points along its length. The series of cameras allow P2P speed enforcement over small sections within the corridor, therefore overcoming the issues associated with the high number of vehicles not completing the entire journey along the A13. The Redfusion feature is branded as multi-point to multi-point (zone) monitoring.

5.2.3 Redflex traffic systems – USA, Australia and New Zealand

Website: www.redflex.com

Redflex provides a total P2P system capable of supplying the average speed enforcement camera equipment and back-office processing software and management. Redflex P2P systems are currently used in Victoria and in the New South Wales heavy vehicle programme. Additionally, Redflex recently supplied the NZ Police with their new mobile spot-speed cameras.

Performance data from Redflex shows their devices are capable of detecting 85% to 92% of vehicles entering or exiting a P2P enforcement corridor. The ANPR system can 'read' 97% to 99% of the number plates captured. The capture of vehicles accessing the P2P enforcement corridor is affected by the:

- positioning of the camera
- provision of a vehicle trigger
- number plate reflectivity
- weather conditions
- front- and rear-facing cameras.

Redflex advised that cameras positioned on gantries provide a higher capture rate than pole mounted cameras at the roadside. Drivers passing pole-mounted cameras can have their number plates obscured by vehicles in adjacent lanes. The potential for obstruction becomes of particular significance as the number of lanes increases.

Additionally, Redflex recommend the P2P camera configuration should be arranged to remove the possibility of vehicle avoidance, where a motorist may manoeuvre outside of the area of road that the ANPR cameras are covering. For example, sections of road with wide sealed shoulders may provide the opportunity for drivers to avoid the P2P system. This matter will need to be addressed when selecting sites for operation.

A further recommendation, to enhance the back-office process, is to provide an additional image of the P2P enforcement site. While the P2P cameras cover one lane plus one-third of adjacent lanes, Redflex suggests a broad scene camera shot be taken to help verify the offence. This will enable the location of the offence to be readily determined.

Lastly, the use of an offset infrared (IR) illuminator will provide additional coverage of number plates, particularly at night.

Redflex's back-office systems are capable of matching the number plates, assessing vehicle speed and producing an infringement file. The infringement file would contain P2P camera entry and exit images along with a data file containing all necessary enforcement details (eg ANPR reads data and time stamps of the offence).

Redflex system specifications include:

- 2 megapixel camera file size 200KB per image
- 11 megapixel camera file size 1MB per image (spot-speed-enforced camera)
- virtual private network encryption capable
- 3G or hardwired communications
- 2 images and offence data per potential infringement file
- plate cameras to provide a localised image of the vehicle
- scene cameras to provide a location shot to help identify the enforcement site
- capacity to include 'blacklist' searches of database files
- offset infrared flash to capture image.

5.2.4 Aspect Traffic

Website: www.aspect.com.au

Aspect provides cameras with inbuilt ANPR software suitable for P2P system applications. Aspect has provided ANPR camera enforcement systems throughout Australia, notably for trials in South Australia and New South Wales. Aspect typically provides camera hardware with in-built ANPR software.

Aspect provided the following information based on experience:

- P2P systems are best located in areas where the enforcement corridor maintains a single speed limit.
- The time stamp for offence data should be linked to coordinated universal time to avoid situations regarding time-zone changes.
- Front- and rear-facing cameras should be used in order to capture all vehicles.
- Some states, such as Victoria, require two independent sources of speed verification for enforcement, which requires multiple detectors and independent clock systems.
- PIPS Technology 382 model is the most appropriate for P2P speed enforcement. Digital images of vehicles entering or exiting the P2P enforcement corridor are captured; number plate information is obtained using the inbuilt ANPR software. Following this, the file on each vehicle is sent to a roadside server where matching and speed assessment occurs.
- The roadside server can be programmed to pass information on to the infringement processing bureau.

Aspect specifications include:

- image size between 5KB and 50KB
- data file size approximately 20KB depending on information transferred
- PIPS cameras capture 95% to 97% of vehicles detected.

5.3 Summary

Research into P2P system suppliers demonstrated that:

- the principles behind the use of ANPR cameras for P2P systems are common

- the improved capture rates are achieved by mounting cameras above each lane
- the suppliers offer a combination of hardware and software component along with back-office support
- there is a variety of trigger methods for the ANPR software to activate (eg inductive loops)
- night-time images are typically captured using infrared illuminator, therefore pictures are greyscale.

6 New Zealand legislation

The section outlines potential legislative issues that require consideration for P2P speed enforcement.

6.1 Overview

The researchers are not legal experts and the following information is intended to provide an understanding of possible legislative changes required prior to the implementation of the systems. The following recommendations are based on the knowledge and understanding of the consultant's review of the relevant New Zealand legislation.

Amendments to existing legislation may be required to provide legal status to evidence collected using P2P cameras. The camera system needs to be approved and the image requirements need to be defined in the Act to enable it to be enforced. Qualified legal advice should be sought before actioning the recommendations.

6.2 Legislation

Consideration was given to the following Acts:

- Land Transport Act 1998
- Public Records Act 2005
- Privacy Act 1993.

6.3 The Land Transport Act 1998

The parent Act for speed enforcement is the Land Transport Act 1998. This Act defines what constitutes a moving vehicle offence (which includes speeding offences). Speed camera offences are explicitly mentioned: Section 145 (1) states that:

...for a moving vehicle offence, an image produced by means of an exposure taken by approved vehicle surveillance equipment... is... sufficient proof of that fact...

The section lists a number of items that can be included on the image, one of which is the date and time when the image was taken. An image taken by a P2P camera, showing the date and time of the photograph, is likely to be used as evidence in determining an offence. However, it is acknowledged that P2P speed camera offences are technically different from spot-speed offences and therefore the legal requirements may also be treated differently and could be more advanced than what is outlined.

The reference to approved vehicle surveillance equipment concerns existing speed cameras in New Zealand. There are currently four camera systems legally approved to collect evidence of speeding violations.

Details are:

- Transport (Approved Vehicle Surveillance Equipment) Notice 1994 gave approval to:
 - AutoPatrol PR-100NZ radar system
 - AutoPatrol SP-200 speed camera system

- Land Transport (Approved Vehicle Surveillance Equipment) Notice 2008 gave approval to:
 - MK4 RUCS Redflex NZRED1 camera system.
- Land Transport (Approved Vehicle Surveillance Equipment) Notice (No. 2) 2008 gave approval to:
 - Redflex radarcam camera system.

The chosen P2P enforcement system will need to obtain approved status before evidence collected from it is of legal standard. Police Calibration Services (PCS) are responsible for the preparation and submission of this approval, which is granted after the calibration unit's report into the camera system is authorised by the Minister of Police.

Section 146 of the Act refers to the calibration of approved vehicle surveillance equipment. Provided the device has been calibrated once every 12 months, and there is a calibration certificate for the device, then it is presumed to be working correctly. Currently, PCS carries out calibration every six months on the existing speed camera equipment. However, if there are reasonable grounds for doubt during a court case, the device may need to be tested to prove it is working correctly.

Still, given that P2P systems are primarily based around correctly recording the time taken to drive through the enforcement corridor, the above specification may be inadequate. Checking the internal clocks on an annual basis, or even every six months, means if any errors are discovered it would be very difficult to find out when the problem first occurred. The authors recommend the timing systems be checked at least once per week, if not more regularly. This would ensure there is a rigorous system in place for this key aspect of the P2P device's performance. The significant change in calibration requirements and use of new equipment may require a change to current legislation; however, this should be confirmed through more appropriate legal examination of these implications. .

6.4 Public Records Act 2005

This Act defines how records received by government bodies should be treated. In essence, records received by the body in the course of their work, in this case the NZ Police, should be kept indefinitely. This is provided the records do not breach a different legislation such as the Privacy Act. However, the records can be destroyed if approval is granted from the Chief Archivist.

With P2P systems photographing all vehicles there will be a considerable amount of data captured that is not related to speeding or vehicles of interest (stolen, unregistered etc) and hence not required for NZ Police purposes. Vehicles complying with the speed limit will still be photographed. These records, provided they are not required to check on infringement queries, may therefore be deleted if approval is obtained.

6.5 Privacy Act 1993

The Privacy Act protects individuals from having their private property exposed by other parties. While it is likely that P2P systems would be installed in relatively remote areas, away from heavily built-up zones, care must be taken to ensure the system's cameras are trained solely on the road. Cameras should not be able to inadvertently capture images within someone's private property, nor capture any other personal information.

7 Integration of a P2P system

This section highlights integration considerations for an enforceable P2P system.

7.1 Overview

Consideration must be given to the existing speed enforcement procedures when introducing a P2P system. The new technology will require a team to certify, operate, maintain, adjudicate, enforce and perform public consultation. The offences captured by P2P speed cameras will require integration into existing Police Infringement Bureau (PIB) procedures.

7.2 New Zealand's speed camera operation

The NZ Police currently take responsibility to operate and maintain the existing speed cameras. Each district deploys their mobile cameras to various high-risk locations within its area and manages the fixed cameras that are assigned to their control. The districts submit offending vehicle information to the PIB. This office validates the data shown in the photograph and issues the infringement notices.

P2P enforcement zones may operate under the control of the local district police staff. The offending vehicle infringement images can then be forwarded to the PIB for verification and issuing of infringement notices. Alternatively the PIB may have access to the P2P system, obtaining directly the offence images for adjudication, therefore reducing the amount of data transfer.

7.3 Obtaining vehicle owner information

The PIB currently accesses owner information through vehicle registration details in order to send infringement notices to the vehicle owners. The P2P system is similar to the spot-speed system in that images of offending vehicles are produced and verified prior to infringement notices being sent to the vehicle owner. The authors do not foresee any issues with this aspect of the operation. The burden of proof will remain on the owner.

7.4 Data storage

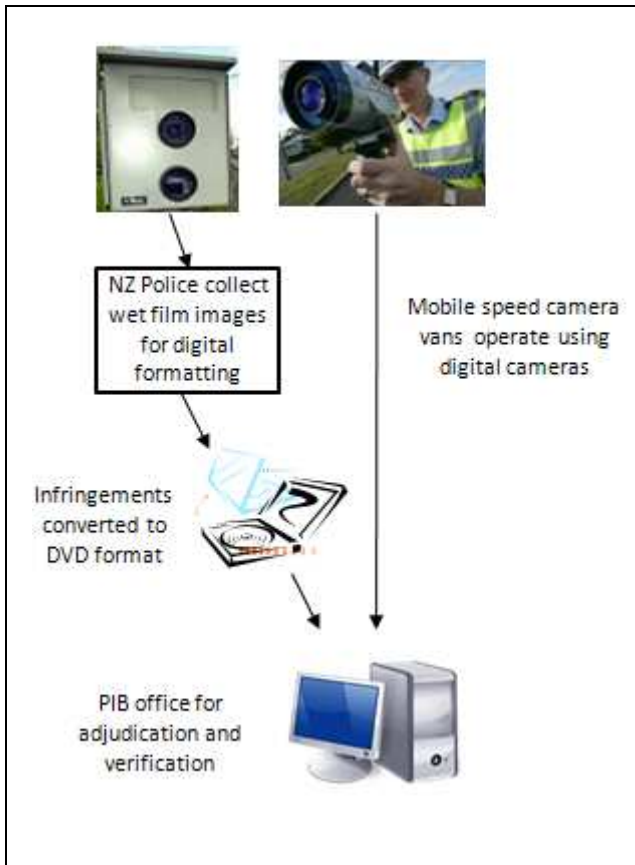
The introduction of a P2P speed enforcement system will result in additional storage requirements at the roadside and in the PIB processing back office regardless of the P2P process method. The roadside storage requirement will be determined by how often the infringement data is transferred to the PIB back office. The additional storage at the PIB back office is determined by the number of infringements issued. With tolerances, the long-term average infringement rate is approximately 1% of the volume.

7.5 P2P system architecture

The primary difference between existing spot-speed and P2P enforcement systems is that with the latter the offences are not detected at the camera site when the image is taken; rather they are calculated during the back-office processing.

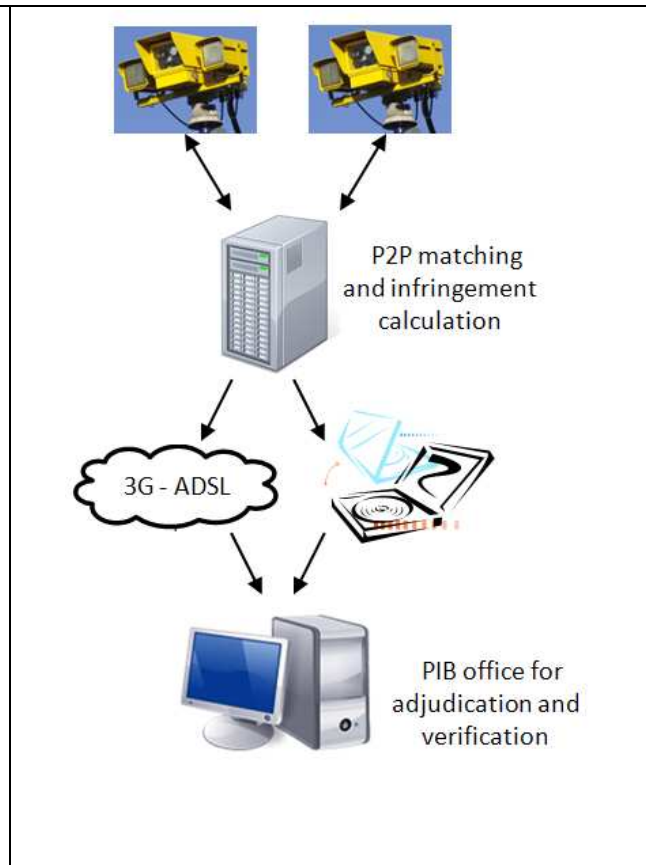
Figures 7.1 and 7.2 outline the current system architecture and the potential architecture of a P2P system. Figure 7.2 also indicates how the P2P system could be incorporated into the existing system architecture.

Figure 7.1 Existing speed enforcement architecture



Source: AECOM 2011

Figure 7.2 P2P system architecture



Source: AECOM 2011

The first generation of P2P systems required hard-wired communication infrastructure to connect two camera sites so processing could be performed at the roadside. Recent developments in communications have allowed the current generation of P2P systems to transfer data and synchronise internal clocks without the physical link between cameras.

As shown in figure 7.1, the existing fixed spot-speed camera system uses a third party during the infringement process prior to adjudication by the PIB and such an arrangement may be suitable during the initial stages of P2P enforcement. The potential architecture for a P2P system shows a third party operator performing the matching process that provides the PIB with a potential infringement file. The PIB would require the third party operator to adhere to an inspection report which will restrict the potential operations; however, the process appears achievable. To maintain the existing spot-speed processing procedures, the potential P2P infringement files may be written to DVD for delivery to the PIB.

As described in chapter 6, New Zealand legislation requires existing speed enforcement camera components to be regularly calibrated by the PCS to maintain a high degree of confidence in the performance of the speed enforcement system. As a result the camera maintenance and data collection procedures will require routine audits and checks to be carried out by the PCS.

In this example, prior to the delivery of the potential P2P infringement DVD the NZ Police have minimal involvement in the data collection process. Once the DVD is received by the NZ Police, the infringements will be entered into the police traffic infringement system and verified following a similar procedure to the existing spot-speed enforcement.

The infringement files will contain time-stamped images of the offending vehicle at the entry and exit. The file also contains data files that provide additional information required for enforcement; notably the site location, entry and exit times, the ANPR read, discrete speed limit, lane and distance. The format of the file and integration into the existing PIB back-office systems will require further investigation and testing to ensure an efficient and well integrated system. As discussed previously, overseas experience suggests a third party supplier initially provide the back-office infringement matching system, with the PIB concentrating on the adjudication and enforcement components. Long term, as in New South Wales, the PIB has the opportunity to develop back-office software that would allow the NZ Police to play an active role in the potential infringement matching process and remove reliance on a third party.

The introduction of this new technology may also provide the NZ Police with the opportunity to alter the infringement structure. First, in contrast to Australia, New Zealand drivers do not currently get penalised with demerit points if they are captured by a speed camera. This could be altered, and as in New South Wales, P2P speed camera offences could incur a greater number of demerit points than a relative spot-speed offence. Second, in Britain speeding drivers are occasionally given the opportunity to attend speed awareness courses instead of being fined. These courses can inform motorists of the risks of speeding and the role that cameras play in road safety. Follow-up discussions with participants suggest these programmes can positively affect attitudes and behaviours.

7.6 Summary

The following should be considered prior to integrating P2P speed enforcement into existing procedures:

- Potential infringement matching is initially carried out by a third party.
- Potential infringements are provided to the PIB in DVD format similar to existing spot-speed camera offences.
- The PIB has the capability to audit the P2P system components.
- It is important for any potential infringement file format to be able to integrate with the existing PIB system.

8 Operational P2P system

This section discusses operational considerations for an enforceable P2P system.

8.1 Identifying potential speed infringements

The first stage of the speed enforcement process is to obtain information that can be used by the ANPR software. Video footage or still photographs can be used for this purpose. ANPR software is able to isolate and assess the number plate from the captured image.

There are various ways of processing the number plate data. Following the capture of vehicle images, the operation may depend on which system is operating:

- Process and store the images at the roadside. The ANPR software will need to be incorporated into the camera. Following this, each camera will send its number plate data and image to a roadside computer where matching will occur. When the matching process reveals an offending vehicle, the images and data files will be extracted to a temporary offence file. All information on offending motorists can then be extracted by the PIB and the infringements actioned. The non-infringing camera images and data files at the roadside can be periodically deleted.
- Alternatively, all images are stored locally at the cameras, with the data files streamed to the processing computer at the back office. The data matching is carried out and when an offence is calculated a request is sent to both cameras to obtain the offence images for adjudication. Significant internal camera memory is required to ensure the earlier images are still available when the PIB request images of offending vehicles. Once all offence images have been requested, the remaining, non-offending vehicle images can be deleted.

The PIB currently keeps data on all vehicles passing the mobile spot-speed cameras. This data is used to investigate offences that are challenged by the offending party. P2P camera data files and images may require archiving to provide supporting evidence during prosecution.

8.2 Adjudication and infringement processing

Prior to issuing infringement notices the PIB should carry out the following:

- Check the vehicle match is correct. The vehicle make, model and colour (if visible) should be the same in both images, as well as the number plate information.
- As described previously it is recommended that the infringement data files from the P2P system do not include the number plate reading within the data block. Therefore, the operator will be required to manually enter the registration number in the registration field as is currently the practice.
- Adjudicate that an actual average speed offence was committed by manually checking the average speed calculation. The step would allow PIB staff to confirm the location of the offence and use the appropriate practical distance certificate to check the average speed shown on the infringement file.

8.3 Operator training

The PIB currently enforces spot-speed camera offences using images and data supplied to the back office. The enforcement of an average speed offence captured by a P2P camera will operate similarly; however, the P2P system adjudication requires the operator to verify the offending vehicle at two points for the

single infringement. While the additional procedures to process offences captured on P2P cameras are minor, PIB operators will require training. Appropriate training is necessary to ensure any misreads by ANPR software are corrected prior to an infringement notice being issued to maintain credibility in the P2P enforcement process.

8.4 Data storage requirements

The introduction of a P2P speed enforcement system will result in additional infringements passing through the PIB and necessitate greater data storage volume. Data storage requirements are dependent on the number of infringement files to be recorded and the size of the individual adjudication files. Conservatively, two high-resolution shots and associated data files equate to just over 2MB.

To illustrate the potential number of infringements that will be gathered in a year, along with their storage requirements, the following example will be used.

In a P2P enforcement corridor with an average daily traffic volume of 20,000 vehicles per day, approximately 17,500 vehicles will be matched. Of these matches it is conservatively assumed that 1% of matches will have exceeded the enforcement speed and therefore will be sent infringement notices. The 175 infringement notices generated daily from this P2P site will add up to approximately 64,000 notices annually. As a result the PIB back office will require approximately 130GB of additional storage per annum.

The PIB currently archives spot-speed files approximately nine months after they are received. Conceivably archiving P2P infringement files could be carried out after a similar period of time.

8.5 Public communication

As P2P enforcement trials commence or the system rollout begins the motoring public should be informed of the effects of the system. For example, this could involve providing information on the way the technology operates, or details of possible fines that offenders will receive, or a summary of the likely road safety benefits of the devices, or providing a consultation phone number or similar which will allow interested parties to discuss the technology further. While no speed enforcement system is likely to be universally popular the act of providing this information can potentially benefit the effectiveness of the enforcement system. As a minimum, the communication programme can act to defuse any negativity that could surface if the P2P system was thrust on an uninformed public.

8.6 Summary

The following need to be considered for the operation of the P2P system:

- alternative methods for creating potential infringement files for adjudication
- the potential to perform the process of matching number plates captured on P2P cameras, at the roadside
- operator training to ensure accurate verification of infringement notices to maintain system credibility
- a conservative infringement rate including tolerance is likely to be 1%.

9 P2P system design

The section discusses design considerations for a P2P system.

9.1 Overview

A review of existing P2P systems, advice from road authorities and suppliers, and a review of research papers revealed the performance of P2P speed enforcement would be influenced by several factors. The performance of the system will be determined by its ability to:

- 1 capture and record images at the entry and exit points
- 2 correctly identify the vehicles that have exceeded the designated speed threshold within the enforcement zone.

Capture rate is the number of successful vehicle images at each camera site expressed as a percentage of vehicles passing the camera.

Read rate is the number of captured number plates that are read correctly by the ANPR system, expressed as a percentage of the total number of captured plates.

The standard P2P system requires images of vehicles entering and exiting the enforcement zone and ANPR software to identify number plates on vehicles within the images. Since the P2P system requires multiple vehicle captures and number plate readings, the performance is determined by multiplying the proportions for each site. For example, a 95% capture rate at both camera sites and a corresponding read rate of 98% would result in a P2P enforcement corridor match rate of 87% ($0.95 \times 0.98 \times 0.95 \times 0.98$). However, 98% is an optimistic read rate estimate because it implies unreadable number plates are not common.

9.2 ANPR performance

9.2.1 Capture rate

Capture rates are influenced by the method in which they identify a vehicle about to enter or exit the enforcement zone. P2P systems continuously capture number plate images from a streaming video and typically achieve capture rates of 80%. The rate of capture can be improved with the use of a static camera with an external trigger that identifies a vehicle's presence. The existence of a trigger will reduce the processing required by the ANPR software as the image captured will probably contain a number plate. External triggers such as induction loops on the ground, lasers and radar will trigger a photograph each time a vehicle passes.

The decision to install an external trigger will be based on the objectives of the system. The trigger would increase cost, complexity and maintenance requirements but would support the enforcement approach by improving the likelihood of offenders receiving infringements.

9.2.2 Read rates

ANPR read rates are influenced by many factors including: lighting conditions, number plate material, position of the number plate on the vehicle, and presence of other text on the vehicle. The quality of the images can be improved by using illuminators offset from the enforcement camera. This typically improves the image quality that is normally achievable. Even so, non-reflective number plates usually reduce the read rate of ANPR.

A significant concern is when the ANPR either reads something on the vehicle that is not the number plate, or reads the number plate erroneously. In these examples the misreads are likely to be consistent between camera sites. Therefore, incorrectly read number plates may be correctly matched as they are incorrectly read at both camera sites. The potential for misread number plates by ANPR emphasises the matching process should be adjudicated manually to ensure the integrity of the system.

9.3 Roadside infrastructure

9.3.1 Mounting structure

The position of the cameras at the roadside influences the achievable capture and read rates at the enforcement site. P2P cameras are typically mounted to overhead gantries, mast arms or posts at the roadside. Overhead gantries allow cameras to be mounted in the ideal position above each individual lane, which reduces the probability of the number plates being obstructed by another vehicle on the road. The overhead gantry also provides an overt way to advertise that motorists are entering a P2P speed enforcement zone. The mast arm and post-mounted cameras at the roadside are a less expensive alternative to a gantry; however, on multi-lane roads the furthest lane may become obstructed by a large vehicle in the kerbside lane. The roadside mounted cameras can be installed either on the verge or in the median. Alternatively cameras may be mounted to existing bridge and tunnel infrastructure that could provide a suitable cost-effective solution.

In the UK, the mast arms at the roadside extend part way over the traffic lanes, therefore allowing cameras to be positioned above traffic lanes without the expense of an overhead gantry. The main disadvantage with mast arm-mounted cameras above traffic lanes is that traffic management and lane closures may be required during maintenance.

9.3.2 Camera orientation

P2P systems can operate as front facing or rear facing, or with both front- and rear-facing cameras. The choice is dependent on the objectives of the system as the first two configurations impose limitations on the number and type of vehicles captured:

- Front-facing systems enable the tractor unit of heavy vehicles to be captured which simplifies the process of identifying the driver but these systems do not capture motorcycles.
- Rear-facing systems enable motorcycles to be captured but only capture the number plate on the trailer of heavy vehicles which complicates the process of identifying the driver.

The alternative of having both front- and rear-facing cameras provides the benefits of both the above systems, but with the disadvantage of the additional cost of extra cameras.

The camera orientation depends on the system objectives and the mix of traffic. If the objective is to capture all vehicles then the front- and rear-facing system is desirable, but if the objective is to influence the speed of the majority of vehicles then the front- or rear-facing system should be selected for locations with high instances of heavy vehicle and/or motorcycle speeding.

In New South Wales the P2P system enforces heavy vehicles only; subsequently all cameras are forward facing to provide images that identify the tractor unit of heavy vehicles. Alternatively, in Victoria the DoJ has installed both rear- and front-facing cameras that provide flexibility in all lighting conditions and increase the overall capture rate.

9.3.3 Lighting

P2P systems typically use infra-red (IR) illuminators to identify vehicles during low light and at night. The illuminators emit IR light visible only to the camera, which allows clear monochrome images to be taken in complete darkness. Given that a vehicle's colour is not the most critical requirement in verifying an offending vehicle, monochrome images would probably be acceptable in New Zealand. In any case, the alternative to illuminators would be to install street lighting adjacent to the camera.

9.4 Time synchronisation

Time synchronisation between the P2P cameras is an essential component of a successful average speed enforcement system. The cameras at either end of the enforcement zone must be calibrated to ensure they do not affect the calculation of speed between the two cameras. The time synchronisation approach should be monitored regularly and the system needs automatic correction when deviations are detected. Discussions with the PCS revealed that within New Zealand the GPS timing devices were the most likely to pass the approved surveillance device requirements. The GPS devices are expensive in the short term; however, the alternatives may be limited in remote areas.

The time resolution of images recorded for the calculation of speed offences will influence the system accuracy. This is of particular concern if the enforcement corridor is relatively short in length. In longer zones the time resolution will not have as much bearing on the overall result. Time resolution refers to the size of the time step used when capturing the images, whereby a higher level of resolution will give a greater level of accuracy in the average speed calculation. Manufacturers' products that have been viewed suggest the time accuracy of each P2P device is at least 1/100th of a second. However, if P2P speed camera processing (average speed calculation) takes place in a system that is removed from the initial ANPR device, the calculation will need to ensure the accuracy from the original device is maintained.

9.5 Summary

Factors to consider when selecting the design of a P2P system include:

- the need for a camera trigger to improve vehicle capture rates
- the location of the cameras and whether they are gantry or post mounted
- depending on the type of vehicles to be captured, the option of front-facing or rear-facing cameras
- regular synchronisation of the internal clocks in the cameras to ensure evidence is robust
- the use of a camera illuminator to allow for the capture of non-reflective number plates, or to increase capture rates in poor visibility
- the level of time resolution may become a factor if the site is relatively short in length.

10 Suitable P2P speed camera sites

The following section summarises corridor selection considerations derived from road controlling authorities and information from system suppliers.

10.1 Overview

The review of current P2P speed camera research identified site selection characteristics for the implementation of P2P average speed enforcement. The discussions with suppliers and road authorities suggested the effectiveness of a P2P system would be influenced by the following site selection considerations.

It should be noted the effectiveness and success of a P2P system will ultimately be determined by the objective: improving safety and/or speed compliance.

10.2 The effect of intersections

Intersections have the potential to reduce the effectiveness of the P2P system. Sites should ideally be free from roundabouts and other controlled intersections. When these are present, motorists joining or leaving the main flow will have an effect on through traffic. As a vehicle enters or exits the through-traffic flow, trailing vehicles will have to slow to allow the turning vehicle to either accelerate to join the main flow or manoeuvre out of the main flow. The extent of this disruption depends on the type of intersection; grade-separated junctions should have minimal impact on the through flow, but on-grade intersections with no turning bays or acceleration zones will have a significant impact.

Another issue is that vehicles entering and exiting at intersections located between the two P2P speed camera endpoints will not be subject to the P2P system as they may be detected at one site only or perhaps at neither camera location.

Therefore, the majority of existing systems attempt to mitigate the effect of intersections by:

- avoiding intersections within the enforcement corridor
- ensuring any intersections that cannot be avoided are minor, with low entry/exit volumes
- placing P2P camera zones in series either side of major intersections.

In any case, drivers who do not travel through the entire enforcement corridor may be influenced by surrounding traffic. Although this issue has not been investigated, the platooning effect of a high proportion of through traffic could be sufficient to influence the speed of the non-through traffic. The platooning effect will increase with the density of the traffic, but higher traffic density also reduces vehicle speeds, therefore the benefit of P2P enforcement may not be significant during periods of high traffic flow.

10.3 Site selection considerations

When selecting potential sites, there are many issues to consider that could have an impact on the effectiveness and costs of the system. These include:

- **Power** – mains voltage electricity supplies are required to provide power to the roadside equipment.
- **Communications** – a communications system is required to transfer data from the roadside to the back-office processing system. The systems on the market can utilise most available mediums (eg

ADSL, 3G, WAN, LAN). The NZ Police do not currently have direct communication links between the speed cameras and the PIB. However, it may be practical to provide wireless communication between the P2P roadside system and the PIB back office. Thereafter, images and infringement information are sent to the PIB in a similar format.

- **Length of road section** – research (Keenan 2004 and ARRB 2005) has shown current fixed-speed enforcement cameras have a limited speed reduction halo effect downstream (between 500m and 1.5km) of the speed camera and little or none upstream of the camera. Therefore, P2P systems should be implemented on sections of road greater than 2km in length as the higher costs of P2P systems are unlikely to produce greater benefits over short distances.
- **Avoiding intersections** – the effectiveness of a P2P system will be reduced according to the extent vehicles can enter or leave the road between the entry and exit cameras. The research found most systems were installed with either no major intersections located within the enforcement corridor, or they comprised multiple discrete links contiguous along the road (eg, the Hume Highway in Victoria and the A77 in Scotland). Back-to-back sites can potentially mean a motorist could incur two or more tickets from one journey. The NZ Police will need to decide whether every offence or only the worst offence should be processed.
- **Free-flow speeds** – depending on the length of the enforced section of road the proximity of entry and exit cameras to acceleration and deceleration zones may affect the number of offences captured. However, the NZ Police currently ensure any spot-speed camera is at least 250m away from a change in posted speed sign. Therefore any acceleration or deceleration can occur outside the monitored area.

The following criteria should also be considered when finalising the potential P2P enforcement zones:

- The posted speed at the site should be constant between the two cameras.
- The location of cameras needs to be assessed for mounting requirements, camera security, vehicle detection loops and power supply.
- There should be allowance for the possible provision of future enforcement sites on the same road.

Appendix B presents the guidelines issued by the UK Department for Transport for the deployment of fixed, mobile, P2P and red-light enforcement systems (*DfT circular 01/2007: Use of speed and red-light cameras for traffic enforcement: guidance on deployment, visibility and signing*).

The guidelines include:

- **length** – average speed zones of between 5km and 20km
- **crash rate** – between six (rural) and eight (urban) fatal or serious-injury collisions per kilometre in the three years prior
- **85th percentile speeds** – at or above the police speed enforcement threshold in urban areas or 5mph (8km/h) above the posted speed limit in rural areas.

While these figures are useful as an indication of what is occurring in other countries it should be noted that Britain's traffic volumes are much greater than New Zealand's and the guidelines are not directly applicable in this country.

10.4 Summary

Factors to take into account when establishing a P2P enforcement corridor include:

- non free-flow intersections should be minimised within the enforcement zone
- enforcement zones should be installed on sections of road greater than 2km
- the opportunity for vehicles to leave the zone without detection should be limited by minimising the number of intersections within the P2P corridor
- enforcement zones should be within discrete speed zones
- the history of crash and casualties within the enforcement zone.

11 New Zealand P2P speed camera site selection

This section describes the process undertaken when shortlisting potential P2P speed camera sites within New Zealand.

11.1 Overview

The selection of suitable sites involved consideration of a number of factors. While the number of crashes on a length of road was obviously an important aspect, issues such as the location of change in posted speed, the number of low-speed corners and proximity of major intersections were also assessed.

11.2 Assumptions

Several assumptions, as listed below, were made when identifying and assessing the suitability of potential P2P speed enforcement zones:

- Only state highway classified roads were chosen.
- Only state highways with regional traffic volumes recorded in the *NZTA state highway traffic data booklet 2005–2009* (NZTA 2010b) were chosen.
- The site was listed in the *KiwiRAP* (2008) risk map report – collective risk category.
- Sections of state highway earmarked for upgrades under the roads of national significance programme were not considered in the analysis.
- Although 85th percentile speed surveys were unavailable from the Ministry of Transport at the time of reporting, these could be commissioned for shortlisted sites in the future.
- The location of existing mobile and fixed spot-speed camera zones did not preclude the use of P2P enforcement.

11.3 Methodology

The research examined the principles of P2P speed enforcement and identified key qualifying criteria for the potential P2P enforcement sites. The qualifying criteria included:

- length of zone
- number and nature of intersections
- discrete speed zones
- traffic volume.

A pragmatic assessment of the New Zealand state highway network was undertaken to develop a shortlist using the qualifying criteria. Potential P2P enforcement sites that satisfied the qualifying criteria were shortlisted for detailed site selection.

The selection criteria were flexible to allow for local experience and rationality checks. The P2P corridors had to:

- be at least two kilometres long
- maintain a discrete speed zone

- be identified through KiwiRAP with a high collective risk rating
- have traffic volumes greater than 15,000 vehicles per day
- have low connectivity to prevent deliberate evasion and minimise natural churn (intersections within the P2P enforcement zone)
- have a history of crash and casualty incidents.

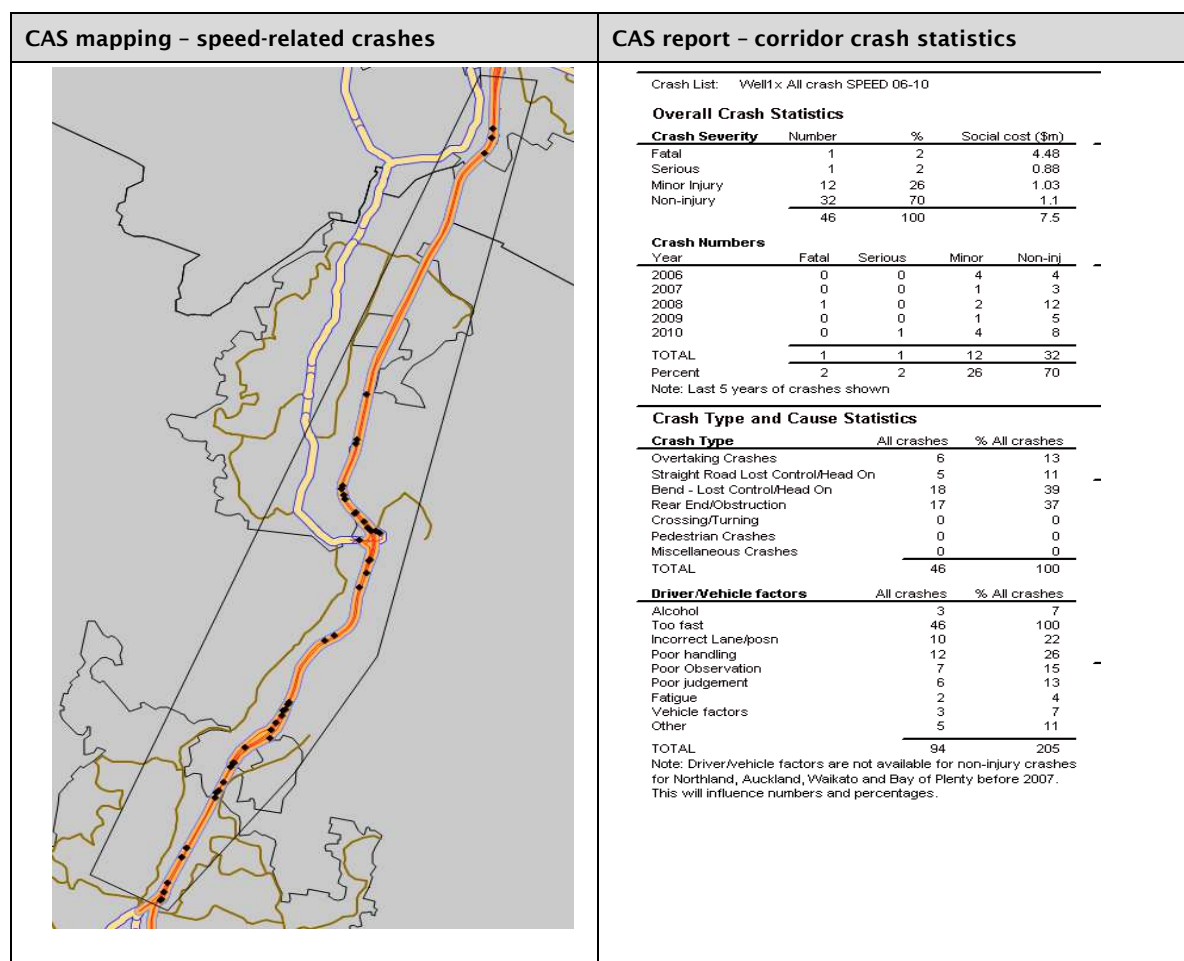
Non-free-flow intersections were limited to a maximum of one per P2P enforcement zone.

11.3.1 Crash and casualty history

11.3.1.1 Crash Analysis System

The Crash Analysis System (CAS) is the NZTA tool that manages, analyses and maps traffic crash related data. The CAS system was used to identify corridors with a history of crash and casualty incidents for inclusion in the shortlisted sites. The system has the capability to differentiate between crash types, contributing factors and crash severity. The CAS mapping tool was used to identify all crash, speed factor crash and fatal and serious crash incidents along the potential corridors to ensure enforcement zones were effectively located. The speed-related crash map and corresponding CAS report for a potential P2P enforcement corridor is shown in figure 11.1.

Figure 11.1 CAS reporting SH1 Wellington



11.3.1.2 KiwiRAP

The New Zealand Road Assessment Programme was nominated by the NZTA as a useful resource to aid in the site selection. The KiwiRAP (2008) risk map report contained information including the relative risk levels on New Zealand's state highway network. The programme looked into crashes that occurred where the speed limit was 80km/h or greater. The 2008 Collective Risk rankings were derived by first splitting roads into links of varying length over which a minimum of 20 fatal or serious-injury crashes had occurred; then assessing the number of fatal and serious-injury crashes per year per kilometre (based on 2002–06 crash data). Sites with 0.19 or more fatal and serious-injury crashes per kilometre per year were classed as high-risk links. The 2008 KiwiRAP Collective Risk ranking identified 32 corridors throughout the nation as being in the highest risk category. Several sites were not considered in the shortlist of potential sites as per the selection criteria above. The corridors not shortlisted due to proposed future upgrades are shown in table 11.1:

Table 11.1 Sites not shortlisted due to proposed upgrades

State highway	From	To	Proposed upgrade
SH1	Warkworth	Wellsford	Puhoi to Wellsford RoNS project
SH1	Orewa	Warkworth	Puhoi to Wellsford RoNS project
SH1	Hamilton	Cambridge	Waikato Expressway RoNS project
SH1	Huntly	Hamilton	Waikato Expressway RoNS project
SH1	Meremere	Rangiriri	Waikato Expressway RoNS project
SH2	Mt Maunganui	Paengaroa	Tauranga Eastern Arterial project
SH1	Levin	Pukerua Bay	Wellington Northern Corridor RoNS project

11.3.2 Local constraints

Local characteristics must be considered when selecting a P2P enforcement zone. The location not only has to meet the aforementioned selection criteria, but must also comply with enforcement policies and road environment considerations.

The enforcement zone must adhere to policies regarding the spacing required between change in speed signage and speed enforcement devices. The NZTA has recently updated its bylaw which describes the location of all speed limits on the state highway network. The current policy for the NZ Police is to operate speed cameras at least 250m from a change in speed sign.

The P2P enforcement zone should be located in a position that reduces the opportunity for motorists to avoid enforcement by taking an alternate route. Just as an intersection may allow a vehicle to leave the P2P enforcement zone without driving past both cameras, the presence of an alternate route may encourage motorists to simply bypass the enforcement corridor altogether.

P2P enforcement zones enforce the posted speed limit along a particular length of road; as a result the presence of a high number of low-speed advisory curves limits the ability to enforce an appropriate speed. The drivers within a P2P enforcement zone are more likely to comply with the posted limit on approaching the curve. At the time of reporting no statistics were available to support the reduced speed at advisory curves; however, anecdotal evidence suggests if the approach speed is below that posted then the lower speed effect may extend into the curve.

11.4 Suitable sites

Potential P2P enforcement sites throughout New Zealand were assessed based on the selection criteria and available data outlined above. It should be noted the shortlisted table below does not restrict implementation of P2P speed cameras to the listed sites. Suitability of sites that did not meet the shortlisting criteria may require an assessment based on the best practices outlined in this report.

The sites listed for detailed analysis are shown in table 11.2. The potential P2P enforcement sites are sorted by region with no relationship to potential suitability.

Table 11.2 Potential P2P enforcement sites within New Zealand

	Regional reference	Name of road	From	To
1	Nth1	Otaika Road	Raumanga	Waipu
2	Nth3	Waro Dr	Kawakawa	Whangarei
3	Nth3a	Waro Dr	Whakapara	Whangarei
4	Nth4	Western Hills Drive, Whangarei	Avenues	Whau Valley
5	Auck2	Northern motorway	Auckland	North Shore
6	Auck3	North-western motorway	Eden Terrace	Waitakere
7	Auck4	Upper Harbour motorway	Hobsonville	Schnapper Rock
8	Auck6	Drury to Glenbrook	Drury	Paerata
9	Auck11	Southern motorway	Mount Wellington	Clover Park
10	Auck12	Southern motorway	Remuera	Mount Wellington
11	Auck13	Southern motorway	Pokeno	Drury
12	Auck14	Southern motorway	Drury	Manukau
13	Waik2	Cambridge Road	Riverlea	Cambridge
14	Waik5	Maramarua	Pokeno	Maramarua
15	Bay2	Maungatapu	Mt Maunganui	Maungatapu
16	Bay3	Te Puna to Bethlehem	Te Puna	Bethlehem
17	Hawk2	Clive to Hastings	Clive	Hastings
18	Hawk3	Napier to Clive	Napier	Clive
19	Well1	Wellington urban motorway	Johnsonville	Porirua
20	Well3	Paremata Haywards Road	Manor Park	Pauatahanui
21	Well5	Hutt Road	Wellington	Petone Off-ramp
22	Cant2	Main Road North	Belfast	Kaiapoi
23	Cant3	Main Road South	Dunsandel	Bankside
24	Cant4	Christchurch Southern motorway	Middleton	Addington

11.5 Detailed site selection

Detailed site analysis was carried out on the 24 shortlisted sites to refine the list of suitable sites to 11. The scores and weighting values attributed to the shortlisted sites were calculated by a comparison of safety and traffic factors listed in section 11.5.1.

11.5.1 Safety factors

The following safety factors were used to determine the ranking:

- **Casualty crashes per kilometre per year** – crash data exported from CAS was analysed for the proposed enforcement zone for the five years from 2006 to 2010. The number of casualty crashes per kilometre per year was determined. The sites with the highest casualty rates were ranked favourably as they would benefit most from the P2P system.
- **Crashes per kilometre per year** – crash data exported from CAS was analysed for the proposed enforcement zone for the five years from 2006 to 2010. The number of crashes per kilometre per year was determined. The sites with the highest crash rates were ranked favourably as they would benefit most from the P2P system.
- **KiwiRAP** – the KiwiRAP (2008) report listed 32 sites as having the highest Collective Risk. Shortlisted sites included in the Collective Risk assessment were scored favourably based on ranking as they would benefit most from the P2P system.
- **Proportion of crashes where speed was the contributing factor** – the CAS analysis tool was used to calculate the total number of crashes and the speed-contributing factor crashes along the shortlisted sites. The sites with the highest proportion of speed-related crashes to total crashes were ranked the highest.
- **Proportion of speeding crash cost to total crash cost** – the NZTA's (2010a) *Economic evaluation manual* assigns an indicative economic cost to fatal, serious-injury and minor injury crashes. The total cost for all crashes and speed factor crashes within the shortlisted sites was recorded. The proportion of speed-related crash costs to total costs was calculated. The sites with the highest proportion were ranked highest.

Each site was ranked on each of the above factors and an average score determined as follows to provide an overall rank:

- A value was calculated for each potential P2P site for the traffic and safety factors outlined above.
- For each of the factors considered, the values for each of the potential P2P sites were ranked.
- The ranked positions for each factor were averaged to provide a total score for the potential sites.
- The total scores were ranked to provide a list of potential sites in order of suitability.

Averaging the rankings of the different factors rather than using the raw values provided a means of comparison between potential sites.

11.5.2 Traffic factors

The following factors were used to determine the priority from a traffic perspective of the proposed sites:

- **Non-free-flow intersections per kilometre** – traffic signals and roundabouts break up the traffic flow and act to inhibit average speed between two points. Therefore, it is desirable for sites to have as few as possible of these features. Sites that had the lowest number were ranked highest.
- **Total traffic volumes** – in order to influence the behaviour of the greatest number of drivers it is desirable for sites to be on roads with high traffic volumes. Therefore sites with the highest volumes were ranked highest.
- **Length of the enforcement corridor** – the corridor length factor was used to score the shortlisted P2P sites. The enforcement corridors with the greater length were ranked highest.

Each site was ranked on each of the above factors and an average score determined to provide an overall rank. Note that no speed survey data was available for shortlisted sites at the time of the analysis.

11.6 Revised site list

The average scores recorded by the safety and traffic factors were weighted² to establish the 11 potential sites for P2P speed enforcement, see table 11.3. The approach placed emphasis on improving road safety across the network while maintaining an influence on driver behaviour along high-volume corridors.

Table 11.3 Potential P2P enforcement sites ranked

	Regional reference	Name of road	From	To
1	Auck3*	North-western motorway	Newton Road	Te Atatu Road
2	Nth3	Waro Drive	320m south of Neumann St, Kawakawa	1020m north of Great North Road, Whangarei
3	Well1	Wellington urban motorway	Helston Road speed limit change	Mungavin Avenue
4	Well5	Hutt Road	415m from intersection SH1	50m west of Cornish Street
5	Auck11	Auck-Hamilton motorway	Mount Wellington Highway	Te Irirangi Drive
6	Auck12	Southern motorway	Green Lane	South-eastern highway (NB on-ramp)
7	Auck14	Southern motorway	Nth of Orams Road	Great South Road , Drury
8	Nth1	Otaika Road	380m south of Toetoe Road	1.3km South Waipu Gorge Road
9	Nth3a	Waro Drive	Russel Road , Whakapara	1020m north of Great North Road, Whangarei
10	Waik5	Maramarua	Pokeno, 200m from SH1N	2.0km north-west of Monument Road, Maramarua
11	Well3	Paremata Haywards Road	Western Hutt Road	Paekakariki Hill Road

*Note: the Auck3 enforcement zone may be affected by proposed Waterview upgrade.

11.7 Illustrative sites

At the request of the NZTA three illustrative sites were selected from the revised site list. These sites were located close to Auckland and Wellington, with one in Northland.

Three illustrative sites were:

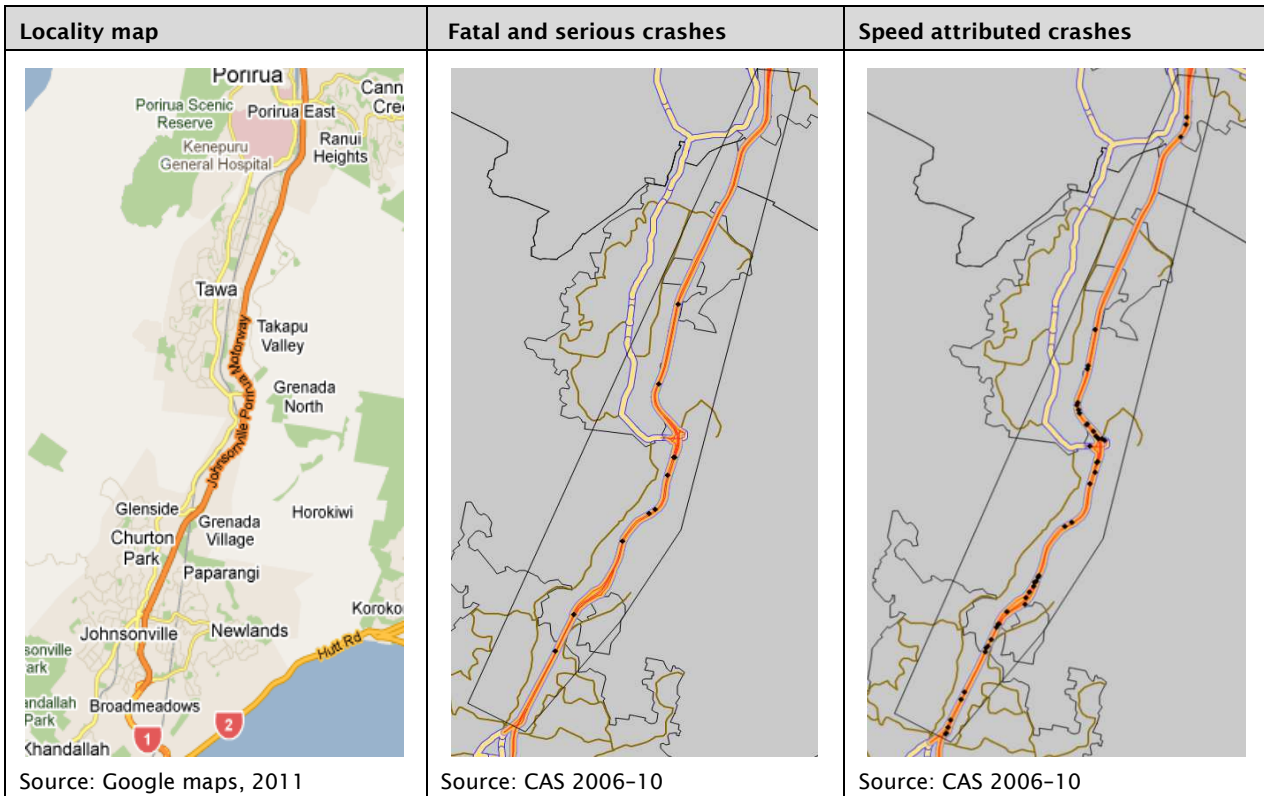
Wellington	Well1	Wellington urban motorway	Johnsonville	Porirua
Auckland	Auck3*	North-western motorway	Eden Terrace	Waitakere
Northland	Nth3	Waro Drive	Kawakawa	Whangarei

² Weighting refers to the comparison of ranking for each of the sites. The weighting applied was used to either increase or decrease the variance in ranking. The weighting of factors was limited to the 'corridor length' and 'casualty rate per kilometre per year'. The 'casualty crash/km/yr' ranking was weighted favourably by a factor of 2 to emphasise the significance of improving safety at potential sites. The 'corridor length' rankings were divided by 2 to reduce significance of length compared to other traffic factors considered.

11.7.1 Wellington

The illustrative site for the Wellington region is State Highway 1 (SH1) between Johnsonville and Porirua. Figure 11.2 shows the corridor and CAS crash data for potential P2P enforcement zone. The CAS map output shows both the location of crashes within the enforcement zone where speed was a contributing factor between 2006 and 2010 and the fatal and serious crashes within the enforcement zone between 2006 and 2010.

Figure 11.2 Locality map and CAS outputs for SH1 north of Wellington



11.7.2 Auckland

The illustrative site for the Auckland region is State Highway 16 (SH16) between Eden Terrace and Waitakere. Figure 11.3 shows the corridor and CAS crash data for a potential P2P enforcement zone. The CAS map output shows the location of crashes that occurred between 2006 and 2010 where speed was a contributing factor. Additionally, the CAS output also displays the fatal and serious crashes within the enforcement zone between 2006 and 2010.

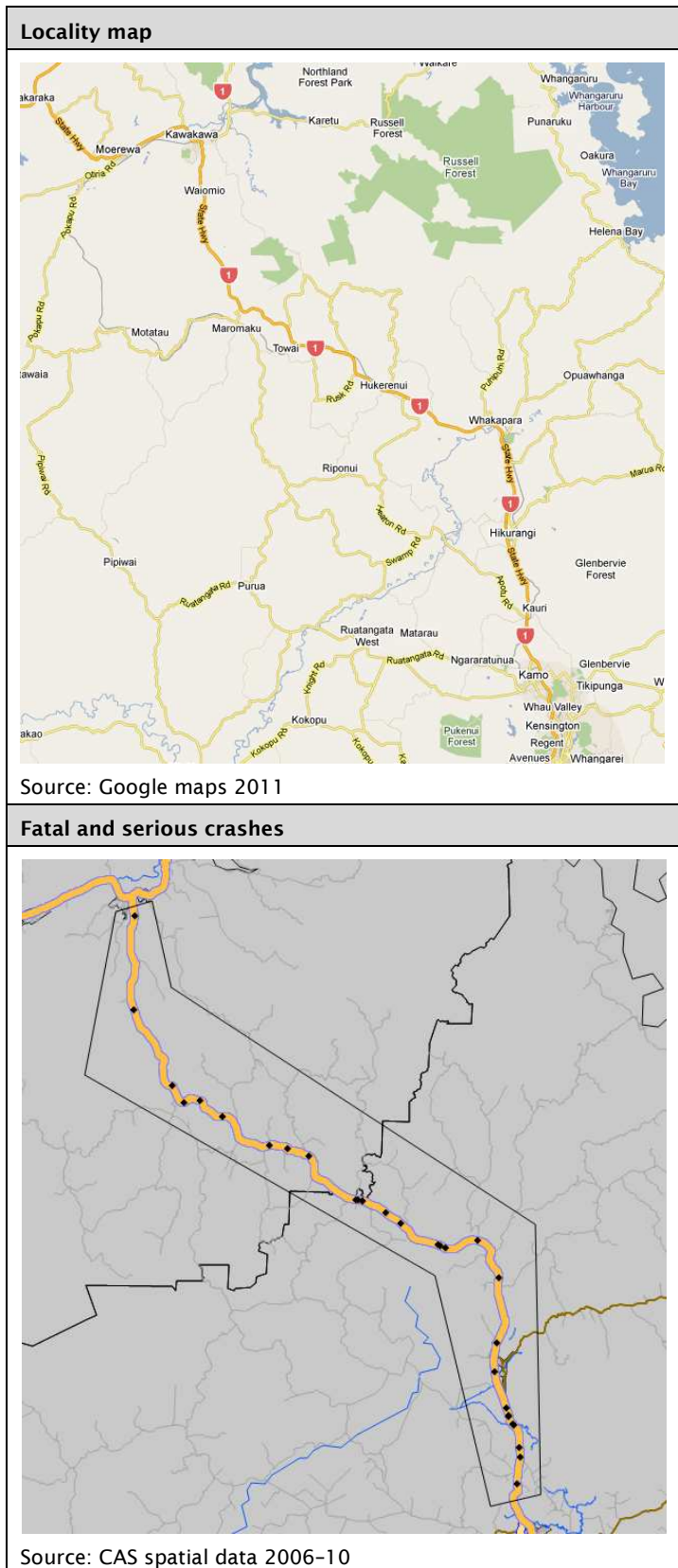
Figure 11.3 Locality map and CAS outputs for SH16 west of Auckland

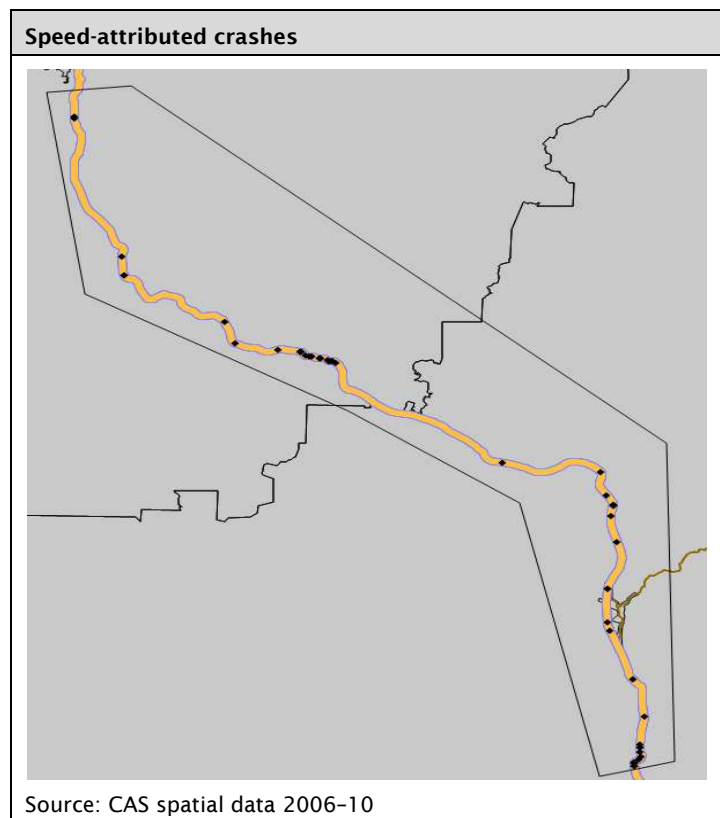


11.7.3 Northland

The illustrative site for the Northland region is SH1 between Kawakawa and Whangarei. The three maps include the site corridor, CAS crash data showing speed-related crashes that occurred between 2006 and 2010, and the location of fatal and serious crashes that occurred during the same period.

Figure 11.4 Locality map and CAS outputs for SH1, Northland





11.8 Summary

A range of factors needs to be assessed when selecting a site for P2P enforcement. Published documents can greatly assist in establishing potential sites (eg KiwiRAP). The factors include:

- historic crash data
- number and nature of intersections
- consistent posted speed
- traffic volume
- site terrain/road geometry
- site length.

These factors can be assigned with weightings and then used to rank a list of potential sites. The research indicated that ranking, with later economic evaluation, is an effective means of determining suitability.

12 Framework for a cost-benefit analysis

12.1 Overview

This section provides an analytical framework for the approach to a cost-benefit analysis. The anticipated cost factors and benefit factors are explained, but in the absence of critical information for the three illustrative sites (most notably, speed survey information) a detailed analysis of each site has not been performed. However, based on similar implementation projects in Australia, a range of benefit-cost ratios is provided as an indication of what to expect.

12.2 Cost factors

The following sections provide an estimate of probable project costs based on experience and information received from system suppliers, and on previous research/implementation studies.

There are two types of costs that are considered when forming the estimate for whole-of-life costs:

- capital costs
- recurrent costs.

12.2.1 Capital costs

This section considers the typical capital costs involved in system implementation and outlines the assumptions they are based on:

- Roadside infrastructure – four pole-mounted cameras to cover two dual carriageway lanes in each direction, a roadside cabinet and ANPR processor. This assumes a mobile communications network is available.
- Power connection – for the purposes of this analysis it is assumed the ready availability of mains power infrastructure is considered during the site survey and selection. Consequently connection of the site to a mains power supply is assumed to be included within the roadside infrastructure costs.
- Design and project management – it is assumed these costs will account for approximately 15% of the roadside infrastructure costs.
- Back-office infrastructure – this is the system that undertakes the processing of ANPR records to calculate the average speed and produces infringement files to be sent to the adjudication and review system. This cost will be vendor and solution specific.
- Adjudication system interface – there will be some development work required to enable the adjudication system to process infringement files produced by the P2P back-office system.
- Contingency – 10% contingency on the capital costs is assumed.

The roadside infrastructure hardware, excluding cabinets and support structures, will have a finite life and will require replacement during the life of the system. The enforcement cameras will have an approximate design life of 10 years; therefore it is assumed the system will be assessed over a 10-year life cycle. The following hardware will require replacement:

- after five years – inductive loops, OCR processors
- after 10 years – ANPR cameras, flash units, inductive loops and OCR processors.

In summary, based on recent data obtained from installations, the estimated capital costs are \$1.1 million.

12.2.2 Recurrent costs

This section considers the recurrent costs that will be incurred following the implementation of a P2P system and the assumptions they are based on:

- Communications costs – it is assumed the system will operate using 3G mobile communications data to transfer data to the control office.
- Operation and maintenance costs – these costs are incurred in routine and preventative maintenance of the system and returning it to working order following a fault.
- Infringement processing costs – the processing of infringement notices generated by the system requires effort from adjudication personnel. Depending upon the volume of infringements additional personnel may be required.

In summary, based on recent data obtained from installations, the estimated recurrent costs are \$850,000 per year.

12.3 Benefit factors

There are several sources of potential benefits from P2P systems, and the potential for benefits to accrue both to society as a whole and to the operator of the system, including:

- crash reduction (society benefit)
- vehicle operating cost savings (society benefit).

The primary objective of the P2P system is to improve road safety. Therefore, the primary benefit to be considered when planning the implementation of P2P speed enforcement is the potential crash reduction. The secondary benefit to road users would be to lower vehicle operating costs due to a lower average speed through the section being considered. While the NZTA's (2010a) *Economic evaluation manual* does allow for benefit calculation based on vehicle operating cost savings this advantage should be left out of benefit-cost analysis so the focus remains on crash reductions only.

12.4 The 'do-minimum'

The development of a cost-benefit model also requires the development of a 'do minimum' base case. In the case of a P2P system it is assumed the base case is to do nothing and to retain the status quo.

The cost of the do-minimum can be assessed by obtaining historic crash information and an accurate prediction of the annual increase in traffic flow. With these figures the NZTA's (2010) *Economic evaluation manual* can be used to calculate the likely economic cost if current crash rates are maintained over the period of the evaluation.

12.5 Crash reduction

12.5.1 Relationship of speed to crash likelihood and severity

Research (Elvik et al 2004; Kloeden et al 1997; Nilsson 1984; 2004) has established the relationship between vehicle speed and both the likelihood of a crash occurring and the severity of that crash. Oxley (2006) states that:

The probability of injury, and the severity of injuries that occur in a crash increases, not linearly, but exponentially with vehicle speed – by a factor of four for fatalities, three for serious injuries, and two for casualty crashes. Even small increases in travel and impact speed results in a great increase in the forces experienced by vehicle occupants and other road users.

Nilsson (1984) established a model to describe the relationship between speed and crashes and casualties. This has been corroborated through research by Elvik et al (2004). The power model compares two variables by raising one to a power; one variable is raised by an exponent that provides the relative change in the other variables, for example:

$$\frac{\text{Fatal Crashes After}}{\text{Fatal Crashes Before}} = \left[\frac{\text{Speed After}}{\text{Speed Before}} \right]^x \quad (\text{Equation 12.1})$$

Therefore if speed is reduced from 90km/h to 80km/h the ratio of speed after to speed before is 0.89. Raising this to the power of 4 (0.89^4) gives 0.6243. Therefore, the number of fatal crashes is estimated to reduce to 0.6243 times the number of crashes before the speed reduction, which is a reduction in fatal crashes of 37.6%.

The Nilsson Power model provides three equations for casualties and three for crashes:

Casualty relationship

- fatalities – the exponent is between 4 and 8
- fatal and serious injuries – the exponent is between 3 and 6
- all injuries – the exponent is between 2 and 4.

Crash relationship

- fatal crashes – the exponent is 4
- fatal and serious crashes – the exponent is 3
- all injury crashes – the exponent is 2.

This means a model can be selected based on the data available, and that sensitivity testing can be performed both between models and using a range of exponents in a single model. It should be noted that the NZTA (2010a) *Economic evaluation manual* assumes linear increases in crash cost with speed. The proposed analysis uses a 4th power relationship³.

12.5.2 Applying the power model

CAS data can be used to obtain the crash data on the stretch of road under consideration. This data includes the:

- number of casualties
- number of fatal crashes
- number of serious injury crashes

³ Further relationships between speed and crashes have been explored by the Transport Research Laboratory (TRL), in particular by Taylor et al in 2000. This research established a 5% reduction in crashes for every 1mph reduction in average speed. The work by Taylor et al has not been used directly in this research; however, it does further substantiate the likely estimates of crash reduction, considering a reduction in speed.

- number of minor injury crashes.

Therefore the following models could be used:

- All injuries – using the total number of casualties

$$\frac{\text{All Injuries After}}{\text{All Injuries Before}} = \left[\frac{\text{Speed After}}{\text{Speed Before}} \right]^{2 \text{ to } 4} \quad (\text{Equation 12.2})$$

- Fatal crashes – using the total number of fatal crashes and an exponent of 3.6 based on Elvik et al (2004)

$$\frac{\text{Fatal Crashes After}}{\text{Fatal Crashes Before}} = \left[\frac{\text{Speed After}}{\text{Speed Before}} \right]^{3.6} \quad (\text{Equation 12.3})$$

- Serious injury crashes – using an exponent of 2.4 based on Elvik et al (2004)

$$\frac{\text{Serious Injury Crashes After}}{\text{Serious Injury Crashes Before}} = \left[\frac{\text{Speed After}}{\text{Speed Before}} \right]^{2.4} \quad (\text{Equation 12.4})$$

- Minor injury crashes – using an exponent of 1.2 based on Elvik et al (2004)

$$\frac{\text{Minor Injury Crashes After}}{\text{Minor Injury Crashes Before}} = \left[\frac{\text{Speed After}}{\text{Speed Before}} \right]^{1.2} \quad (\text{Equation 12.5})$$

- Non-injury crashes – using no exponent, as based on Elvik et al (2004)

$$\frac{\text{Non Injury Crashes After}}{\text{Non Injury Crashes Before}} = \frac{\text{Speed After}}{\text{Speed Before}} \quad (\text{Equation 12.6})$$

The next major factor required to apply the power model to the calculation of crash reduction benefits is the availability of cost data. The latest *Economic evaluation manual* (NZTA 2010a) states that when considering all vehicles and all movements in a 100km/h area, the costs in July 2006 dollars are as follows:

- cost per fatal crash – \$3,800,000
- cost per serious injury crash – \$405,000
- cost per minor injury crash – \$24,000
- cost per non-injury crash – \$2,400.

These figures should be updated to current values when running the evaluation.

Consequently equations 12.2 to 12.6 listed above can be used to develop an estimate of the potential benefits from deployment of P2P systems.

12.5.3 Summary of benefits

Through the application of the above models and crash costs the annual benefits of the P2P system may be calculated as follows:

- The total number of crashes over a five-year period may be found through the CAS system. Under-reporting factors are applied to increase serious, minor and non-injury crash numbers to a more realistic number.
- The existing average annual crash rate is determined by dividing the number of crashes over the preceding five-year period by five.

- The ratio of speed-before to speed-after was calculated using the existing 85th percentile speed and the assumption this would be reduced to the posted limit. This assumption is based on overseas experience that has found P2P systems can reduce the 85th percentile speed to 'at' or 'below' the posted speed limit.
- The rate of crash reduction was calculated for each of the four power models.
- The new annual crash rate was determined by multiplying the rate of reduction by the existing annual crash rate.
- The annual crash reduction was calculated by subtracting the new annual crash rate from the original.
- The annual crash saving was calculated by multiplying the annual crash reduction by the cost per crash.

12.6 Results from P2P speed camera implementation projects

As mentioned previously, detailed speed survey information was not obtained for the three illustrative sites, and so therefore the direct application of the benefit-cost framework has not been undertaken at this time. However, based on similar P2P speed camera implementation projects conducted in the Australian Capital Territory (ACT), where cost and benefit information is available, the results show the benefit-cost ratio ranges between 6.5 and 14.4. This demonstrates that with careful consideration of site selection (speeds and anticipation of crash reductions) that the projects may be of very high economic worth.

12.7 Conclusion

The benefit-cost factors are least sensitive to capital costs (ie relative low variability), followed by recurrent costs (a function of traffic volumes and infringement rates) and most sensitive to the anticipated crash reductions at a particular site. The anticipated cost-benefit results, based on analysis from other similar projects indicates the projects are worthwhile because the benefit-cost ratio is substantially greater than one and the net present value is positive for a range of discount rates assessed.

13 Conclusion and next steps

The fundamental principles behind average speed enforcement are common to P2P systems operating throughout the world. Average speed enforcement is an established and proven technology since it was first introduced in the 1990s. The United Kingdom, The Netherlands, Italy and Austria are countries with reputable average speed enforcement systems. In areas where P2P enforcement has been implemented they have observed reductions in serious-injury and fatal crashes as well as greater compliance with posted speed limits.

Existing speed enforcement within New Zealand utilises a combination of fixed spot-speed cameras, mobile speed cameras and police officer initiated infringements. The introduction of P2P speed camera technology will need to complement the current speed enforcement techniques. The P2P speed enforcement has the advantage over traditional spot-speed enforcement as the P2P system encourages compliance over a greater distance.

The research suggests safety benefits observed overseas are likely to be replicated within New Zealand on corridors that meet suitable criteria. In the UK, P2P enforcement installed on corridors with a history of high-speed crash rates have observed reductions in fatal and serious crash rates in the years following installation. The study suggests the use of P2P speed camera enforcement within New Zealand would be likely to observe similar benefits to those systems operating overseas.

The introduction of an average speeding offence will require changes to current New Zealand legislation. The authors have not provided expert legal advice in this report; rather the information is intended to give an understanding of possible legislative changes required prior to the implementation of the systems.

The implementation of P2P speed enforcement will require cooperation by the NZTA, NZ Police and P2P system suppliers to provide a credible speed enforcement system. The PCS will need to perform rigorous testing on the P2P system prior to it being accepted as an approved surveillance device for average speed offences.

The PIB, which coordinates the adjudication and issuing of infringements, will require changes to the back-office procedures to cater for the new enforcement system. There are a number of suppliers of P2P systems that can provide the combination of processing software and back-office support. It is recommended the infringement matching process, at least initially, be performed by a third party. This will allow the PIB to maintain its primary role of adjudication and issuing infringements.

An assessment of state highways considered in the analysis found 24 sites satisfied the criteria for P2P speed enforcement. The corridors were deemed suitable for detailed analysis if they fulfilled the criteria relating to:

- history of crash and casualty crashes
- length of zone
- number and nature of intersections
- discrete speed zones
- traffic volume
- connectivity.

The detailed site analysis identified 11 potential sites for the introduction of P2P by applying a range of traffic and safety criteria, which included:

- **casualty crashes per kilometre per year (2006–10)** – the sites with the highest casualty rates were ranked favourably as they would benefit most
- **crashes per kilometre per year (2006–10)** – the sites with the highest crash rates were ranked favourably as they would benefit most
- **KiwiRAP 2008** –high-risk sites in the KiwiRAP assessment were scored favourably based on the highest ranking benefiting most
- **proportion of crashes where speed was a contributing factor (2006–10)** - the sites with the highest proportion of speed-related crashes to total crashes observed were ranked highest
- **proportion of speed factor crash cost to total crash cost (2006–10)** – the sites with the highest proportion were ranked favourably.

The average scores recorded by the safety and traffic factors were weighted to establish the 11 potential sites for P2P speed enforcement. The approach placed an emphasis on improving road safety across the network while maintaining an influence on driver behaviour along high-volume corridors (see table 11.3).

At the request of the NZTA three illustrative sites were selected from the potential site list (see section 11.7). These sites were located in the Wellington, Auckland and Northland regions. The top ranked sites from each region were included in the focus group discussions.

An implementation programme on the Wellington urban motorway would allow the performance of the P2P system within New Zealand to be assessed. The programme's objectives should include testing of integration, operation and roadside infrastructure of the P2P system. This would also allow the PCS time to complete the necessary testing to meet the requirements for an approved vehicle surveillance device.

In addition, it is recommended covert speed survey data is collected upstream, downstream and within the proposed enforcement corridor prior to the commencement of testing. The data will provide a base case for comparison against the P2P system test results and quantify the speed limit compliance rate due to the introduction of P2P speed enforcement. Pending the results of the programme a business case will outline the results and in what form P2P speed enforcement will be implemented in New Zealand.

13.1 Next steps

- Commission speed surveys of potential corridors that meet the suitability criteria.
- Implement a phased P2P programme on the site identified as meeting the criteria for a suitable trial corridor:
 - commission speed survey upstream and downstream of the trial corridor to observe the speed behaviour outside the enforcement zone
 - develop a programme of works and objectives of the pilot trial
 - give the PCS sufficient time to gazette the technology for speed enforcement
 - provide the PIB with sufficient time to update back-office procedures to handle the introduction of an additional speeding offence.
- Develop a business case outlining the potential rollout of P2P speed enforcement in New Zealand.
- Design a specific P2P enforcement site assessment of power, communications and geometry requirements, together with detailed costing.

14 Bibliography

- Autostrade per l'Italia (2008) Electronic speed monitoring. Accessed 7 October 2010.
www.autostrade.it/en/assistenza-al-traffico/tutor.html?initPosAra=3_4
- Cameron, M (2008) Development of strategies for best practice in speed enforcement in Western Australia – supplementary report. *Monash University Accident Research Centre report no.277*. 50pp.
- Elvik, R, P Christensen and A Amundsen (2004) Speed and road accidents: an evaluation of the power model *TOI report 740/2004, Institute of Transport Economics, Oslo*. 134pp.
- Eriksen, AM (2010) Speed cameras – the one-in-five gamble for drivers in an illegal hurry. Accessed 9 September 2010. www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10633552
- Kable (2009) ANPR speed cameras allow higher limits. Accessed 10 September 2010.
www.kable.co.uk/highways-agency-anpr-speed-20jul09
- Keenan, D (2003) Speed cameras – measuring the impact on driver behaviour. *European Transport Conference, Transport Safety*.
- Keenan, D (2004) Speed cameras – how do drivers respond? *Traffic Engineering & Control* 45, no.3: 104–111.
- Leask, A and R Milne (19 April 2009) NZ's new busiest speed camera revealed. Accessed 10 September 2010. www.nzherald.co.nz/index.cfm?objectid=10567360
- Morrah, M (21 July 2010) New crime-fighting tech raises privacy concerns. Accessed 20 September 2010.
www.3news.co.nz/New-crime-fighting-tech-raises-privacy-concerns/tabid/423/articleID/166858/Default.aspx
- New Zealand Police (2009) *Annual report 2008/09*. Wellington: NZ Police. 101pp.
- New Zealand Police (2010) *Annual report 2009/10*. Wellington: NZ Police. 89pp
- New Zealand Road Assessment Programme (KiwiRAP) (2008) How safe are our roads? 61pp. Accessed October 2011. www.kiwirap.org.nz/pdf/KIWRAP%20Magazine%20final%20new.pdf
- New Zealand Transport Agency (NZTA) (2010a) *Economic evaluation manual*. Vols 1 and 2. Wellington: NZTA.
- New Zealand Transport Agency (NZTA) (2010b) NZTA state highway traffic data booklet 2005–2009. Accessed October 2011. www.nzta.govt.nz/resources/state-highway-traffic-volumes/docs/SHTV-2005-2009.pdf
- New Zealand Transport Agency (NZTA) (2010c) Speed limits on state highways bylaw 2010/10 *New Zealand Gazette (Supplement)* 112. Pp2967–2994.
- Office of the Auditor-General (OAG) (2002) *Bringing down the road toll – the speed camera programme*. 89pp
- Oxley, J (2006) Road safety implications of excessive and inappropriate vehicle speed. Accessed 12 September 2010. www.austroads.com.au/pdf/TestMethod2/4._Excessive_and_inappropriate_speed__Sep_06_.pdf
- Stefan, C (2006) Section control – automatic speed enforcement in the Kaisermuhlen Tunnel. *Kuratorium fur Verkehrssicherheit* 25pp

SUPREME (2007) Thematic report: enforcement. *Summary and publication of best practices in road safety in the member states, part F6*. 86pp.

Taylor, MC, DA Lynam and A Baruya (2000) The effects of drivers' speed on the frequency of road accidents. *Transport Research Laboratory (TRL) report 421*. 50pp.

Transport for London (TfL) (18 January 2010) TfL to trial average speed cameras on A13. Accessed 13 September 2010. www.tfl.gov.uk/corporate/media/newscentre/archive/14023.aspx

Appendix A: Certificate of enforcement zone length

SCHEDULE 1A

Regulation 106(3)

CERTIFICATE UNDER SECTION 78A



I am a licensed surveyor within the meaning of the **Surveying Act 2004** and I am approved for the purposes of section 78A of the **Road Safety Act 1986** by the Roads Corporation.

I certify that the shortest distance, expressed in metres, that would be travelled by a motor vehicle travelling on the southbound carriageway of the Hume Freeway between:

- (a) the vehicle detectors at 65 metres South of Amaroo Road, Craigieburn and
 - (b) the vehicle detectors at 60 metres South of O'Herns Road, Epping
- is 7,747 metres.

Signature of person issuing certificate:



Name:  - Licensed Surveyor Registration No. 

Date: 20 December 2006

Appendix B: Department for Transport Guidelines

Rule		Fixed speed camera sites		Mobile speed camera sites		Routes		Red-light or combined red-light speed
1	Site or route length requirements	Between 0.4km and 1.5km		Between 0.4km and 1.5km		Between 5km and 20km		From stop line to stop line in direction of travel
2	Number of KSI ⁴ (killed or seriously injured) collisions	At least 3 KSI collisions per km in the baseline period ⁵		At least 1 KSI collision per km (average) in the baseline period		A minimum of 3 existing core sites within the length (there are no further requirements) or Has at least 1 KSI collision per km (average) in the baseline period and meets the PIC ⁶ total value below		At least 1 KSI collision within the junction in the baseline period. Selection must be based on a collision history of red-light running
3	Total value required ⁷	Built-up 22/km	Non-built-up 18/km	Built-up 11/km	Non-built-up 9/km	Built-up 8/km	Non-built-up 6/km	10
4	85th percentile speed at proposed sites	Speed survey shows free-flow 85th percentile speed is at or above ACPO ⁸ enforcement threshold in built-up areas and 5mph over maximum speed limit in non-built-up areas. This can apply to all vehicles or a vehicle class but must be compared consistently.						Not applicable
5	Site conditions that are suitable for the type of enforcement proposed	Loading and unloading of camera can take place safely		Location for mobile enforcement is easily accessible and there is space for enforcement to take place in a visible, legal and safe manner		The location of collisions in the baseline period will determine the length of route		Loading and unloading of camera can take place safely
6	Suitability of site for camera enforcement	<p>The highway authority must undertake a site survey, demonstrating the following:</p> <ul style="list-style-type: none"> • The speed limit has been reviewed, confirming that camera enforcement is the right solution. • There is no other cost-effective engineering solution that is more appropriate. • That the Traffic Regulation Order (where applicable) and signing are lawful and correct. 						
<p>New camera sites will be selected using an assessment that includes the level of fatal, serious and slight collisions. The combined level of collisions will be expressed as a numerical scale (see below) and assessed relative to the road classification for the site – whether it is either a ‘built-up’ or ‘non-built-up’ area and according to the type of site, ie route, fixed, mobile or red light.</p> <p>Fatal or serious injury collision = 5 (ie 2 serious collisions = 10)</p> <p>Slight injury collision = 1 (ie 5 slight collisions = 5)</p> <p>‘Built-up area’ is defined as a road with a speed limit of 40mph or less</p> <p>‘Non-built-up area’ is defined as a road with a speed limit of 50mph or more</p>								

⁴ KSI: killed or seriously injured collision

⁵ The baseline period is the most recent 36-month period of complete crash data.

⁶ PIC: personal injury collision, either fatal, serious or minor

⁷ Total number of PICs within the three year period

⁸ ACPO: Association of Chief Police Officers